A VOCATIONAL EDUCATION TRAINING MODEL FOR ROV PILOTS AND AUV OPERATORS

THOMAS LEANDER MERCER

A VOCATIONAL EDUCATION TRAINING MODEL FOR ROV PILOTS AND AUV OPERATORS

by

Thomas Leander Mercer, CD, rmc, B.Eng.

A thesis submitted to the School of Graduate Studies

in partial fulfillment of the

requirements for the degree of

Master of Ocean Engineering

Faculty of Engineering and Applied Science

Memorial University of Newfoundland

April, 2010

St. John's Newfoundland

Abstract

A current concern is the training required to bring new underwater vehicle operators to a level where they will be proficient operational leads capable of performing all aspects of a "typical" mission. Globally, there is a significant lack of trained underwater vehicle operators. As underwater systems become more specialized and sophisticated they demand a higher level of skills from their operators and support crews.

Stakeholders of the various projects in which underwater vehicles are employed such as offshore oil and gas, resource management and security rely heavily on the data collected, the functions performed by the vehicles, and the expertise of their operators.

Currently most operators of these vehicles evolve into their respective fields through academic interests or operational requirements without specific background knowledge of the systems or the environment in which they will operate. Some operators migrate from other platforms and use their previous knowledge as a baseline.

The content of their baseline knowledge is a paramount concern. There is a need to find a reliable method to train operators for a growing underwater vehicle marketplace, and moreover ascertain what education level is required as a baseline and then decide how we can take advantage of their prior learning skills.

The AUV manufactures are doing their part, but there is an increased need to work in concert with academia, industry, military and other equipment manufacturers to achieve the best training methods possible for this growing industry.

The ROV industry is working toward competency validation and certification using the IMCA as a baseline reference. There is no such reference for AUV operators; however this thesis produces a baseline knowledge guideline for an AUV operator, and through an investigation into the TAFE packages identified 58 out of the 69 competencies required as pre-existing units within the TAFE framework.

The existence of the TAFE competencies introduce a method to leverage off of existing knowledge baselines as students acquire the skills required to operate underwater vehicles though an avenue of Vocational Education.

Acknowledgments

I would like to thank Mr. Vince Stack for his support with patience, resolving issues related to formatting and page numbering.

I also would like to thank Ms. Karen Donnelly for kindly proof reading my thesis and telling me to reduce the use of words: Etcetera.

Of course my wife Lynne, whose constant reminders of my looming deadlines, motivated me toward completion.

A special thanks to my Mother of ninety years who will be greatly surprised that I finished this effort.

Of course a last but not least thank you goes out to Dr. Neil Bose, who is truly a very patient advisor.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

List of Abbreviations and Symbols

ADAS	Australian Divers Accreditation Scheme
ADCI	Association of Diving Contractors International
ADCP	Acoustic Doppler Current Profiler
AODC	Association of Offshore Diving Contractors
APL	Assessment of Prior Learning
AQF	Australian Quality Framework
AQTF	Australian Quality Training Framework
AUSI	Autonomous Undersea Systems Institute
AUV	Autonomous Underwater Vehicle
AUVAC	Autonomous Undersea Vehicle Applications Center
AUVROV	Autonomous Underwater Vehicle-Remotely Operated Vehicle
BOSIET	Basic Offshore Safety Induction and Emergency Training
BST	Basic Safety Training
COTS	Commercial Off-The-Shelf
CSA	Canadian Standards Association
CTD	Conductivity, Temperature, Depth
CV	Curriculum Vitae
DCBC	Diver Certification Board of Canada
DND	Department of Defence (CAN)

List of Abbreviations and Symbols (continued)

DOD	Department of Defense (US)
DP	Dynamic Positioning
DPVOA	Dynamically Positioned Vehicles Owners Association
EOD	Explosive Ordnance Disposal
FGRL	Fugro General Robotics Ltd.
GPS	Global Positioning System
GRI	GRI Simulations Inc. (Formerly Geo-Resources Inc.)
HES	Health, Environment and Safety
HROV	Hybrid Remotely Operated Underwater Vehicle
HSE	Health and Safety Executive
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
ISE	International Submarine Engineering
KSG	Knowledge and Skill Guidelines
LARS	Launch and Recovery Systems
LBL	Long Baseline
LMRS	Long-term Mine Reconnaissance System
MATE	The Marine Advanced Technology Education Center
MI	Fisheries and Marine Institute of Memorial University of Newfoundland

List of Abbreviations and Symbols (continued)

NORSOK	Standards are developed by the Norwegian petroleum industry
NRC	National Research Council of Canada
NRC-IOT	National Research Council of Canada - Institute of Ocean Technology
NTF	National Training Framework
NTIS	National Training Information Service
NTS	National Training System
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment
PPP	Public-Private Partnerships
RCC	Record of Current Competency
ROV	Remotely Operated Underwater Vehicle
RTO	Registered Training Organization
SAROV	SAAB Hovering Hybrid AUV/ROV Technology
STCW	Standards of Training and Watch-keeping for Seafarers
SUT	Society for Underwater Technology
TAFE	Technical and Further Education
TMS	Tether Management System
UAV	Unmanned Aerial Vehicles

List of Abbreviations and Symbols (continued)

USBL	Ultra Short Baseline
UUV	Unmanned Underwater Vehicle
VET	Vocational Education Training
WHOI	Woods Hole Oceanographic Institution
XBT	Expendable Bathythermograph

List of Appendices

Chapter 1 Introduction

1.1 Background

An Autonomous Underwater Vehicle (AUV) or Unmanned Underwater Vehicle (UUV) is similar to a Remotely Operated "Underwater" Vehicle (ROV) in that they both are highly sophisticated machines designed to perform tasks in marine environments. On one hand ROV's, notwithstanding some experimental hybrid models (HROV's), are designed to operate with continual human guidance via a tethered (usually high-bandwidth fiber-optic) communication link, whereas AUV's by pure definition are self-directed or self-sufficient and once programmed can complete tasks without human intervention or guidance. Communications, however, with submerged AUV's can occur through low-bandwidth acoustic telemetry. This capability can enable operators to monitor in-situ data obtained by the vehicle and respond by transmitting commands to effectively reprogram the vehicle and thereby change its behaviours.

The programming required for AUV's is non-trivial considering the tasks that an AUV is required to perform. These tasks include navigation, obstacle avoidance, data collection, data processing, and communication. Communication can occur; between AUV's in the situation where AUV's operate in cooperative arrays, between AUV's and a control station during covert operations for example payload delivery (mainly a military function), and between the AUV and its sensors such as digital image processing, sonar applications, and chemical sensors.

The programming required for ROV's is not as complicated. For example, ROV's perform navigation and obstacle avoidance under the watchful eyes of the ROV pilot who in real time observes the feedback from the ROV's sensors (sonar, altimeter, doppler, cameras) and using their own spatial perception they manipulate the thrusters, manage the tether payout and tether force as required to guide the ROV's path, heading it to its desired location under varying subsurface conditions. Once on station the ROV operator uses the tools and manipulators to carry out specific tasks. This technique occurs in almost all classes of ROV's with the exception of some ROV's designated as Class V Experimental ROV's.

Both ROV's and AUV's however, require trained personnel to perform all tasks required to support the operation. This support covers all aspects of a mission from mission planning and logistics, pre-dive and post-dive maintenance procedures including modifications and repairs of equipment as well as interfacing onboard computers, sensors and communication equipment. The personnel must be able to operate within Occupational Health and Safety guidelines. They must employ risk management techniques for both the mission and the personnel involved. And they must participate in professional development initiatives to remain current with industry standards.

The training should be comprehensive enough so that the personnel can switch between vehicles within their domain of expertise, either AUV or ROV, by completing some basic 'refresher' or 'familiarization' training on the unfamiliar vehicle that will enable then to participate as an effective team member on the new equipment.

1.2 Stakeholders

There are basically five main stakeholder categories of the underwater vehicle industry:

1. The manufacturers of underwater vehicles and their related equipment;
2. The industries that use the vehicles mainly 'big oil' or similar consortiums with interests in subsea technologies;
3. The military;
4. Academia; and
5. Training institutions.

Figure 1.1 Venn-Diagram of Stakeholders of Underwater Vehicles as shown on following page represents the relationship between these main stakeholders.

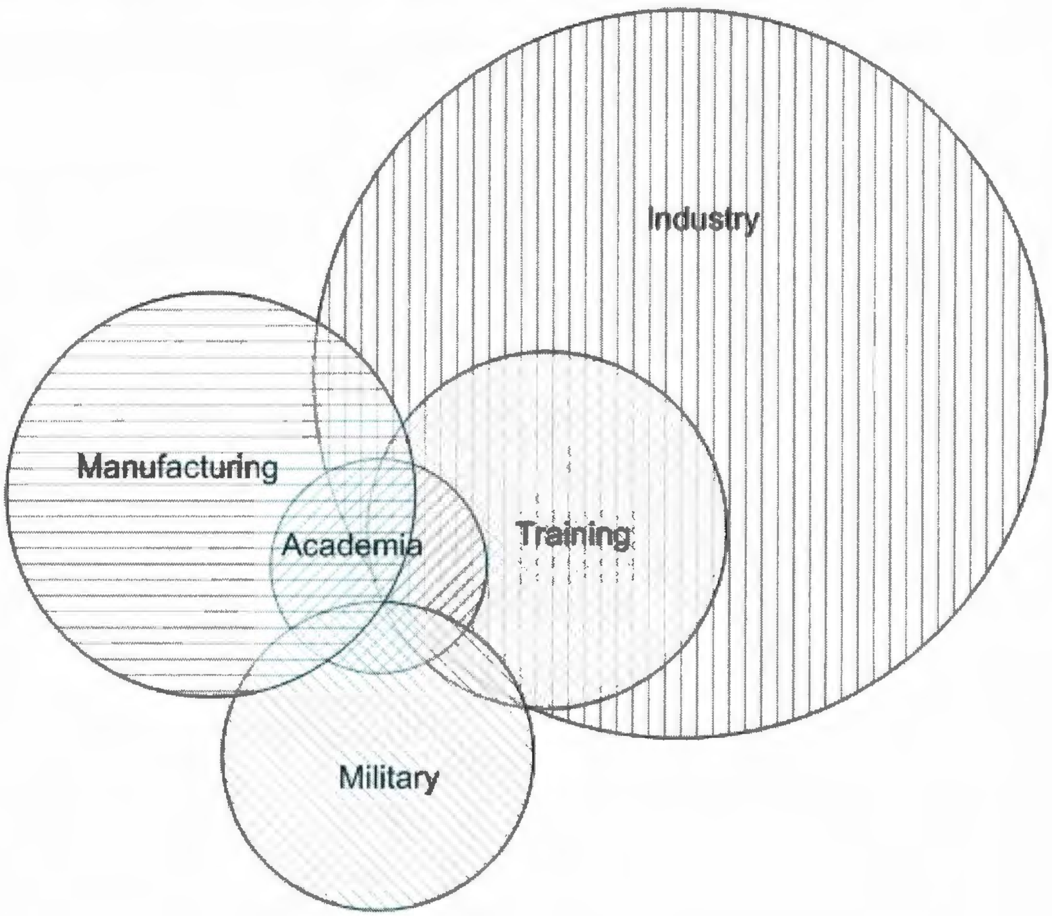
Several public-private partnerships (PPP) have been formed in order to leverage resources, reduce costs and share information among stakeholders. One such entity is the Autonomous Undersea Vehicle Applications Center (AUVAC), a program under the

Autonomous Undersea Systems Institute (AUSI) a not-for-profit research institute focused on promoting commercial applications of AUV's, platforms and sensors.

The AUVAC's mission statement as presented on their website is as follows:

"AUVAC is an incubator formed by an association of academic, private sector, and government organizations to advance AUV system and subsystem technology and to promote AUV interoperability and availability in support of the international ocean community's needs" (AUVAC Website, 2010).

Figure 1 1 Venn diagram of Stakeholders of Underwater Vehicles



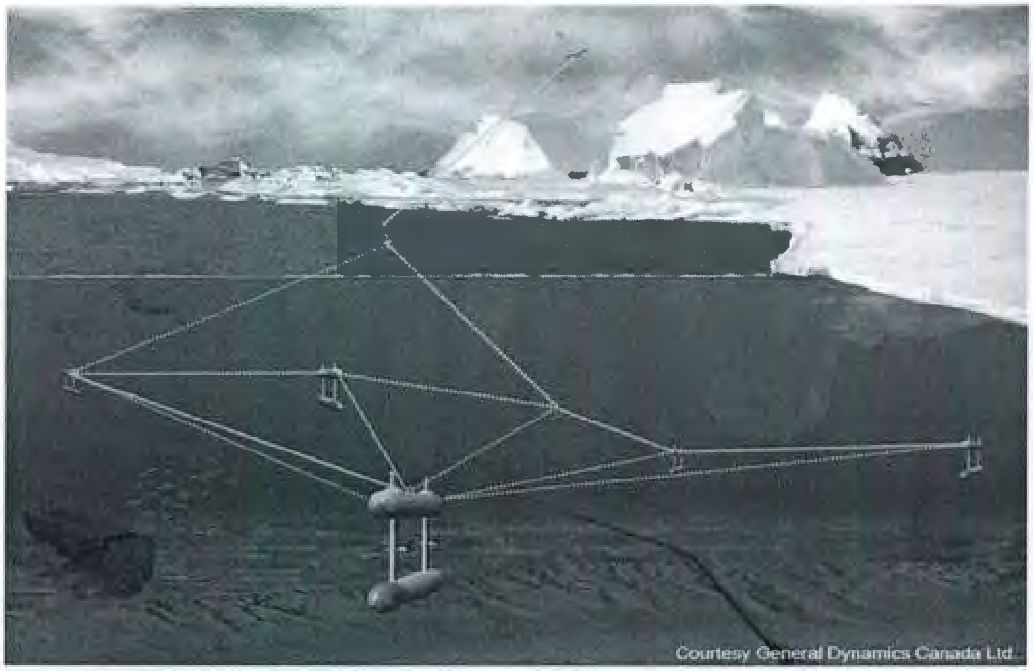
1.2.1 Equipment Manufacturers

AUVAC's website lists a manufacturing membership of over 136 manufacturers of underwater vehicles and systems. These are only the companies listed as members of the organization. In addition to these many new companies are developing innovative vehicle designs as mentioned by James Ferguson of International Submarine Engineering (ISE), a company with a thirty-five year history of underwater vehicle innovation. He states in his paper presented to the International Symposium on Unmanned Untethered Submersible Technology (UUST) 2009 (AUVAC Website, 2010) "that most of the 450 AUV's that have been built to date are optimized for survey operations, and that there is a need to develop vehicles that have better maneuvering capabilities".

Marport Canada Inc. of St. John's Canada for example is developing a seabed inspection AUV in partnership with the National Research Council of Canada- Institute of Ocean Technology (NRC-IOT). The partnership draws on the resources of three of the five stakeholders namely industry, academia and manufacturing to produce an innovative hybrid AUV. This AUV has hover capabilities whereas most survey optimized AUV's are long-range cruise configured. A press release 19 March 2010 entitled "*Sonar company sounds out new markets*" stated that "St. John's-based Marport Canada Inc, which builds sonar for commercial deepwater fishing, is releasing its SQX-500 submarine. The submarine was built with NRC help and is suited for use in Defence, offshore energy and ocean science applications" (AUVAC Website, 2010).

Marport has partnered with Memorial University of Newfoundland, the NRC-IOT and General Dynamics Canada. They plan to leverage off of their 500 Metre SQX-500 and develop a 3000 Metre AUV. Marport envisions that SQX-500 'swarms' will be used to map the Arctic seabed. A swarm of AUV's are essentially many AUV's working together in an area. Each AUV is autonomous however, they are capable of communicating with each thereby sharing information and updating their algorithms to facilitate the completion of the overall mission objectives. Figure 2.2 (AUVAC Website, 2010) shows an artist's representation of Marport SQX-500 Swarm under Arctic ice.

Figure 1 2 Marport SQX-500 Swarm



Source AUVAC website, 2010

This isn't the first time a Canadian university has aided in the development of AUV's. Memorial University of Newfoundland developed C-Scout (1999-2001) and the University of Victoria developed AUVic (2004-2008). The University of Alberta and the University of McGill in Montreal have also pursued AUV development (Ferguson, 2009).

1.2.2 Industry

Many industries are not only users of AUV and ROV technologies they are also involved in vehicle development. "ISE is currently under contract with Cybernetix SA of Marseille, a provider of robotic solutions, and the French oil company Total to develop a hybrid AUV that will transport a work class ROV to satellites where it will dock and provide power for the ROV" (Ferguson, 2009).

Offshore companies routinely use ROV technology to perform underwater construction, inspections, diver support, and operations. Oil and gas exploration and production companies, telecommunications and power distribution companies, survey and mapping companies, mineral exploration companies, construction engineering and civil defence organizations are all stakeholders in the underwater vehicle consortium.

Since the move into deeper ocean environments, moving from typically offshore environments to subsea environments, these stakeholders increasingly rely on underwater vehicles to perform deep-sea construction projects that were once within the limits and in the domain of human divers.

The industrial stakeholder has been key in forming not for profit organizations such as the International Marine Contractors Association (IMCA). IMCA protects stakeholders from substandard contractor services by outlining a competency framework that incorporates required skills, experience, training and assessment, as well as the professional affiliations required of member contractors who have a desire to do business with the stakeholder group.

1.2.3 The military

The military can be considered a global leader in implementing AUV and ROV technologies. It is no secret that military organizations spend large amounts of money developing technology. Most Navies are embracing these underwater vehicles as a cost effective means to gather large quantities of data with minimum human risk in several areas of their operations. They are also funding the effort with more vigor since the 'terrorist age'. The military have developed Unmanned Aerial Vehicles (UAV's) as an effective 'search and destroy' tool and they seem to be headed toward the same methodologies with AUV technologies. The US Navy in their document "The Navy Unmanned Undersea Vehicle (UUV) Master Plan" (UUVMP, 2003), cite nine sub-pillar capabilities required of UUV's:

1. Intelligence, Surveillance, and Reconnaissance;
2. Mine Countermeasures;
3. Anti-Submarine Warfare;
4. Inspection / Identification;
5. Oceanography;
6. Communication / Navigation Network Node;
7. Payload Delivery;

8. Information Operations; and

9. Time Critical Strike.

In order to realize these nine sub-pillars the Navy's report recommended the following:

1. Develop four UUV classes;

    a. Man Portable (<100 lbs),

    b. Light Weight (~500 lbs),

    c. Heavy Weight (~3000 lbs), and

    d. Large (~20,000 lbs).

2. Develop standards and implement modularity;

3. Establish a balanced UUV technology program;

4. Increase experimentation in UUV technology;

5. Coordinate with other unmanned vehicle programs; and

6. Field systems in the fleet.

The US Navy is trying to leverage off of the range of vehicle classes from man-portable to large, as well as from sometimes expendable through to non-expendable. They would prefer adaptable Commercial Off-The-Shelf (COTS) systems however this is sometimes impossible due to the nature of their business. They are in multiple contracts with various industries, manufacturers and scientists developing their own customized systems by leveraging the best that the other stakeholders have to offer.

Kongsberg Maritime designs and manufactures COTS AUV's and related equipment and their REMUS and HUGIN product lines are employed by industrial, academic, and military stakeholders. Kongsberg states that "Kongsberg Maritime is a committed, reliable, dependable and long term partner for navies seeking superiority in the underwater battlespace" (Kongsberg, 2010).

SAAB Underwater Systems of Sweden started making underwater vehicles for the Navy 100 years ago. These vehicles, torpedoes, were not as sophisticated as today's ROV's or AUV's however, SAAB has approximately 35 years experience making ROV's and approximately 25 years experience making AUV's. SAAB is currently producing a SAROV Offshore hybrid concept family of vehicles. The SAROV Offshore family has all the advanced features of the SAAB military Hybrid AUV/ROV's combined with the rugged and proven SAAB Seaeye technology. Together the SAAB Hybrid and the SAAB Seaeye technology this adds up to vehicles with full 360 degrees maneuverability, interfaces for sensors and auxiliary equipment and the extremely long excursion range as desired by Military stakeholders.

1.2.4 Academia

Academic interests range from pure scientific exploration through to seeding a commercial venture through private, industry and government grants. Canadian institutions have acquired AUV's for research. From an academic standpoint using AUV's for research normally means that operators likely are in the position of operator for a short while, during which time they complete their masters or PhD studies however, most operators come from a variety of backgrounds and some are lacking such training as control theory, management, electrical, electronic, microprocessor/software interfacing, and ocean hydrodynamics. Operators may have all the theoretical prerequisite training required to become an excellent operator but may be missing the technical aptitude required to perform maintenance, modification or repair tasks on the vehicles various subsystems.

1.2.5 Training Institutions

Training institutions as they exist today are in business to train operators, generate profit and at the same time support the underwater vehicle industry. The industrial shareholders have tried to guide the training institutions through their competency frameworks as mentioned in 1.2.2 above. Notwithstanding efforts to regulate training requirements the institutions are still guided by requirements of the non-industrial stakeholders and sometimes they operate without clear direction. There currently are few standards developed for consistent training.

Training is a 'hub' of the underwater vehicle industry in that all stakeholders rely on training in some form or another; manufacturers may produce an excellent sophisticated and reliable product using input and collaboration from stakeholders however, without proper training the vehicles will not operate at their optimal performance level and the tasks performed or data collected may fall short of the desired objectives.

1.3 Importance of Proper Training

The stakeholders in the underwater vehicle industry have invested considerable time, financial resources, material resources and manpower into their respective areas of expertise. They also have the expectation that their operators are capable of performing all the tasks required to make each mission a success.

Operating underwater vehicles is more than performing the actual 'cruise'. The overall process of the 'cruise' complete with pre and post planning, data acquisition, data processing, repair and maintenance workshops, testing facilities, surface vehicle support, launching systems, control rooms, specialized equipment, and proper management is an expensive endeavour. It can also be a dangerous endeavour. Therefore, safety training must be included along with general operations training and specialized training to protect the most valuable asset of the operation: human life.

Stakeholders of the various projects in which AUV's and ROV's are employed rely heavily on the data collected along with the functions performed by the vehicles and the expertise of their operators. The quality of the vehicles, which have evolved though many years of engineering analysis and prototyping, is generally outstanding. In order to complement the vehicles there is a requirement that the quality of the operators be outstanding as well.

Training is more than 'attending' a brief overview of vehicle capabilities with a small time devoted to handling and operational practice. Operators as well, are not usually trained by only one organization. As operators migrate from other platforms they use their previous knowledge and experiences as a baseline. The content of their baseline knowledge is a paramount concern however, as are the methods used to leverage off of the baseline toward full competency in the operation of the vehicles in question.

There is a need for comprehensive training in all aspects of underwater vehicle operations, as well as sufficient 'hands-on' and simulation training both of which must provide measurable objectives and feedback that will enable the student to learn from the within the training environment. Real experience is earned not learned, however a solid academic and technical background coupled with other essential 'workplace skills' will position operators in 'the driver's seat' ready to accumulate invaluable experience on top of their previous baseline knowledge.

Chapter 2 Data Acquisition

2.1 Internet Research

Answers to questions pertaining to the ROV industry, such as the availability of industry standards, training facilities, recognition of training, number of personnel on a team, education entrance requirements, classifications of ROV vehicles, industry accepted minimal training requirements and related experience, and supervisory skills were easily found using the internet as a primary research tool. Whereas answers to questions pertaining to the AUV industry were not as easily found. Therefore a survey was used to supplement research on the AUV industry.

2.2 Email Survey

An email questionnaire was used in order to gather information for the AUV industry with respect to the existing training, standardizations, and certifications. Two versions of the questionnaire (one for manufacturers and one for users) were prepared and each questionnaire included 36 questions in the following 10 areas:

1. Background information (4 questions);
2. Training (9 questions);
3. Formal training (3 questions);
4. On job training (3 questions);

5. Refresher training (2 questions);

6. Marine specific training (3 questions);

7. Specific technical skill sets required (3 questions);

8. Management skills (2 questions);

9. Regulatory Bodies (3 questions); and

10. Future Considerations (4 questions).

In all, 55 surveys were emailed out to various users and manufacturers of AUV's with a return rate of 11 %. The average response for 'cold-call' direct mail or email surveys listed on many websites is between 2-5 %. The response of this survey then is high given those results. The blank questionnaires as well as one complete with a compilation of the replies are included in Appendix A. A summary of the results follows:

2.2.1 Background Information

The four questions in this area were designed to obtain opinions on: the level of education required to operated an AUV, i.e. whether a university degree or a trades qualification is required to operate an AUV; the essential background knowledge required when working as an individual or when working within a team environment; and which facets of prior learning would enable a novice operator to quickly attain operational status.

The replies to this section were quite specific to the respondents operational experience, however, a consensus is that ability and experience along with at least one specialty in an area of either; electrical, mechanical or software abilities would be preferred regardless of educational qualifications of a university degree or a college diploma.

Generally crew sizes are small and therefore it is necessary that some members have the technical aptitude to perform troubleshooting and repairs while on deployment. It is not necessary that each member performs all duties, but what is necessary is that the combined skill sets and knowledge of the team are capable of performing all duties. Other areas of concern were training in failsafe-fault responses and extrapolation of collected data.

2.2.2 Training

The intent of the nine questions in this area was to ascertain: whether or not training provided either by users or manufacturers is specialized, generic or proprietary; if it provides a comprehensive academic background; the educational timeframe required for an operator to become capable of deployments; if there are areas conducive to cross training operators on various platforms; whether or not each trainee requires comprehensive and complete training on all aspects of underwater vehicles and the training required to become a supervisor.

The responses to this section indicate that training delivered is specialized and generic. Generic training is provided for common sense AUV operations, and underwater systems in general, and then specialized or specific with respect to the AUV of concern. Some of the specific (specialized) training delivered ventures into the proprietary intellectual property areas of the specific AUV manufacturer.

The training does not provide a comprehensive academic background and some respondents indicated that training 'fell woefully short' and success hinged not on the training received but on the overall general competency of the individual operator.

With respect to the educational time frame required for operators to become capable of deployments the responses ranged from a couple of missions to a range of five to ten missions of three or four hour duration. These missions are considered short duration and after experience is gained with them then the operators should be ready to venture into deployment of longer missions.

The question regarding common elements that would be paramount in helping operators' transition from one vehicle type to the other fell into three categories; physical limits, autonomous systems, and operational considerations. The collected responses are reproduced in the following list:

1. Battery Systems;

2. Network and Communications;

3. Acoustic Communications;

4. Navigation;

5. Mapping;

6. Electronics;

7. Robotics;

8. Underwater Connectors;

9. Underwater Actuators;

10. Vessel Operations;

11. Deployment;

12. Maritime Knowledge; and

13. Experience.

The question regarding the requirement of comprehensive training for operators in all aspects of underwater components generated a mixed response. Fifty percent of respondents answered that comprehensive training was very important and the remaining fifty percent rationalized that given the number of people on a team is small, generally three-four persons, and though desirable to have the complete team cross trained, however, realistically this is virtually impossible to attain especially during initial team building. All competencies are desired, but in the end combinations of some specialization by each team member and the others with general overall (basic) knowledge in all areas filling in the gaps.

The question concerning training required of supervisors solicited responses of "we don't have supervisors: we work as a team," to supervisors progress from operators to supervisors via gained experience and mentoring practices.

The answers to the question on the number of live deployments done during operator training ranged from, 'we don't do courses' or 'it's all live' to AUV operators that originally started out in ROV systems or manned underwater vehicles require less training. In the latter case the answer was one cruise with 10-20 deployments along with detailed lab work is a good adaptation to the AUV especially related to launch and recovery operations.

With respect to the question on transferability of training to other platforms other than the platform on which the operators were trained the response was there are overlaps but there are also limits and subtle differences, which if not addressed can lead to significant problems. These differences lie in the nature of the missions and the higher stakes involved in various operations rather than the fundamental differences within the different technologies themselves.

One question asked about experiences with cross-training personnel who were initially trained on other manufactures vehicles. While some respondents did not experience cross training, others had some varied levels of integration. One respondent offered that a trained operator could be efficient on another system in a few days and a supervisor in a few weeks. They added that this is an excellent way to optimize human resources for the long haul.

Another respondent who had personnel experience migrating from one platform to another mentioned that although there are similarities there are also differences and with that in mind "a little or casual mistake can really ruin a day." To use a few colloquial phrases: this is likely either a case of 'too little knowledge is a dangerous thing', or 'familiarity breeds contempt'.

2.2.3 Formal Training

The three questions in this area address the issues of: availability of formal training for AUV operators; leveraging off of previous education and experiences; and availability of current accredited AUV training centres. The response to the first question, except for the manufacturer's response is that there is no formal training available for AUV operators. One response indicated that they gave a 10-15 day maintenance and operations course, consisting of checklists, vehicle and payload configurations, data control, vessel mobilization and maintenance.

The question of relevance in this set then is related to the absence of formal training for AUV operators, namely what methods are used to take advantage of previous experience and education in order to advance them to operators? One respondent did not have an opinion on this topic; of the others four state that they use an informal training environment and training on the job to get them to an operational level. It was noted as well, that using this approach puts a lot of trust in the new individual with the aspirations that they will act sensibly and reasonably and not 'beat up' the expensive equipment while on the steep learning curve. One respondent noted that they had had no previous experience in AUV operations and were basically 'placed' in the job. They advise against this type of placement.

The last question in this set looks at current accredited AUV training centres other than those of a specific manufacturer. The results were unanimous there does not currently exist any such centre however, Cybernetics in France is considering such an endeavour.

2.2.4 On job Training

The three questions in this area solicit information on: the best vehicle to use for training or the use of simulators versus actual AUV's; whether or not on job training is used as a primary method of instruction; and the use of apprenticeship training.

One respondent suggested that the REMUS family of AUV's developed by Woods Hole Oceanographic Institution (WHOI) and currently being manufactured by

Hydroid would be the AUV of choice for training stating that it is user friendly and a good place to start.

With respect to simulation versus actual real time operation of the live vehicle the responses were mixed, half of the respondents thought that simulation and real time operation were beneficial however, the simulation should not be used to replace the entire mission, and it should only be used for specific sub systems. It was stated that simulation cannot replace hands on learning and that many missions of hands on experience are required: “one mission doesn’t ***learn*** you an AUV”. Simulators cannot replace sea states and work conditions, as operational aspects are not trained: they are experienced.

All respondents use on job training to train operators and typically a team of three can do with one novice operator but lab training must be provided for the background to balance out the training. With respect to apprenticeship training, the intent of the question was to determine if skilled trades’ technicians could be employed and then trained on the job thereby offering their previous skills as experience toward the new skill. The respondents seemed as they were unsure of this question and the responses were 50-50 for yes and no.

2.2.5 Refresher Training

The two questions in this section relate to the recommended intervals for refresher training and the propensity of the manufacturer to share hardware and software modifications. The refresher intervals elicited responses from not applicable, through after one year without cruise experience to "every cruise is a refresher to us."

The responses for the propensity of manufacturers to share data were of two mind sets, one from the user side that stated new hardware and software modifications are done and then given back to the manufacturer so that they can then roll them out into their products. The other response from a manufacturer stated that details of modifications are conveyed back to the user so that they may update the knowledge themselves.

2.2.6 Marine Specific Training

The three questions in this area ask: about the paramount aspects of marine training; the requirements of training and expertise in the use of marine navigation; and whether or not operators be required to complete courses and attain certificates in offshore safety, survival and marine emergency duties.

One response indicated that there was a sharing of information between underwater vehicle operators and ship operators however; unskilled or untrained ship operators can cause problems for AUV work. Another response indicated that the use of common sense and seamanship is very important. With respect to marine navigation all respondents agreed that use of electronic and paper charts are essential to planning and operations. The safety and survival question received one no, the other respondents indicated that in some cases the client demands the qualifications and they are therefore necessary.

2.2.7 Specific Skill Sets Required

The three questions in this section ask: which type of training is mission critical; if knowledge of microcontrollers and embedded systems is an essential skill; and what skills are required in addition to a degree (control question).

The mission critical items are planning and navigation including charts, acoustics, security systems, batteries, and specific knowledge related to scientific payloads. Only one respondent thought that knowledge of microcontrollers and embedded systems is an essential AUV operator skill. The skills that are required in addition to a degree are software and interfacing, electrical engineering, sea and underwater vehicle experience.

2.2.8 Management Skills

The two questions in this area are asked to find out the requirement for; engineering management and risk management training for AUV operators. The respondents were all in agreement that engineering management was not an essential requirement. Only one respondent disagreed that risk management training was required. Of the others risk management involved; common sense go/no-go decisions for deployment, ongoing assessment of the deployment that considers equipment and human consequences of action or inaction, and insight into the technical, operational and user related risks of the mission keeping in mind that a successful mission is only that which brings home a complete and consistent data set.

2.2.9 Regulatory Bodies

The three questions in this area ask: if there are any current regulations designed to protect the AUV industry; if there are any current AUV certifications; and if there is a requirement for a regulatory body to oversee standardized AUV operator training. Each respondent indicated that there are no current regulations. One did mention that the Society for Underwater Technology (SUT) is considering regulations to protect the integrity of the AUV industry. The response was also quite clear that there are also no current AUV certifications that would verify that an operator is trained in a particular area of AUV operations.

> The response of the question regarding the requirement of an international organization to oversee standardized training for AUV operators was generally no, with a few observations:
>
> 1. This does not even exist for manned subs; and
>
> 2. The probability that one or more agencies in the near term may set up training courses for AUV operators and maintainers is relatively high. This will likely create the requirement of an international standardization. Then this standardized training will become a mandatory practice.

2.2.10 Future Considerations

This section has four questions that ask; the preferred location of an AUV training facility; the features desired, simulated or real, in a training facility; the type of desired bottom features; and the best vehicle to use for training.

The answers for preferred location are:

1. Near deep warm sheltered water: Eastern Mediterranean;

2. No one site, but important to have a variety of water depths and terrain features;

3. Somewhere with 365 days of ice free waters, less than one hour by boat to useful water depths of 50 to 100 metres with wind less than 10 knots and sea heights less than one-two feet. Little boat traffic and near a pub; and

4. Not realistic.

The features should be:

1. Muddy bottom;

2. Rough terrain, sandy bottom only in initial stages of training; and

3. From easy to progressively harder terrain, sand to canyons to under-ice to deep water.

The best vehicle would be:

1. Something you could afford to lose;
2. Use the actual vehicle that you will deploy with; and
3. A member of the REMUS family of AUV's.

One note from this question set is that the easier a vehicle is to program the more use it will receive.

Chapter 3 Standards and Certifications

3.1 Standards

The Remotely Operated Vehicle (ROV) industry is largely driven by offshore commercial oil exploration and production. Engineering standards are high as are manufacturing standards. Quality of both are important but after the vehicle is delivered it is up to the ROV team to maintain the vehicles integrity by performing regular maintenance, repairing and replacing components as required and performing modifications on an as required basis. Troubleshooting an elusive fault or battling a strong cross current on the way to a target are the jobs of the technician and pilot respectively. Both of whom work under the watchful eye of the ROV supervisor.

The quality, experience and competence of the pilot doing the flying, the technician performing maintenance and the supervisor are jobs of utmost importance. Their job descriptions with its demanding performance objectives can only be met from a solid background knowledge, adequate and appropriate training, excellent team skills, periodic assessments of their competencies, excellent record keeping and problem solving skills, management and logistic skills, a desire to continually perform above standards and a commitment to maintaining a safe working environment.

Performing above a particular standard is difficult especially if standards are not developed.

3.1.1 IMCA Standard

The International Marine Contractors Association (IMCA) is an international trade association for offshore, marine and underwater engineering companies. It has a membership of approximately 250 companies in over 35 countries and promotes industry 'Best Practices' through worldwide communications in the offshore scene.

The IMCA actually classify AUV's under their ROV classification system as a *Class V – Prototype or Development Vehicles* (IMCA R 004 Rev. 3 July 2009). Keeping this in mind the following frameworks and guidelines referencing ROV's also includes AUV's.

IMCA promotes visibility and transparency in the marine industries by providing a series of documents available for distribution, which are, sectioned into six main series ("Publications", 2010).

These are:

1. *Competence & Training Series*;

2. *Diving Division Series*;

3. *Marine Division and DPVOA Series*;

4. *Remote Systems & ROV Division Series*;

5. *Offshore Survey Division Series*; and

6. *Safety, Environment & Legislation Series*.

Three of these series are of utmost importance to underwater vehicle operations:

1. *Competence & Training Series*;

2. *Remote Systems & ROV Division Series*; and

3. *Safety, Environment & Legislation Series*.

The *Competence & Training Series* outlines various core competencies and minimal training objectives that must be achieved in order to qualify for a particular area of expertise. These areas are based on relevant job descriptions that are developed for various marine activities, as well as guidelines to ensure that the core competencies and performance reviews are documented and verifiable.

As stated in ICMA's information pack: *Competence Assurance & Assessment Introduction for Experienced Freelance Personnel* ("Publications", 2010), IMCA launched a competence assurance and assessment guide in 1999 (with revisions as recent as November 2009), which provide a framework from which its contractor members can demonstrate the competence of their respective personnel to their various clients and regulators. IMCA states that their objective is to maintain the competence and currency of their member companies through a process of 'self regulation', which they find is better than surfing through the plethora of individual requirements required by each member company (IMCA , n.d.).

To meet the objective of self regulation the IMCA developed a framework for experienced freelance personnel and for its clients and contractors to use as a guide, and as such the onus is on the individual companies to roll out their own policies and procedures, as well as maintain an ongoing competency record set which fall within the guidelines set out by IMCA. The IMCA however, does not issue competence certificates, but they do allow qualifying members to state that their qualifications are "IMCA-approved".

Collectively the members of IMCA have agreed to recognize the competency of personnel who have followed this route, as well as recognize the experience gained by them through their employment with member employees. The IMCA membership is also proactive in promoting their scheme, for example the IMCA is scheduled to hold a workshop in Aberdeen, UK on 24 March 2010, which will encourage competence schemes. The title of the workshop is "Getting the message across" and during which they will promote the effectiveness of the collective organization with respect to the training, competency, and reliability of their personnel that form the aggregate of their workforce.

In order to demonstrate their competency and work experience the IMCA states that 'Freelance personnel' must maintain a portfolio outlining as evidence their expertise, experience and assessment. The IMCA gives guidance as to the contents of the portfolio and reminds members that they should not breach contractor-client confidentiality with respect to project or company details related to such activities as confidential survey reports or drilling techniques (IMCA, n.d.).

IMCA also states that each company should have members identified as assessors and that they should train them periodically as required to maintain their currency and expertise. IMCA provides details on assessor training in their publication *Guidance on Assessor Training* (IMCA C 007) ("Publications", 2010).

Assessors are identified as knowledgeable, qualified and experienced managers or supervisors, who have the ability to consistently apply the criteria outlined by the IMCA in an unbiased manner. Their assessment of the employee will become part of the evidence required to demonstrate an individuals' *Competence Assurance & Assessment* documentation, which is made available to contractors and potential employers.

The evidence required is broken down into the following six major sections:

1. <u>Competence appraisal</u>. The competence appraisal is a form comprised of an appraisal of an individual's competence completed and signed by one or more assessors. The appraisal form is broken down into various sub categories, such as safety, teamwork, and specialist abilities. Each one of these sub

categories are described by specific attributes, which are then cross-referenced to methods used to demonstrate the individual's competence;

2. Work records. A set of records comprised of copies of forms, documents, logs and other various paperwork pertaining to the individual's work, approved by the company and demonstrate the person's involvement by name and signatures of both individual and a company witness;

3. Witness testimonies. Are observed, verified and signed events which demonstrate the individuals expertise and must answer the basic statements of *Who, What, When, Where,* and *How*;

4. Essential knowledge. This evidence is supplied in the form of a completed written questionnaire that has been designed to capture an individual's knowledge pertaining to various aspects of their competence from specific working details of their current position to general safety practices;

5. Curriculum Vitae (CV). A current CV detailing the scope of their working experience, offshore trips, equipment and systems, and regions of employment; and

6. Professional logbook. This logbook provides detailed documented and verified day-to-day employment activities.

The *Competence Assurance & Assessment* documentation is designed to capture an individuals' expertise throughout their progression in their respective fields. In the case of ROV's the IMCA developed frameworks for the following 10 levels:

1. ROV Pilot Technician Grade I;
2. ROV Pilot Technician Grade II;
3. Senior ROV Pilot Technician;
4. ROV Tooling Technician Grade I;
5. ROV Tooling Technician Grade II;
6. ROV Senior Tooling Technician;
7. ROV Tooling Supervisor;
8. ROV Supervisor;
9. ROV Superintendent; and
10. Specialized ROV Representative.

Each one of these frameworks is designed to capture and provide demonstrated evidence for the performance objectives required for each of the respective task levels. As well, the six major evidence criteria are fortified at each level with instructions on which specific evidence must be substantiated as outlined by the publication IMCA C 005 ("Publications", 2010). For example an "ROV Pilot Technician Grade I does not need to supply "Supervisory" evidence as does an ROV Supervisor, neither are they required to have "Navigational Ability", as does a Senior ROV Pilot Technician.

The IMCA model not only provides a framework for evidence of trained or progressing operators, but also describes basic or entry level requirements that must be met prior to training new personnel into the field of ROV operations.

The *Remote Systems & ROV Division Series* in its publication *Entry level requirements and basic introductory course outline for new Remotely Operated Vehicle personnel* (IMCA R 002 Rev. 2- May 2009) is designed for novice personnel with no previous marine occupational training or any type of offshore industrial experience or orientation.

The document sets out the basis of an introductory course by first providing a matrix of minimum qualifications required for entry into the basic course. Included in the matrix are:

1. <u>Academic qualifications</u>. The preferred academic qualifications are in the areas of electrical, electronic, hydraulic or mechanical systems. These

qualifications can stem from technical trade training, military occupational (vocational) training or a nationally recognized higher education academic qualification with the addition of at least one year of technically relevant industrial experience;

2. Personal attributes. Since ROV operators/technicians are part of an effective team they should have the following personal attributes;

    a. Enthusiastic,

    b. A team player,

    c. Good oral and written communication skills (English essential),

    d. Self-motivated,

    e. Have a practical ability, and

    f. Have common sense.

3. Medical requirements. The medical requirements state that candidates require a level of fitness sufficient enough to pass a rigorous offshore medical. Candidates must not have physical disabilities that would prevent offshore employment.

Once the academic qualifications, personal attributes and medical requirements screening has been met then the candidates will be permitted to undergo an ROV familiarization introductory module prior to their first trip offshore.

Training institutions do allow candidates to complete ROV familiarization courses without screening however; the IMCA documentation recommends against individuals taking this training without the appropriate prerequisites as they will not meet industry standards and will therefore be unemployable in the field. Furthermore the document goes on to state "Training establishments should not identify personnel as 'graduates' of a course … if the individuals concerned did not meet the entry level requirements" ("Publications", 2010).

The introductory module is designed to be more safety awareness training than ROV specific. It is recommended that individuals complete the introductory module before their first trip offshore. The course is not mandatory. The idea is that if candidates take the course they will have a better understanding of the ROV operation leading to a positive experience that should progress into a successful career as an ROV Pilot/Technician.

The ROV specifics will be covered at a later time according to IMCA within the guidelines of the *Competence Assurance & Assessment: Guidance document and competence tables-Remote Systems & ROV Division* (IMCA C 005) and its 10 levels of

ROV operator as outlined above. These tables will be addressed and referenced in this paper in Chapter 6 on the Vocational Education Model.

The introductory safety module framework supplied by IMCA is a guide that they encourage whether it is modified or adapted by ROV contractors or training establishments to conform to specific company or industry needs. The framework contains 5 subject areas:

1. Overall Safety and Environmental Awareness. This course should contain; material on offshore hazards, safe working and workshop practices, company specific accident reporting arrangements, familiarization with safety legislation, personal protective equipment (PPE) and personal safety awareness, work permits, lock-out procedures, quality and control standards and regional security issues;

2. Introduction to ROV Systems – Outline Knowledge. This course should contain information on a range of offshore operations, installations, vessels used for ROV operations such as dynamic positioning (DP) vessels or facilities. Here the candidate should learn about platform and rig types, drill ships, dive support vessels, as well as, the operations carried out from each. The course should also instruct the candidate on the functional positions and roles of other personnel working on these offshore facilities such as 'Offshore Installation Manager', 'Tool Pusher', and 'Offshore Medic';

3. Remotely Operated Vehicle (ROV) Systems. This course is meant to supply the candidate with a background to the use of ROV systems. It should cover ROV Classifications and typical ROV operations including launch and recovery operations. Here the candidate learns about limitations of various classes of ROV (for example they learn that an observation class ROV cannot do intervention work) as well as, various tools and sensor fits available. It is important that actual equipment be available during this course so that the candidate can avail of a full fidelity demonstration in order to appreciate the complications and intricacies involved in ROV systems;

4. Lifting Equipment (Maintenance and Operation). Lifting equipment by its very nature is specific to each ROV or support vessel and varies from system to system; therefore, for this course the candidate should become aware of the Launch and Recovery Systems (LARS) in general terms. Familiarization with the types of LARS that they will likely encounter on a first trip, types of slings or slinging systems, frequency of re-certification with respect to safety for cables, shackles and other rigging equipment; and

5. Duties of the Members of an ROV Crew. The crew duties vary by ROV system, classification, and team size, however this course should provide the candidate with a 'snapshot' of crew duties for typical configurations of each classification type and their respective tasks.

The knowledge learned by completion of this introductory module should prepare the candidate for their first offshore operation primarily: to observe the ROV deployment.

The ICMA *Safety, Environment & Legislation Series* is modeled after International Maritime Organization (IMO) guidelines, which supplements the International Convention on Standards of Training and Watch-keeping for Seafarers (STCW) requirements for maritime crews.

The IMCA provides two documents for guidance with respect to basic safety training or familiarization on vessels. The first document *Guidance on the initial and refresher familiarization of vessel crews* (IMCA S&L 003, June 2000) is intended for vessel crews who are primarily 'maritime' personnel. The other document *Basic safety training and vessel induction for non-marine personnel working offshore* IMCA SEL 007 Rev. 1-January 2008 ("Publications", 2010), is intended for 'non-marine' or 'project crews' working offshore.

The ICMA document *Basic safety training and vessel induction for non-marine personnel working offshore* provides guidance on basic safety on a worldwide basis and it should be noted that in most areas the guidelines within this document are sufficient, however, there are places and countries in the world where more stringent requirements are in effect. Training institutions and companies need to assess their prospective areas of operations to ensure adherence to the local standard.

For the basic safety training portion the ICMA document uses the definitions of personnel categories of personnel visiting offshore rigs and other mobile units as outlined in IMO Assembly Resolution A.89 of November 1999 to provide guidance on who needs the training and to which level. The categories range from a visitor to the offshore platform, to personnel assigned with the duties of providing safety training and emergency assistance to others.

The level of basic safety and familiarization training given to individuals is based on the four categories of personnel ranging from a *Category A* visitor who may spend up to three days on board to *Category D* maritime personnel. ROV operators fall within *Category B*, which in itself normally does not require a qualification in Basic Offshore Safety Induction and Emergency Training (BOSIET) course (sometimes called BST) however; since the ROV operators are non-marine project personnel who regularly work offshore then they are required to complete the BOSIET course. These BOSIET courses are delivered over a minimum timeframe of three days by various training establishments and may only be recognized in a local area by 'preferred trainers'. The 'preferred trainers' are BOSIET providers recognized and accepted by a particular industry or organization. The BOSIET course covers four main areas:

1. Introduction to offshore safety;
2. Helicopter safety and escape training;
3. Sea survival training; and

4. Firefighting and self-rescue.

Safety training is an essential component of offshore duties and one that must not be overlooked within the training envelope of ROV or AUV operations.

The vessel induction for non-marine personnel working offshore portion of the document recommends that all personnel regardless of which of the four categories they fit into should attend a vessel induction course. The purpose of the induction is to familiarize either new personnel or personnel returning after a long absence away from that particular vessel, with the vessel's safety and quality systems, as well as other project type familiarization that may be required based on the specific operational duties of the vessel. The course content contains but is not limited to general vessel tours, firefighting and man overboard drills, security awareness, 'stopping the job', safe operation of watertight doors and automatic fire doors.

The guidelines and framework provided by the IMCA allow it members to gain competence through proper selection, induction, training and work experience as they progress through their respective fields of employment and then demonstrate their competence through evidence presented through assessments, testimonials, log books, witnessed work performance and their CV.

3.1.2 NORSOK Standard

The NORSOK Standard U-102 *Remotely Operated Vehicle (ROV) Services* (U-102r1, 2003) is developed with broad petroleum industry participation by interested parties in Norway and is owned by the Norwegian petroleum industry. The NORSOK Standard defines basic requirements for personnel, systems and equipment for ROV operations within the petroleum industry. NORSOK references ICMA as both a normative and informative reference for its standard. The NORSOK Standard U-102 covers such areas as:

1. ROV classifications;
2. Administrative requirements;
3. Personnel qualifications requirements;
4. Interface requirements;
5. Technical and Operational requirements; and
6. Health, environment and safety (HES) requirements.

The main purpose of the document is to provide a single common standard for ROV operations within its jurisdiction. It was developed with an industry wide effort detailing requirements for ROV services.

1. The ROV classifications use the same classification scheme as the IMCA document in which the AUV is assigned to Class V – Prototype or development vehicles.

2. The Administrative requirements section it states that the contractor shall make the personnel competency matrix (as outlined in the IMCA documents) for allocated personnel available to the employer prior to mobilization.

3. The Personnel qualifications requirements section lists crew requirements with respect to manning levels required on each of the ROV classifications (except for Class V) and a statement is made that the overall crew competence should be obtained by proper planning and training. The document also states; "The personnel operating ROV systems require training in a wide range of specialized fields". The document outlines that ROV personnel should have formal training in one of the following areas:

    1. Electronics;
    2. Automations;
    3. Remote Systems;
    4. Hydraulics;
    5. Electrical.

In addition to one of these five base areas specialist training may be required for specialized maintenance of tooling systems or the operation of specialized temporary sensors or equipment. As a whole the crew must have sufficient collective training to maintain the complete ROV system.

The IMCA competency scheme is referenced as a minimal requirement and several additional requirements are included such as in the case of ROV supervisor, they must have formal administrative/leadership management training, or in the case of the ROV trainee have formal training in the operation and maintenance of the system in question.

With respect to the ROV High Voltage System, the maintenance personnel shall, as a minimum, be qualified as a ships electrician or automation technician or equivalent and have additional high voltage training in performing maintenance on the ROV system in question. They should have completed courses held by the manufacturers of the ROV high voltage equipment. They should also be familiar with the Association of Offshore Diving Contractors (AODC) document *Code of Practice for the Safe use of Electricity Underwater* AODC 035 (now maintained by ICMA) as well as the IMCA document *High Voltage Equipment: Safety Procedures for Working on ROV's* (IMCAR005).

4. The Interface requirements section lists various typical interfaces from connection points for communications and data transmissions, to motion characteristics for the launch area and the availability of fresh water wash down outlets. These typical interfaces must be included in any training regime.

5. The Technical and Operational requirements sets out all the technical requirements for each of the first four main classes of ROV. The operational requirements also state the composition and function of the ROV operators control room including the responsibilities of the ROV operator. The operational requirements reinforce the documentation required during operations as well as risk assessments that must be done by ROV supervisor. This section also references NORSOK U-100 *Manned Underwater Operations* and defines the operational organization with respect to interaction between ROV team and a Dive team. In the case of dive operations the ROV team reports to the diving supervisor.

6. The Health, environment and safety (HES) requirements state that personnel should be trained in occupational health and safety and crew should participate in programmes for monitoring the working environment to ensure preventative (risk reducing) measures are implemented. All contractors must have routines, which provide quantitative documentation on all HES data. "All management and employees shall ensure that environmental

considerations are taken into account in all phases of the activity" ("U-102rl", 2003).

Overall the NORSOK Standard U-102 strengthens a requirement for formal training for ROV/AUV operators. They must be competent in their fields with proper and adequate formal training that encompasses all aspects of operations planning, mobilization, deployment, operations, and recovery. Throughout it all health, safety and environmental concerns remain paramount. Not only is formal training required in all these areas but they must also be able to back up their expertise with evidence as outlined by the IMCA.

3.1.3 MATE Standard

The Marine Advanced Technology Education Center (MATE) based in Monterey California, USA, focuses on community college education and the creation of strong links between community colleges, tertiary education, research institutions, industry, military and government. MATE whose mandate is to provide guidelines for the marine occupations and training centres as stated on their website.

> The MATE Center's mission is to help prepare America's future workforce for ocean-related occupations. The MATE Center utilizes information from employers to improve and develop educational programs with a focus on marine technology. The Center focuses on community college education and the creation of strong links between community colleges and high schools, technical schools, 4-year institutions, research institutions, and industry, government, military, and labor organizations ("Guidelines", n.d.).

The (MATE) guidelines for ROV Technicians provide a knowledge and skills guide (KSG) overview chart that details the knowledge base required for specific job functions. MATE has completed guidelines for: Marine Technicians that work aboard research vessels; Hydrographic Survey Technicians and; Remotely Operated Vehicle (ROV) Technicians, with more marine occupation KSG proposed for future work.

MATE's KSG's ("Guidelines", n.d.) are developed with a systematic approach. First MATE selects a marine occupation for which they will produce a KSG. Next they hold a highly structured curriculum-building workshop with technical trades' people under the guidance and direction of professional facilitators. The facilitators and technical trades people then define the job functions and tasks of the marine specific occupation. The resulting draft from this workshop is then sent out to many technical professionals to validate the documents. The iterative process results in a KSG.

For each occupation the KSG process produces a matrix mapping job functions and individual task areas to the knowledge and skills required to perform those jobs as well as performance indicators that measure how well a particular task has been completed.

For example the MATE *ROV Technicians* overview chart is a matrix that maps 6 main *Job Functions* to 26 *Task Areas*. These task areas are then referenced to *Performance Indicators* and *Technical Knowledge and Skills.*

The main *Job Functions* are:

1. Operate equipment;
2. Pilot the ROV;
3. Perform maintenance/repairs on equipment;
4. Maintain communications;
5. Use seamanship skills; and
6. Integrate system modifications (Advanced skills).

Looking at one job function/task combination for example, under *operate equipment* a task from the matrix is *operate acoustic positioning system* the *performance indicators* associated with this task are;

1. ROV arrives at destination in a safe and timely manner,
2. Customer items are positioned correctly,
3. ROV is tracked successfully, and
4. Environmental parameters are measured correctly.

In order to achieve these *performance indicators* the ROV technician needs the following *knowledge and skills*;

1. Ability to operate acoustic equipment,

2. Knowledge of and ability to apply principles of acoustic positioning,

3. Knowledge of original equipment manufacturer (OEM) – specific acoustic equipment, and

4. Knowledge of environmental conditions (e.g. salinity, temperature) and how to measure these parameters (e.g. using Expendable Bathythermograph (XBT)).

Training requirements can then be derived using the *Technical Knowledge and Skills* from the KSG matrices. In the above case there is a requirement for the understanding and operation of acoustic systems including the knowledge of how the output of the equipment is affected by environmental conditions. Furthermore, knowledge of how to measure those environmental conditions is required as is, operation of specialized equipment. As well, the technician is required to maintain, troubleshoot and repair the OEM specific acoustic equipment and replace the unit if required. The KSG for *ROV Technicians* is a good indicator of the skill sets and education level required of an ROV operator.

An AUV operator faces similar challenges and tasks. Combining MATE's other developed KSG's; the KSG for *Hydrographic Survey Technicians,* with the KSG for *Marine Technicians who work aboard research vessels,* as well as the KSG for *ROV*

Technicians forms a good base skill set for and indicates the education level required of an AUV operator. The complete KSG matrices developed by MATE are included as Appendix C.

3.2 Certification

The Diver Certification Board of Canada (DCBC) is a federally incorporated not-for-profit body whose authority stems from agreements with the National Energy Board of Canada, the Canada-Newfoundland Offshore Petroleum Board and the Canada-Nova Scotia Offshore Petroleum Board.

The DCBC is the only Canadian national body, which offers certification to commercial divers and supervisors who can demonstrate that they have sufficient training and experience to enable them to meet the competency requirements of the appropriate section of the Canadian Standards Association (CSA) Competency Standard for Diving Operations (CSA Standard Z275.4) ("Rovcertification", 2009).

The DCBC certifications are recognized by Australia by the Australian Divers Accreditation Scheme (ADAS), France, Norway, South Africa, the United Kingdom by the Health and Safety Executive (HSE) and the IMCA.

The DCBC is in the process of developing a certification regime for ROV personnel as outlined in their document, *Certification Scheme for Remotely Operated Vehicle (ROV) Personnel (Draft Revision #12).* The intent of the DCBC scheme is to ensure the safety of personnel, equipment, assets and the environment during ROV operations.

The DCBC used the following documents as references for their product:

1. IMCA C 005 *"Competence Assurance & Assessment Scheme"*;

2. NORSOK Standard U-102 *ROV Services*; and

3. MATE *Guidelines for ROV Technicians*.

Although the DCBC uses the ICMA and NORSOK documents as references it does not make any reference to Class V ROV's. The Canadian document albeit in draft form only classifies ROV's to Class IV, seabed working ROV's, Class V in both the NORSOK and ICMA scheme are for prototype or development vehicles which also includes AUV's. It is presently unclear where the AUV fits into the Canadian certification model but upon successful roll-out of the ROV certification model subsequent revisions of the document may include AUV operator certifications.

The DCBC document contains five appendices:

1. Appendix A: Simulator Criteria;

2. Appendix B: Certification Matrix;

3. Appendix C: Application Procedure (Under development);

4. Appendix D: Approved Logbook Format (Under development); and

5. Appendix E: Assessment of Prior Learning (Under development).

The first two Appendices; Appendix A, and Appendix B appear to be complete as far as this Draft #12 is concerned in that they do not carry the label 'Under development' as do Appendices C through E. However, as of the August 2009 both Appendices A and B appear to be lacking detail notwithstanding the omission of 'Under development' in each Appendix title. The author of this thesis, therefore anticipates a major amendment in subsequent revisions of the standard.

The DCBC recognize that due to the complexity of ROV systems, ROV operators require training in a wide range of specialized fields. The ROV operator is a pilot, a troubleshooter, and a maintainer and as such must have broad based competencies. The DCBC requires that all ROV candidates maintain a DCBC recognized log book. ROV candidates that do not meet the DCBC certification category requirements but can provide documented evidence that they have been employed in that particular certification category will be permitted to complete a DCBC Assessment of Prior Learning (APL), which will be used to determine if the candidate is eligible for certification. As of this time the APL is contained in DCBC's Appendix E that is undergoing development.

The DCBC will issue the following certifications:

1. ROV Pilot/Technician Level 2;

2. ROV Pilot/Technician Level 1;

3. ROV Senior Pilot/Technician; and

4. ROV Pilot/Technician Supervisor;

Entry requirements into a program leading to certification of ROV Pilot/Technician Level 2 are similar to those stated in the document ICMA R 002 outlining the requirements for entry level into the basic introductory course for new ROV personnel. In addition to the ICMA requirements the DCBC adds that a minimum of 20 documented and supervised hours for ROV piloting experience is required on an actual ROV or an acceptable ROV simulator.

For each of the other three levels of operators there is a minimum time frame and number of logged piloting hours that must be attained at the previous level. At each level the operators must demonstrate the competencies of the level below them in addition to demonstrating the competencies for the level in which they are seeking certification.

In the case of ROV Pilot/Technician Level 1 and ROV Senior Pilot/Technician credit will be given for time spent on Class III or Class IV vehicles toward certification at the Class I & Class II levels.

The ROV Pilot/Technician Supervisor has the additional requirement of completing formal administrative/leadership training as well as an industrial supervisor course. They must also have:

1. Ability to understand and implement ROV manuals and project procedures;
2. Competence in training ROV personnel using best practices;
3. Competence in evaluating ROV personnel as to their competencies and safety practices;
4. Ability to document and communicate tasks; and
5. Evidence of assessment as a trainee supervisor on a minimum of 20 ROV deployments.

The Criteria for Acceptable Simulators as outlined in Appendix A of the DCBC standard is vague. There are 9 criteria areas and under each is stated a 'one line' requirement. Subsequent drafts of the document will likely revisit the simulator criteria.

Chapter 4 State of Underwater Vehicle Training

4.1 ROV Training

Currently offered ROV training courses, with a few exceptions, are primarily guided by the IMCA guidelines IMCA C 005. Each of the 10 levels of ROV operator as described in 3.1.1 must demonstrate a particular set of competencies. For example courses for the entry level ROV Pilot/Technician Grade II are approximately 3 weeks in duration and follow the IMCA competency framework as outlined in Table 4.1. In addition to the 48 hours of theory the trainee must complete 72 hours of ROV piloting, 12 hours of which must be on an actual (not simulated) ROV.

The typical cost of this type of course is approximately $US 6000. Without the correct entrance requirements however, the cost can double, as there is an additional 4-week training session for candidates that do not have the electrical or mechanical background prerequisites. Upon completion the candidate is presented with a certificate of attendance stating that they did in fact complete the course as prescribed by the IMCA.

Table 4.1 IMCA Framework Requirements for ROV Pilot \Technician Grade II

IMCA CODE IMCA TITLE	Demonstration
R/R04/000/01 Safety Awareness	Basic understanding of regulations Ability to locate all relevant health, safety and

IMCA CODE IMCA TITLE	Demonstration
	quality procedures at the worksite Participated in an offshore safety induction Has read and demonstrated an understanding of company safety management system Ability to follow safety instructions and use appropriate safety equipment for deck and worksite operations Ability to identify different areas in the workplace and the hazards associated with each
R/R04/000/02 Teamwork and Co-operation	Establishment and maintenance of good working relationships Ability to recognize personal limitations and request assistance from others when necessary without undue disruption and willing to offer assistance when needed Use of clear, concise and correct verbal communications with supervisor
R/R04/000/03 Emergency Procedures	Read and demonstrated an understanding of company emergency procedure documents and where to find them Ability to raise alarm and to alert others Ability to describe own role in emergency situations and that of colleagues

IMCA CODE IMCA TITLE	Demonstration
R/R04/000/04 Piloting Skills	Demonstrates ability to navigate an ROV to the work site, demonstrating spatial awareness of umbilical positions, turns and loads on at least three different occasions Is able to describe the function of standard ROV controls to demonstrate their use in navigating the ROV
R/R04/000/05 ROV Systems R/R04/000/05 ROV Systems	Understands power up /power down safety sequence Assistance with the completion of pre-dive checks of an ROV Assistance with the launch of an ROV in normal environmental conditions Assistance with completion of post-dive check of an ROV
R/R04/000/06 Preventative Maintenance	Ability to describe why and when planned maintenance is needed Assistance in preparing work area Ability to determine what system isolations are required at the work area Ability to determine relevant tools for the work to be undertaken, under supervision
R/R04/000/07 Safe Operating Techniques	Ability to describe correct /safe operation of launching system Ability to describe roles of ROV team members

IMCA CODE IMCA TITLE	Demonstration
	during launch and recovery operations
R/R04/000/08 Navigational Ability	Ability to utilize navigational aids in order to direct and assist in piloting ROV Ability to describe how sonar is used in navigation Ability to describe how acoustic positioning systems are used in ROV systems Ability to change range / scale to suit operation taking place
R/R04/000/09 Administration	Records ROV dive information onto dive logs Records video information onto video tape in the required format Audio dubs video material in real time utilizing correct terminology and specified procedures
R/R04/000/10 Technical Ability	Ability to identify all components on a typical hydraulic system and describe their function Ability to identify all components on a typical ROV electrical system and describe their functions Ability to identify the correct component for change out Ability to assemble tools needed in change out, including personal protective equipment

Source IMCA

In addition to the Pilot/Technician Grade II as described above, extra expense would be incurred should the candidate first attend a 10 day ROV induction course also described by the IMCA, which give candidates an insight into the chosen ROV career.

Most short duration ROV training courses follow the same format. Some have more sophisticated simulators to augment their various classes of ROV's, while others are limited to only one particular class (i.e. observation) of ROV and have limited simulator facilities available. From Internet research it became obvious that some training organizations were eager to accept reservations and potential payment for courses without verifying that the candidate met the prerequisites for the course. The downside of this is that upon completion of the course, notwithstanding an attendance certificate, a potential employer, following IMCA guidelines, could deem the candidate not qualified and subsequently unemployable in the field. It is a case of buyer beware.

The Fisheries and Marine Institute of Memorial University of Newfoundland (MI) offer a joint Diploma of Technology and Bachelor of Technology in ROV operations. The Diploma of Technology program is of two-year duration and graduates will be eligible to be certified as ROV Pilot/Technician Level II ("Underwatervehicles", n.d.).

Candidates who have completed previous Diploma of Technology programs in fields such as electronics, mechanical, or electrical fields could be offered advanced standing. This program includes one year of common technical courses, followed in the second year by mechanical/electrical/electronic refresher courses as well as courses specific to ROV operations. This program contains four weeks of ROV pilot training, two weeks of offshore safety (BST) and an eight-week work term. The MI program is the only Post Secondary ROV program of this type in Canada.

MI uses a GRI Simulations Inc. (GRI) ROV simulator to provide a physics-based virtual reality 3D training environment for its ROV pilot/technician candidates. The GRI simulator provides mission planning and rehearsal scenarios in the following areas:

1. Location and retrieval of debris;
2. Field inspections;
3. Pod posting;
4. Sub rescue;
5. Transponder recovery; and
6. Ship hull inspection.

These 6 scenarios are the standard supplied COTS scenarios however, the user has the option of adding additional scenarios to the scenario database.

Fugro General Robotics Ltd. (FGRL) has developed an ROV simulator (ROVolution®) on which they can train and assess ROV piloting skills. Their product is a sophisticated 'real-time' simulator, which can model any ROV using a physics-based virtual reality 3D world. Instrument payloads on ROV's can be easily adjusted with software changes and the system provides a consistent repeatable training with instructor-controlled failure modules. The software supports certified user-training courses. FGRL will customize their software package to model any ROV system and scenario.

The FGRL system also has the capabilities of performing actual mission familiarization and rehearsal flight time. The system inputs clients' subsea field site drawings as 3D models and stores them in a scenario database. Clients can then 'call up' the scenario and 'rehearse' the real mission. This system has benefits for both pilots and their employers. Since the system operates in a physics-based environment, details such as current profiles and turbidity can be realistically added to the scenario to enhance fidelity.

4.2 AUV Training

Considering the responses from the survey used to collect data for this paper it can be said that current AUV training is virtually non-existent. Manufacturers provide basic training on the functionality of their systems during short courses that range from a few days to a couple of weeks in duration. Academic and scientific AUV teams work in collaboration with each other and various research and development efforts to develop the skills required during their research missions. Not only are they operators but they are also maintenance technicians, scientists, and logistic specialists. Military stakeholders funded by 'deep pockets' contract consultants to provide training for their underwater vehicles in a mostly 'train the trainer' scenario.

AUV Training does occur informally within a personal 'closely-knit' team environment, without industry wide standardization. The result is that team building occurs through necessity via recruitment of specialized individuals from various fields and that there is no common baseline level of knowledge defined for training.

Currently there are no standards that describe the entry requirements into the AUV industry and competency lists are non-existent. AUV's are deployed the world over however, the industry is still in it's infancy. Some have likened it to 'wild-west' of automobile manufacture, before standardization and mass production.

According to the MI website, a Bachelor of Technology in Underwater Vehicles is imminent (Underwatervehicles, n.d.). This likely will encompass both ROV and AUV vehicles and involve graduate research studies in collaboration with the St. John's Ocean Technology Cluster ("Stjohns", n.d.). MI does not mention which standard, if any, they will follow during their training regime. There is an understanding that solid baseline knowledge is required: It has yet to be defined.

Chapter 5 The TAFE Model

5.1 TAFE and NSF

The Australian Technical and Further Education (TAFE) system is the largest provider of tertiary education and training in the Asia-Pacific region. TAFE is a government-owned and nationally operated system of colleges and TAFE qualifications are recognized and transferable internationally (History, n.d.).

Australia's National Training System (NTS) is an industry led system for Vocational Education and Training (VET) and has three major elements, which are collectively called the National Skills Framework (NSF) (Ntis, n.d.). They are:

1. Australian Quality Training Framework (AQTF);

2. Australian Quality Framework (AQF); and

3. Training packages.

The AQTF assures quality of the training delivered for VET by setting the standards required of Registered Training Organizations (RTO's). Upon meeting the standards the RTO is permitted to issue VET qualifications. Individuals or organizations can apply to become a RTO and thereby have the authority to issue course completion parchments.

The AQF sets out all nationally agreed education and training qualifications in Australia. (AQF), which offers the following styles of courses:

1. Associate Degrees, Bachelor Degrees, Masters Degrees, and Doctorial Degrees;
2. Diplomas and Advanced Diplomas; and
3. Vocational Graduate Certificates (Levels I- IV). In order of hierarchy, with Certificate IV being the highest level. Level I is considered a base level and is comprised of all mandatory courses, whereas Levels II-IV are comprised of optional (elective style) courses as well as required study;
    a. Level I basic,
    b. Level II trade specific,
    c. Level III trade qualification, and
    d. Level IV VET qualification.

The optional (elective) courses taken in various areas of study can be combined to form additional qualifications. For example if during a course of study in the field of mechanics, a student chose to take electives in electronics, then at the completion of Certificate IV in mechanical technology the student may have several courses within the electronics technology curriculum that could then be applied toward a Certificate in electronics technology.

As well as having the opportunity to diversify fields during a course of study the AQF offers the ability to assess an individual's lifelong experience using a Record of Current Competency (RCC), under a Recognition of Prior Learning (RPL) assessment. The assessment comprised of evidence of work experiences, Curriculum Vitae (CV), employment reports, employee assessments, log books, testing on core competencies, experience and training in similar fields, will give credit toward a particular certification as well as provide areas of study that must be completed in order to satisfy all required objectives and competencies for the certification in question.

The AQTF training products include national training packages and accredited courses, which outline the qualifications, competencies and assessment criteria for specific areas of training. The training packages promote quality, consistency and industry relevance ("Overview", 2010). The training packages describe the knowledge and skills that industry has identified as required so that employees can perform effectively in the workplace. They are effectively standards that identify what has to be assessed and it is up to the teachers, trainers and mentors to develop delivery and learning strategies.

The students will be assessed against the standard and if judged competent they will be granted the qualification. This criteria based assessment provides a means for instructors to ensure that the students have met the objectives of the course by measuring them against a set of assessment guidelines. The respective industry groups, to ensure currency, periodically review these guidelines and package contents.

5.1.1 Training Package Components

The training packages are comprised of mandatory materials (endorsed by industry), and optional non-endorsed materials. The mandatory materials consist of a set of competency standards, qualifications and assessment guidelines. The mandatory materials are compulsory to the training package and cannot be changed, as they have been quality assured to meet industry skill and qualification requirements. The optional support materials are comprised of a set of learning strategies, assessment materials and professional development materials that can be used by the trainer or assessor as required as long as they do not compromise the integrity of the compulsory components.

The training package is broken down into smaller competency standards know as units of competency, and they define the skills and knowledge that industry has identified as required to enable people to work effectively in the workplace.

The training packages and their individual units of competency exist for a large number of disciplines. The same unit of competency can appear in a variety of training packages. For example a unit of competency for Occupational Health and Safety (OHS) appears in the training package for electronics technician as well as in the package for commercial welding.

To train an AUV operator selected units of competencies can be selected from various packages as required to build up their knowledge and skill sets in those particular areas. In the case where no particular unit exists an AUV specific unit can be tailor-made to facilitate the teaching and assessment of the required competencies.

5.1.2 Performance Criteria

The particular performance criterion for any given unit within the package is guided by industry standards, and is under periodic review to ensure currency. The performance criteria are the learning outcomes of the unit.

5.2 Employability Skills

Employability skills are key competencies or enabling skills (Back, 2007, p25) that cross all disciplines. These employability skills are a part of the TAFE system. The employability skills were developed through a national project managed by the Business Council of Australia and the Australian Chamber of Commerce and Industry, which resulted in the *Employability Skills for the Future* report produced in 2002 (*Back 2 Basics*, 2007,p25).

In the TAFE system the employability skills are:

1. Communication skills;
2. Teamwork skills;
3. Problem-solving skills;

4. Initiative and enterprise skills;

5. Planning and organizing skills;

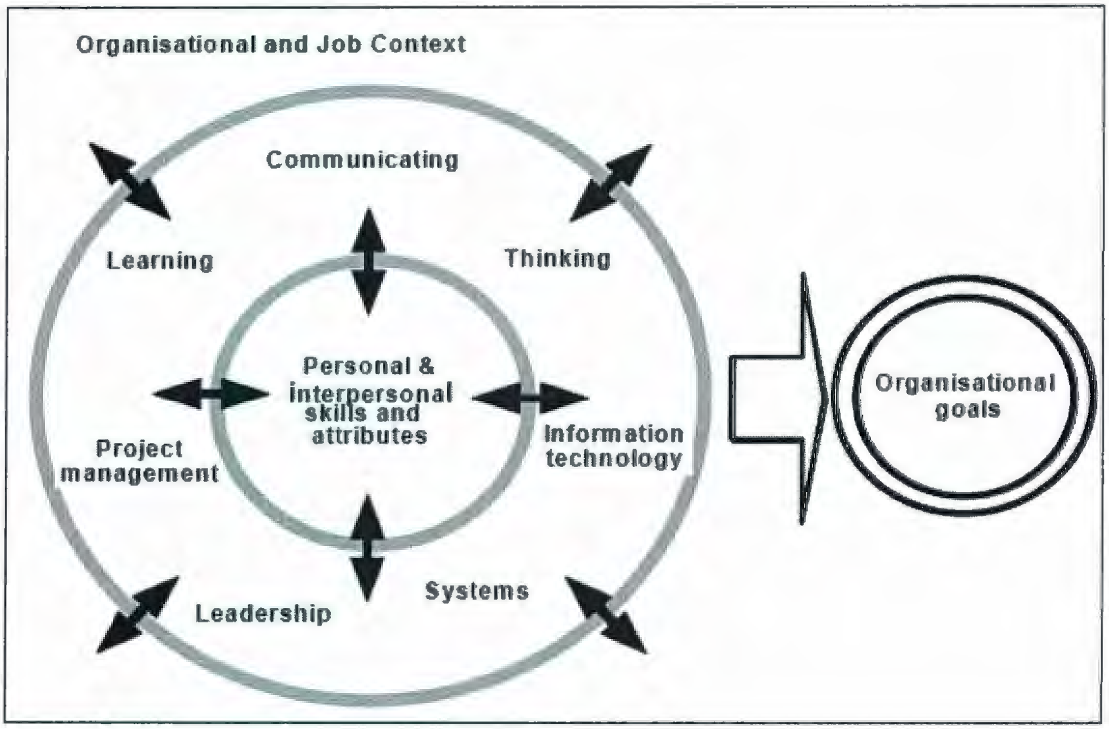
6. Self-management skills;

7. Learning skills; and

8. Technology skills.

Dr. J. Field provides a model of the interaction of these employability skills published in a case study *Industry Speaks: Skill Requirements of Leading Australian Workplaces* (Field, 2001) as shown in figure 5.1. Dr. Fields' case study and subsequent employability skill list originated from the study *Employability Skills for the Future* and is slightly different from the now adapted TAFE framework.

Figure 5. 1 A Model of Employability Skills (Field, 2001)



Source: Industry Speaks

The study consisted of a research interview with 13 large enterprises in Australia. These enterprises were comprised of companies from the food service industries, aviation, engineering, manufacturing and banking sectors. The common themes that emerged from the study were compiled into TAFEs employability skills:

1. Communication Skills;
    a. Speaks, listens and empathizes with others,
    b. Writes clearly,

c. Comprehends information in a range of formats,

d. Makes clear and logical presentations,

e. Effectively negotiates,

f. Effectively facilitates meetings,

g. Effectively coaches peers and clients, and

h. Forms and articulates logical arguments.

2. Thinking Skills;

a. Assesses quality and relevance of information to decision,

b. Analyses, evaluates, interprets, extrapolates and differentiates data,

c. Interprets needs and responds accordingly,

d. Brings a multidisciplinary approach to decision making, and

e. Takes a system approach to problem solving.

3. Learning skills;

a. Uses networks (both people and technology) to support learning,

b. Supports others in their learning, and

c. Open to new ideas.

4. Skills in managing projects and priorities;

a. Plans, Schedules and maintains realistic timelines,

b. Appreciates interdependencies and systems implications of projects,

c. Attains cooperation,

d. Allocates resources effectively,

e. Monitors progress and recommend actions, and

f. Ensures quality.

5. <u>Skills in working with and understanding systems;</u>

   a. Understands role within work environment,

   b. Understands workplace relationships with respect to people, processes and technology, and

   c. Takes a holistic or systemic approach to work.

6. <u>Skills in applying & using information technology;</u>

   a. Understand principles of software,

   b. Uses IT as a management tool, and

   c. Identifies uses of IT on problem solving.

7. <u>Leadership skills;</u> and

   a. Provides a vision and sets goals,

   b. Monitors performance,

   c. Influences encourage and support others, and

   d. Accountable for self and team.

8. <u>Personal and interpersonal skills and attributes;</u>

   a. Have a sense of humour,

   b. Confident,

c. Enthusiastic about work,

d. Willingness to seek information to solve problems, and

e. Good judgment.

As previously stated these employability skills are key competencies that cross all disciplines. Moreover they are the basic skills required to acquire, retain and excel on a job. Employability skills can be taught. These skills are transferrable between occupations and once learned they are skills that employees take with them. They are their set of life skills which contribute to empowerment. Employers require empowered employees to work as a team and solve problems as they arise, by taking initiative as required. Employers recognize that employability skills are extremely important for sharing ideas, coordinating efforts, managing activities and learning.

There was a time when employers wanted a 'cookie cutter' work force, where creativity was to be avoided. They wanted employees who would 'just do a job' and nothing else. In today's technically advanced workforce, especially considering underwater vehicle operations with its advanced technology and integration of systems 'just doing a job' is not enough. As a matter of fact seldom can one individual or more especially individuals from one specific academic or technological background 'just do a job' in isolation. They require a team capable of solving all problems, technical or otherwise, by taking the initiative applying their employability skills: their "common sense".

Chapter 6 A Vocational Education Training Model

6.1 Introduction

There is a need for comprehensive training in all aspects of underwater vehicle operations so that operators can attain the competency required to perform all required tasks within the scope of the vehicles operating domain. The size of an underwater 'team' is normally small however, the aggregate academic education, technical background, work experience, employability skills and competencies provide the team with core knowledge and experience that is required to achieve mission success. Each member of the team is an integral part of the whole contributing more than their base knowledge as they build on each other's experiences and competencies while adding to the overall development of an effective team.

Several organizations have developed competency standards for ROV operations whereas standards for AUV operations are not specifically developed although AUV's are considered ROV's under some vehicle classification schemes. Both ICMA and NORSOK classify an AUV as an ROV and their respective competency schemes can be used as guidelines for AUV training as well as ROV training. MATE does not use the same classification system, but does provide a KSG for *ROV Technicians* (included in Appendix C) which, when combined with MATE's KSG's for *Hydrographic Survey*

Technicians (included in Appendix C), and *Marine Technicians who work aboard research vessels* (included in Appendix C) provide a base guideline that can be adapted to AUV competency guidelines.

The training required qualifying both ROV and AUV personnel could be described within a TAFE package framework. TAFE units of competency exist for a plethora of occupational areas, which when collected and mapped to standardized requirements for ROV operations would provide an assessable framework for an ROV package.

Similarly AUV operators requiring a different scope and depth of knowledge than ROV operators can use existing guidelines such as MATE's KSG's as well as units of competency from TAFE packages in electronics, aerospace, manufacturing, and marine operations to tailor make an AUV operators package.

Both AUV and ROV training can be assessed by measuring the trainees' performance against a set of required assessment guidelines, which provide a means for instructors to ensure that the students have met the objectives of the course.

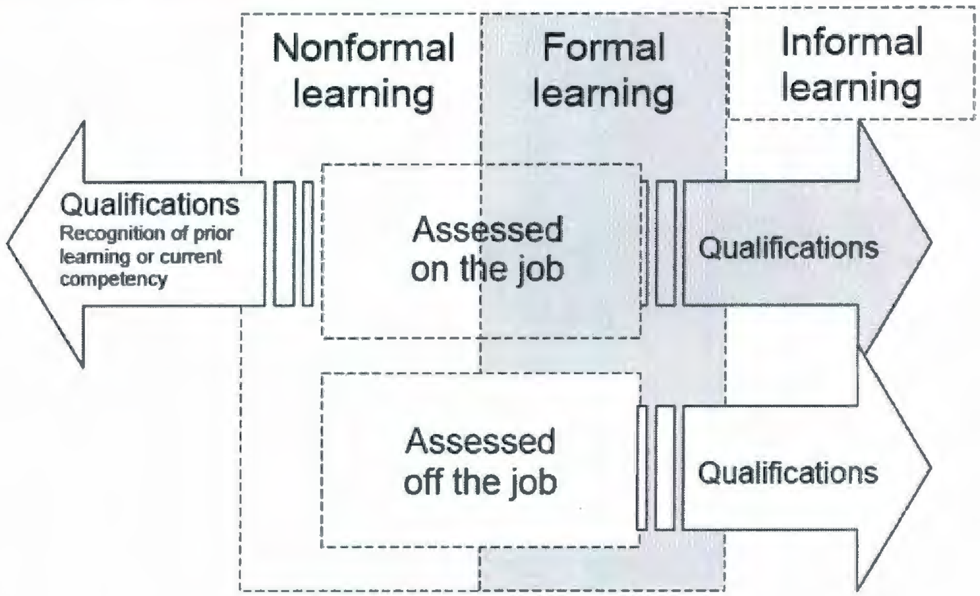
By using a TAFE model of training an organization can collect existing units of competency and map them to the objectives of the respective tasks required. In the case where no existing units can fulfill the objectives a new unit could then be built with the required competencies assessed. The overall collection of units could then be registered as a new package. This package could then be used to train operators in underwater operation.

6.1.1 Recognition of Prior Learning

Learning can occur in many ways although not all methods are as effective as others. Learning is a 'lifelong' process and some life skills are acquired over time throughout many various situations and environment, and often individuals are not aware that they are in fact learning. Traditionally higher learning has been the 'keystone' of academic success however, it in itself is not an indicator of employability, as there are certain attributes that are desirable for an employee to possess and these attributes span disciplines. There is a need to assess the learning that an individual acquires and understand how learning is used in the workplace.

Figure 6-1, shows the pathways through which learning used in the workplace can occur and be assessed. We know that learning can be formal (deliberate and recognized through tertiary education and various training courses), or informal (incidental learning occurring through life experiences) or nonformal (occurring on the job or through structured programmes that do not lead to qualifications) (Doyle, et al, 2009).

Figure 6- 1 Prior Learning Assessment



Source Doyle et al.

Combining formal, non-formal and informal learning for workforce development (Misko, 2008), shows how combinations of formal, informal and non-formal learning, coupled with cross-training, multi-training and mentoring programs can be used to progress workers through their respective job fields.

Most organizations recognize that formal learning is required for job entry. This is especially true when considering most accredited occupations require a formal learning process. The reality is however, that most of a persons learning is acquired through informal and non-formal learning. There are many people in the workforce who are currently under-employed with respect to their potential aptitude.

The employer should be interested in the final results of learning such as the expertise, skills and technical job knowledge required to do the job. It is no secret that technology is advancing faster than the skills of the workforce. To keep up with the demand for skilled labour, employers and educators must realize that prior learning should be recognized in order to use it as a stepping-stone to fill the gaps in the educational stream as they permit the growth and acceleration of the workforce.

> In the new, global knowledge economy of the 21st century prosperity depends on innovation, which, in turn, depends on the investments that we make in the creativity and talents of our people. We must invest not only in technology and innovation but also, in the Canadian way, to create an environment of inclusion, in which Canadians can take advantage of their talents, their skills and their ideas; in which imagination, skills and innovative capacity combine for maximum effect (The Right Honourable Jean Chretien, Prime Minister of Canada) (Knowledge, 2002).

Combining formal, non-formal and informal training to develop skills needs a commitment from both employers and employees: the trainees. Not only must there be a commitment from the employers but the trainee must also have a willingness to learn. It is common practice at the entry level to combine formal training with informal on the job training. The result is on-the-job training, where there is a lack of structure, and a lack of assessment of the outcome of the training.

The TAFE design of various entrance and exit points for the package via units of competency would complement apprentice training and thereby strengthen formal and non-formal education.

An alternative of this is a combination of formal on the job and informal on the job training, where not only are new employees performing on-the-job training, but they also take regular theory lessons and are assessed on the outcome by senior trades' people or technicians. These lessons occur at the workplace in 'mini' classrooms designed for the sole purpose of providing constructive programmed training combined with assessment techniques, followed by practical use of the new found skills. This learning bay technique, (Dehnbostel, Molzberger, 2006) is used by German companies with great success.

Another method of integration or combinational learning involves using experienced workers who have gained practical on job skills and then blend that with learning acquired in non-formal settings. Before the workers go back to the job site they will then use simulators to practice their combined skills in scenarios similar to the ones expected of them in the workplace. When they return to work they will be ready and virtually experienced to perform their tasks at a higher level than before their training.

The common elements that are required to thrive, survive and effectively contribute to any working scenario, not withstanding appropriate working knowledge in the field, are employability skills. Employability skills are the non-technical skills that an individual requires in order to be an effective and successful participant in the workforce. Everyone has heard of and likely used the term '*common sense*', but the exact definition and logic of this eludes most everyone. The capturing of employability skills may offer insight into a measurement of '*common sense*'.

To take full advantage of prior learning, including employability skills for both new and experienced operators the use of a TAFE based system which not only provides entry and exit points for apprenticeship training, but also provides competency building on a continual basis is required. The TAFE system as previously described offers 4 certification schemes from Certification I – Certification IV, as well as diploma and advanced degrees based on accumulation of units of competency, assessment, and package requirements.

The underwater vehicle industry needs a trained competent workforce of operators, technicians, and designers that understand the inherent problems of planning, maintenance, deployment, operations, recovery, data interpretation, innovative functional designs and risk management. A TAFE style based program could provide RPL, standardized and measurable competency development and progression toward advanced degrees in not only underwater operations, but also underwater systems design as well.

6.2 Courses Required

Training for AUV operators and ROV pilots/technician can be separated into 30 areas of competency each encompassing a major area of study. Table 6-1 Courses of Study for AUVROV VET shows the 30 subject areas for AUV and ROV vocational education training. Each major subject area is comprised of multiple units of competencies. The collection of competencies can be combined into 2 major package areas, one for ROV the other for AUV operations. Most of the individual competency units required for the packages can be found within other TAFE approved packages.

Table 6-1 Courses of Study for AUVROV VET

Acoustics	CAD/CAM	Controls	Communications	Computer Interfacing
Electronic	Fabrication	Hydrodynamics	Logistics	Mission Planning
Modifications	Oceanography	Positioning Systems	Propulsion Systems	Risk Management
Occupational Health & Safety	Sensors	Sonar	Software Design	Electrical
Cabling & Fiber Optics	Hydraulics	LARS	Maintenance	Mechanical
Operations	Robotics	Subsea Structures	Manipulators	Manufacturing Practice

Source Author

The TAFE system generally consists of one package with many units (competencies). In this AUVROV VET scheme there are two packages with multiple units, and the units are comprised of multiple competencies. The units in this scheme are comparable to packages in the TAFE scheme and within the units multiple competencies exist.

The AUVROV VET scheme then consists of two packages one package an AUV package the other a ROV package. Progression through the respective packages occurs by completing individual competencies, which are mapped to standards. Once a major area of study (a unit) has been completed with all the required competencies assessed, then that unit is given a weight toward the overall package.

The package will be completed and certification given when all units for that package have been successfully assessed. Partial completion of a unit occurs by completion of various competencies within the unit. Partial completion of various units will combine to give varying levels of completion (certifications). Elective style courses can be selected from competencies that normally do not appear in a unit.

As the industry grows additional packages could be added that include pre-existing units and thereby build on the framework, competencies and skills previously attained by the trainees. For example courses for designing AUV's or subsystems could be implemented that use the operators' baseline knowledge thereby speeding the progression through the package to competency in design.

This type of progression or any progression through a package for that matter can occur while an offshore worker is on 'days off' by offering the competencies in short duration courses. The continuum of knowledge building results in a recognition of higher learning and increased competencies for the industry.

6.2.1 ROV Courses

The competencies required for the ROV related courses can be mapped from IMCA, NORSOK and MATE standards as well as from the DCBC certification scheme. Many of the units can also be found within TAFE units of competency. Where competency descriptions do not exist in the TAFE system a new competency, mapped to the standards can be added to the competencies in the major area of study (the individual unit). As technology demands increase so will the knowledge required of operators and technicians resulting in the requirement of the addition of new units to their respective package.

6.2.2 AUV Courses

The competencies required for AUV related courses can use some of the IMCA standards, omitting specific piloting behaviours, and the MATE KSGs for ROV Technician, Hydrographic Survey Technicians, and Marine Technicians who work aboard research vessels ("Guidelines", n.d.). The combination of these defined skill sets would provide a solid baseline upon which to base AUV competencies.

The MATE ROV KSG as discussed earlier provides knowledge in:

1. Operating equipment;

2. Performing maintenance and repairs on equipment;

3. Maintaining communications;

4. Using seamanship skills; and

5. Integrating system modifications.

The MATE Hydrographic Survey Technician KSG provides knowledge in the following areas:

1. Conduction of pre-cruise logistics and survey planning;

2. Conduction of field operations;

3. Management of data; and

4. Maintenance of equipment.

The MATE Marine Technicians KSG provides knowledge in the following areas:

1. Operation of equipment/instrumentation;

2. Maintenance of instrumentation;
3. Repair, install and calibrate equipment/instrumentation;
4. Design and fabricate equipment/instrumentation;
5. Collect physical, biological and oceanographic data;
6. Manage and maintain computer networks;
7. Use software to perform scripting and programming;
8. Launch and retrieve sampling equipment;
9. Mobilize/de-mobilize scientific equipment;
10. Write reports; and
11. Facilitate pre and post-cruise logistic.

These 20 knowledge competencies from the MATE KSG's along with requirements from the IMCA standards provide input for a model framework for AUVROV VET.

6.3 The Model Framework

The model framework for the AUVROV VET as designed by the author consists of 30 units comprised of 69 proposed competencies as presented in Table 6-2. A thorough investigation into the TAFE packages by the author resulted in the identification of 58 out of the 69 competencies as being pre-existing units within the TAFE framework. These competency descriptions were then compiled into course descriptions using a standard 'course description' format, and are included as Appendix B.

The model thus far has not identified which particular units belong to either, or both of, the AUV or ROV packages. This work will be completed when the remaining 11 proposed competencies have been described.

Table 6-2 Framework Model for AUVROV VET

	Units	Competencies	Major Area	Package	
				AUV	ROV
1	AUVROVACOU01	NUE 171 Sonar Transducers & Arrays NUE 172 Sonar Systems Operational Principles NUE 174 Sonar Applications NUE178 Principles of Underwater Sound Transmission	Acoustics		
2	AUVROVCADD01	MEM09002B Interpret technical drawing MEM09003B Prepare basic engineering drawing MEM09010C Use CAD to create and display 3D models	CAD/CAM		
3	AUVROVCNTL01	MEMI8060BMaintain, repair control instrumentation MEMI8062B Install, maintain and calibrate instrumentation sensors, transmitters and final control elements MEMI8067BTune control loops – multi controller or multi element systems	Controls		
4	AUVROVCOMM01	AUVROV Specific Communications Systems NUE189 ElectroComms Principles	Communications		
5	AUVROVCOMP01	UEENEED028B Develop and test code for Microcontroller devices MSL977005A Integrate data acquisition and interfacing systems	Computer Interfacing		

		Memory types, PLC, Microcontrollers			
6	AUVROVELTR01	MEM18057B Maintain/service analog/digital electronic equipment MEM12004B Perform precision electrical/electronic measurement MEM05001B Perform manual soldering/desoldering electrical/electronic components	Electronic		
7	AUVROVFABS01	MEM05001B Perform manual soldering/desoldering electrical/electronic components MEM18001C Use hand tools MEM18003C Use tools for precision work	Fabrication		
8	AUVROVHYDR01	Introduction to hydrodynamics	Hydrodynamics		
9	AUVROVLOGS01	AUVROV Specific Logistical Procedures TLIP1307A Implement and monitor logistics planning and process	Logistics		
10	AUVROVMISP01	LMTGN3002B Organize and plan work to achieve planned outcome AUVROV Specific Mission Planning Competencies	Mission Planning		
11	AUVROVMODS01	MEM18055B Dismantle, replace and assemble engineering components MEM18058C Modify electronic equipment	Modifications		
12	AUVROVOCNG01	CPPSIS6020A Develop 2D and 3D Terrain Visualizations Introduction to Oceanography, Physical, Biological, chemical	Oceanography		

13	ROVAUVPOSS01	AURE321831A Install marine electronic components/systems TDMMH1607A Determine Positioning of the Vessel using LBL, SBL, INS, DP, Acoustic Doppler	Positioning Systems		
14	AUVROVPROP01	AUVROV Specific Thrusters, Propulsion Systems, Electric Motors, Ballast systems	Propulsion Systems		
15	AUVROVRISK01	MNQGEN500A Implement and maintain management plan to control risk	Risk Management		
16	AUVROVSAFE01	MEM11011B Undertake manual handling MSAPMOHS200A Work safely	Occupational Health & Safety		
17	AUVROVSENS01	MEM18062B Install, maintain and calibrate instrumentation sensors, transmitters and final control elements	Sensors		
18	AUVROVSONR01	UEENEEH040B Diagnose and rectify faults in sonarapparatus and systems CPPSIS6017A Conduct Advanced Remote Sensing Analysis	Sonar		
19	AUVSWDESIG01	UEENEEH015B Develop software solutions inmicrocontroller based systems Assembly and High Level Language	Software Design		
20	ROVAUVELEC01	MEM10003B Install and test electrical wiring and circuits up to 1000 volts a.c. and 1500 volts d.c MEM18046B Fault find/repair electrical equipment/components up to 1000 volts a.c./1500 volts d.c. MEM18049B Disconnect/reconnect fixed wired equipment	Electrical		

		MEM10002B Terminate and connect electrical wiring MEM12002B Perform Electrical/electronic measurement NUE202 Insulating Oil- Testing and Decontamination			
21	ROVAUVFIBR01	ICTTC015C Locate and identify cable system faults ICTTC065C Splice optic fiber cable	Cabling and Fiber Optics		
22	ROVAUVHRAL01	MEM18021B Maintain hydraulic systems MEM18019B Maintain pneumatic systems	Hydraulics		
23	ROVAUVLARS01	MEM18006B Repair and fit engineering components TDMMR3301A Perform rigging and lifting operations on board a vessel	LARS		
24	ROVAUVMANT01	MEM18065B Diagnose and repair digital equipment and component TDMMR2301A Operate and maintain batteries, starter motors and power distribution systems	Maintenance		
25	ROVAUVMECH01	MEM18018C Maintain pneumatic system components MEM12023A Perform engineering measurements MEM18013B Perform gland packing MEM07001B Perform operational maintenance of machines/equipment MEM18005B Perform fault	Mechanical		

		diagnosis, installation and removal of bearings			
26	ROVAUVOPER01	AUVROV Specific Operational Characteristics	Operations		
27	ROVAUVROBS01	Introduction to Robotics including calculations of Kinematic Equations, Reverse Kinematic Equations MEM07039A Write programs for industrial robots MEM18061B Maintain/calibrate complex control systems	Robotics		
28	ROVAUVSUBC01	Typical Sub Sea Structure Identification, Purpose and Operation	Sub Sea Structures		
29	ROVMANIPS001	Practical Manipulator Operations Simulated Equipment Actual Equipment	Manipulators		
30	ROVWKSHOP001	MEM18002B Use Power tools/hand held operations TDMMB1301A Carry out shipboard fabrication and repair operations MEM08015B Apply protective coatings (advanced)	Manufacturing Practice		

Source Author

6.3.1 Common off the Shelf Courses

Currently 58 common pre-existing courses (TAFE units of competency) have been identified by the author, however, further investigation into other packages will likely reveal that other areas of competency with very similar outcomes exist and can be used in the AUVROV VET framework. Simulation providers also have IMCA aligned pre-existing scenarios and fault modules that can be used in AUVROV VET training provided their simulation equipment is selected for the training.

Chapter 7 Facilities Required for VET

7.1 Location

As determined by the survey, one location will not suit all potential users, and for that matter, some users are of the opinion that trying to select a location is not a valid exercise. The survey did bring out a few interesting points:

1. The location should be close, within one (1) hour of useable water depths of 50 to 100 metres, with small sea heights and light winds ideally less than 10 knots;

2. The area should have access to deep warm water as well as a variety of water depths and various terrain features from gentle 15° slopes to rugged canyon features; and

3. It should be ice-free year round.

The preferred location, as far as the author of this thesis is concerned should be selected in New Zealand or Australia. This would offer accessibility to the TAFE system for educational support, access to varied subsurface bottom features and access to the Antarctic for one of the most interesting places in the world to take an AUV for a 'cruise'.

7.2 Equipment

Producing an equipment list for an underwater vehicle VET is not trivial. The list of equipment should contain but is not limited to: reliable, proven and cost effective COTS AUV's, and ROV's; simulators for ROV piloting similar to the FGRL ROVolution®, simulators to support the selected AUV under bench test, a LARS suitable for both AUV and ROV deployments, an ROV minimum of Class II, a TMS, a dive support vessel, various workshops, machine shops, high-voltage training systems, ROV 'cabins', electronics, computer and communication laboratories, sub-marine mock-ups of subsurface infrastructure and a large test tank for acoustic research work.

The task of setting up an AUVROV VET would be greatly expedited if an existing maritime style college focused on the creation of AUVROV VET by leveraging off of its current infrastructure and human resources.

7.3 Advisors

Each class of stakeholder as listed in 1.2 should have an advisor on the AUVROV VET advisory committee, as each class would have access to the product of the training: A qualified underwater vehicle operator. Inclusion on the advisory committee promotes stakeholder cohesiveness.

7.4 Partners

The AUVROV VET program should partner with; academic and government sponsored research institutions, equipment manufacturers, AUV and ROV manufacturers, preferred simulator providers, and industry to position itself on the cutting edge of technological advances and to be informed of operational best practices.

Articulation agreements should be established between colleges and universities to build strong partnerships between these institutions. Articulation agreements would enable students to be recognized for competencies earned at either institution.

Chapter 8 Conclusions

8.1 Contributions of this Thesis

This thesis shows that while considerable guidelines are explicitly in place for ROV training, the guidelines for AUV training have not yet been formally developed. As a result there is essentially no AUV operator training available. The only AUV training lies in the domain of specific manufacturers and localized user support groups.

The ROV industry is working toward competency validation and certification using the IMCA as a baseline reference. There is no such reference for AUV operators, however, using the IMCA frameworks for Competence Assurance & Assessment and training as well as the guidelines for ROV Technician, Hydrographic Survey Technician, and Marine Technicians who work offshore, as developed by MATE a baseline knowledge guideline can be developed for an AUV operator.

This AUV KSG can then be mapped to existing COTS courses available within existing frameworks such as the TAFE units of competencies. This thesis identified 58 courses that cover appropriate competencies, and the additional competencies not covered by COTS courses can be assessed by developing appropriate competencies to cover the unmapped knowledge and skills now defined within the new AUV KSG. The total competencies then can be grouped into units based on major areas of study. The units then become packages that will either be designated AUV or ROV specific qualifications.

The use of existing TAFE courses will enable an APL for those individuals who have previously completed courses within the TAFE system and if successful they can then take advantage of their previous baseline knowledge as they work toward competency as an operator of an underwater vehicle.

8.2 Suggestions for Further Work

The following work should be completed:

1. The remaining unmapped competencies should be delineated and assigned a unit;
2. The units should be collected into appropriate AUV and ROV packages;
3. Partner with other stakeholders to build membership in an advisory committee;
4. Partner with higher training organizations and investigate articulation agreements;
5. Locate a precise location for a school;

6. Identify which specific equipment is required for training for both types of underwater vehicles;

7. Register with TAFE to become a RTO;

8. Application to TAFE should be made to include new competencies as a part of a registered underwater vehicle package; and

9. Develop partnerships for industry wide certification and regulation.

Bibliography and References

AQTF Overview (2005). Retrieved March 29, 2010, from http://www.dest.gov.au/NR/rdonlyres/FD41EE53-97F9-45CE-8322-F272D15E0128/10885/AQTF_2005_Overview.pdf

AUVAC (n.d.). Retrieved March 7, 2010, from http://auvac.org/resources

(2007). Back 2 Basics: a guide to Australia's vocational education and training system for teachers and trainers (3rd ed., pp. 24-25). Queensland: Information Technology and Product Services.

Dehnbostel, P., & Molzberger, G. (2006). Combination of formal learning and learning by experience (JN Streumer ed.). Rotterdam: Springer. Retrieved March 7, 2010

Deputy Assistant Secretary of the Navy and OPNAV N77 (Submarine Warfare Division). (2003, December). The Unmanned Undersea Vehicle (UUV) Master Plan Update. Retrieved February 24, 2010, from http://www.navy.mil/navydata/technology/uuvmp.pdf

Diver Certification Board of Canada. (2009, October). ROV Certification. Retrieved March 11, 2010, from http://www.rovcertification.com/

Doyle, J., Simota, T., & Werquin, P. (2009). Recognition of nonformal and informal learning: Country note for Australia. Paris: Organisation for Economic Cooperation and Development.

Ferguson, J. (2009). Canadian AUV Development 1979-2009 [Electronic version]. UUST 2009.

Field, L. (2001). Industry Speaks: Skill requirements of leading Australian Workplaces. Retrieved March 7, 2010, from http://www.dest.gov.au/NR/rdonlyres/11E5861-4B67-443D-ADF9-606D409048CF/2211/case_study.pdf

IMCA. (n.d.). IMCA Remote Systems and ROV Division Publications. Retrieved February 12, 2010, from http://www.imca-int.com/divisions/rov/publications/imca.html

IMCA. (n.d.). IMCA Website. Retrieved February 2, 2010, from http://www.imca-int.com/

(2002). Knowledge Matters: Skills and Learning for Canadians. Ottawa: Canada's Innovation Strategy.

Kongsberg. *(n.d.). Retrieved March 15, 2010, from http://www.kongsberg.com*

Marine Institute Underwater Vehicles Program (n.d.). Retrieved March 7, 2010, from http://www.mi.mun.ca/underwatervehicles

MATE. (n.d.). MATE Knowledge and Skills Guidelines. Retrieved March 2, 2010, from http://www.marinetech.org/marineworkforce/guidelines.php

MATE. (n.d.). MATE Strategy. Retrieved March 2, 2010, from http://www.marinetech.org/about/strategy.php

Misko, J. (2008). Combining formal, nonformal and informal learning for workplace development. Adelaide: NCVER. Retrieved March 8, 2010, from http://www.ncver.edu.au/research/commercial/op03830.pdf

National Training Information Service (n.d.). Retrieved February 7, 2010, from http://www.ntis.gov.au

NORSOK. (2003, October). NORSOK Standard U-102: Remotely Operated Vehicle(ROV) Services. Retrieved February 11, 2010, from http://www.standard.no/PageFiles/978/U-102r1.pdf

NRC St. John's - Ocean Technology Cluster Fact Sheet (n.d.). Retrieved March 12, 2010, from http://www.nrc-cnrc.gc.ca/eng/clusters/factsheets/stjohns.html

Technical and Further Education. (n.d.). TAFE NSW. Retrieved March 5, 2010, from https://www.tafensw.edu.au/about/history.htm

Appendix A: Email Survey

I am an Engineering Graduate Student from Memorial University In Newfoundland Canada. I am completing my masters in ocean engineering. I am studying how the AUV industry can keep up with the demand for operators so that companies can continue to supply outstanding products to industry, military and academia. The ROV industry has NORSOK, or ICMA recommended standards that provide a framework for ROV operators/technicians and for the most part they involve a 3-7 week course for basic operator, as you know.

From an academic standpoint using AUV's for research normally means that operators are in that position for a short while, during which they complete their masters or PhD studies however, most operators come from a variety of backgrounds and some are lacking such training as control theory, and others microprocessor/software interfacing. How do we bridge the gap?

I am interested in the training required to bring new AUV operators in the field up to a level where they will be proficient operational leads capable of performing all aspects of a "typical" AUV mission. As underwater systems become more specialized and sophisticated they demand a higher level of skills from their operators and support crews. Currently most operators of these vehicles evolve into their respective fields through academic interests or operational requirements without specific background knowledge of the systems or the environment in which they will operate.

Stakeholders of the various projects in which AUV's are employed rely heavily on the data collected and the functions performed by the vehicles and the expertise of their operators. The qualities of your vehicles are outstanding and have evolved though many years of engineering analysis and prototyping. In order to complement your vehicles there is a requirement that the quality of the operators be outstanding as well.

All operators are not trained by one organization. Some operators migrate from other platforms and use their previous knowledge as a baseline. The content of their baseline knowledge is a paramount concern.

I have included a plethora of questions and I would appreciate it if you could find the time to answer a few of them for me. My real focus is on trying to find a reliable method to train operators for a growing AUV marketplace, and moreover ascertain what education level is required as a baseline and then decide how we can take advantage of their prior learning skills.

Especially as we enter an era of ice-free arctic environments there will be an increased need for experienced operators. The AUV manufactures are doing their part, but there is an increased need to work in concert with academia, industry, military and other equipment manufacturers to achieve the best training methods possible for this growing industry. Here are some questions that I have.

Background Information

1. Do you require a University Degree, Technical Diploma or Associates Degree to operate an AUV?

2. Is it preferable to have operators that have a wide base of knowledge in such areas as: underwater vehicle design, hydrodynamics, mechanical systems, electrical systems, hydraulic systems, electronic circuits, microprocessor interfacing, fiber optics, acoustic communications theory, oceanography and numerical analysis; or is it preferable to have operators that have specialized skills who would work in a group environment with others of complementary skill sets?

3. Which facets of prior learning would be most beneficial to bring a novice operator up to operational status?

4. Would it be advantageous to train skilled trades people versus university graduates?

Training

1. Is the training that you provide specialized, generic or proprietary in nature?

2. Does your training provide a comprehensive academic background?

3. Is there a minimum educational time frame or number of completed missions that should be completed before an operator is considered capable of deployment?

4. Since AUV systems are inherently varied by type and manufacturer, what common elements would be paramount in cross training operators to be capable of operating vehicles of various types or from different manufacturers?

5. Does each trainee require complete training in all underwater vehicle components?

6. Do supervisors require more training than operators?

7. How many 'live' deployments do you do in your current operator training courses including launch and recovery operations?

8. Is your training transferrable to other platforms?

9. Have you had much experience cross-training personnel to operate your vehicles who were initially trained on other manufactures vehicles?

Formal Training

1. What formalized training is available for AUV operators?

2. If a formal training environment were not available to train operators, what would be the best method to take advantage of their previous experiences and education to advance them to qualified operators?

3. Are there any current accredited AUV training centres other than those of the specific manufacturer?

On Job Training

1. What is the best vehicle to use for training? The actual vehicle operated in real-time or simulators along with 'bench top' components for illustrative purposes?

2. Do you use on job training currently as your prime method to train operators?

3. Is apprenticeship training an appropriate method to develop AUV operators?

Refresher Training

1. At which interval do you recommend that operators complete refresher training?

2. Do you notify your clients after hardware and software modifications have been completed so that they can complete further training?

Marine Specific Training

1. What marine specific training is paramount in safe AUV operations?

2. What level of marine navigation or chart work, either paper based charting or electronic charting is required of an AUV operator?

3. Should operators be required to attain certificates in offshore safety and survival, first aid, and marine emergency duties?

Specific Technical Skill Sets Required

1. In your opinion what type of training is mission critical for your operators/technicians to obtain?

2. Is knowledge of microcontrollers and embedded systems an essential AUV operator skill?

3. What skill sets are required in addition to a Degree in an Engineering/Computer Science/Earth Science?

Management Skills

1. What risk management and assessment training should be included in an operators training?

2. Would courses in engineering management be considered essential for AUV operator training?

Regulatory Bodies

1. What regulations currently exist which protect the integrity of the AUV industry?

2. Are there any current AUV certifications, which would verify that an operator is trained in a particular area of AUV operations?

3. Is there a requirement for a regulatory body or international organization to oversee standardized training for AUV operators?

Future Considerations

1. If you were to select a preferred worldwide location from which to conduct your AUV training centre where would that be?

2. What features, including simulated bottom features would this contain?

3. For training purposes would a sandy bottom be preferred to one comprised of rocks and coral?

4. Which type or class of vehicle would provide the best training environment for operator candidates while keeping in mind the benefits of cross training?

Thank you for your time and cooperation. I will provide feedback in response to your email.

Thom Mercer

BEng

Graduate Student in Ocean Engineering

Memorial University of Newfoundland Canada.

Currently Teaching in Doha

Thomas Mercer

Instructor Telecom Engineering

School of Engineering Technology

College of the North Atlantic - Qatar

E-mail: thomas.mercer@cna-qatar.edu.qa

Website: www.cna-qatar.com

SURVEY 2

I am a grad student working under Neil Bose and he suggested that I email you with a few questions that I have related to my Thesis. I am interested in the training required to bring new AUV operators in the field up to a level where they will be proficient operational leads capable of performing all aspects of a 'typical' AUV mission. As underwater systems become more specialized and sophisticated they demand a higher level of skills from their operators and support crews. Currently most operators of these vehicles evolve into their respective fields through academic interests or operational requirements without specific background knowledge of the systems or the environment in which they will operate. Stakeholders of the various projects in which AUV's are employed rely heavily on the data collected and the functions performed by thevehicles and the expertise of their operators. The qualities of your vehicles are outstanding and have evolved though many years of engineering analysis and prototyping. In order to complement your vehicles there is a requirement that the quality of the operators be outstanding as well. I know you train operators for your clients and that has served them quite well, however all operators are not trained by your organization. Some operators migrate from other platforms and use their previous knowledge as a baseline. The content of their baseline knowledge is a paramount concern. I have included a plethora of questions and I would appreciate it if you could find the time to answer a few of them for me. My real focus is on trying to find a reliable method to train operators for a growing AUV marketplace, and moreover ascertain what education level is required as a baseline and then decide how we can take advantage of their prior learningskills. Especially as we enter an era of ice-free arctic environments there will be an increased need for experienced operators. The AUV manufactures are doing their part, but there is an increased need to work in concert with academia, industry, military and other equipment manufacturers to achieve the best training methods possible for this growing industry. Here are some questions that I have.

Background Information

1. Do you require a University Degree, Technical Diploma or Associates Degree to operate an AUV?

2. Is it preferable to have operators that have a wide base of knowledge in such areas as: underwater vehicle design, hydrodynamics, mechanical systems, electrical systems, hydraulic systems, electronic circuits, microprocessor interfacing, fiber optics, acoustic communications theory, oceanography and numerical analysis; or is it preferable to have operators that have specialized skills who would work in a group environment with others of complementary skill sets?

3. Which facets of prior learning would be most beneficial to bring a novice operator up to operational status?

4. Would it be advantageous to train skilled trades people versus university graduates?

Training

1. Is the training that you provide specialized, generic or proprietary in nature?

2. Does your training provide a comprehensive academic background?

3. Is there a minimum educational time frame or number of completed missions that should be completed before an operator is considered capable of deployment?

4. Since AUV systems are inherently varied by type and manufacturer, what common elements would be paramount in cross training operators to be capable of operating vehicles of various types or from different manufacturers?

5. Does each trainee require complete training in all underwater vehicle components?

6. Do supervisors require more training than operators?

7. How many 'live' deployments do you do in your current operator training courses including launch and recovery operations?

8. Is your training transferrable to other platforms?

9. Have you had much experience cross-training personnel to operate your vehicles who were initially trained on other manufactures vehicles?

Formal Training

1. What formalized training is available for AUV operators?

2. If a formal training environment were not available to train operators, what would be the best method to take advantage of their previous experiences and education to advance them to qualified operators?

3. Are there any current accredited AUV training centres other than those of the specific manufacturer?

On Job Training

1. What is the best vehicle to use for training? The actual vehicle operated in real-time or simulators along with 'bench top' components for illustrative purposes?

2. Do you use on job training currently as your prime method to train operators?

3. Is apprenticeship training an appropriate method to develop AUV operators?

Refresher Training

1. At which interval do you recommend that operators complete refresher training?

2. Do you notify your clients after hardware and software modifications have been completed so that they can complete further training?

Marine Specific Training

1. What marine specific training is paramount in safe AUV operations?

2. What level of marine navigation or chart work, either paper-based charting or electronic charting is required of an AUV operator?

3. Should operators be required to attain certificates in offshore safety and survival, first aid, and marine emergency duties?

Specific Technical Skill Sets Required

1. In your opinion what type of training is mission critical for your operators/technicians to obtain?

2. Is knowledge of microcontrollers and embedded systems an essential AUV operator skill?

3. What skill sets are required in addition to a Degree in an Engineering/Computer Science/Earth Science?

Management Skills

1. What risk management and assessment training should be included in an operators training?

2. Would courses in engineering management be considered essential for AUV operator training?

Regulatory Bodies

1. What regulations currently exist which protect the integrity of the AUV industry?

2. Are there any current AUV certifications, which would verify that an operator is trained in a particular area of AUV operations?

3. Is there a requirement for a regulatory body or international organization to oversee standardized training for AUV operators?

Future Considerations

1. If you were to select a preferred worldwide location from which to conduct your AUV training centre where would that be?

2. What features, including simulated bottom features would this contain?

3. For training purposes would a sandy bottom be preferred to one comprised of rocks and coral?

4. Which type or class of vehicle would provide the best training environment for operator candidates while keeping in mind the benefits of cross training?

Thank you for your time and cooperation. I will provide feedback in response to your email.

Thomas Mercer BEng.

Graduate Student in Ocean Engineering

Memorial University of Newfoundland

Compiled Answers to Survey Questions

Background Information

1. Do you require a University Degree, Technical Diploma or Associates Degree to operate an AUV?

- Our group 2 PHD, 2MSc, 2 Technical Diploma: on an individual basis No.
    - Ability is more important than qualification. But within the overall group a certain mix of skills are needed.
- **We normally require a university degree but we take a look at the whole picture. Experience and demonstrated accomplishments will go a long ways.**
- To operate (drive) an AUV, no diploma or degree is required. However, to maintain an AUV, technical training is essential. Normally, to keep the size of the operating crews to a minimum, the operators have to be maintainers as well. In our experience, university graduates and technical associates work equally as well.
- Our operators mostly have a technical diploma equivalent to 3 years after school.

2. Is it preferable to have operators that have a wide base of knowledge in such areas as: underwater vehicle design, hydrodynamics, mechanical systems, electrical systems, hydraulic systems, electronic circuits, microprocessor interfacing, fiber optics, acoustic communications theory, oceanography and numerical analysis; or is it preferable to have operators that have specialized skills who would work in a group environment with others of complementary skill sets?

- It depends very much on factors such as: How many people are in the operation (1-4)
    - What are the level of spare equipment… from component level through to entire spare AUV
    - What is the maturity of the vehicle and its reliability? Typically not very reliable (some Gliders)
    - For AUTOSUB
        - We take 3 or 4 people on mission.
        - We take system level spares. E.g. spare transponder, and component level spares
        - Reliability: Several faults occur during cruises, this is typical
        - With only 3 people you need a moderate range of skills.
            - Last mission:
                - Generalist, electronics, hydrodynamics, software, control, navigation, some mechanics
                - SW and IT specialist
                - Mechanical engineer with wide range of mechanical skills, as well as driving the LARS

- **We require that operators are familiar with basic software and hardware and beyond that, we expect them to have at least one area of specialization. This could be in electronics, software development, or just about anything else. We don't do a lot with fiber optics (yet) and we have enough expertise on oceanography so we'd favor the more vehicle-related aspects rather than scientific or data-reduction capabilities.**
- In an operating team, it is essential to have one person with solid grounding in electrical systems, one with a solid grounding in mechanical systems, and one who can use whatever software programs accompany the AUV. Quite often in our experience, the electrical and software people are the same.
- You also need to define how missions and failsafe-fault responses are planned (ahead of time ashore, or onboard (launch vessel). Generally some of this is done aboard and one or two of the operating crew will nee to have exposure to these systems.
- Finally, you need to figure out who is responsible for processing the mission data, and therefore if your operating team needs experience in these programs as well as the interpretation of the data. Most often, the agency chartering the AUV will want to look after this.
- AUV teams are small, 3 persons in our case. The difficulty with small teams is to cover the required competences. 1) to operate AUV safely and optimally, 2) to be able to troubleshoot and perform maintenance without external help at sea Lead competencies without ranking.
    - Electronics and electrical systems
    - Computer hardware, operating systems management and networks
    - Understanding/experience of underwater vehicle systems and sea operations.
- The competencies in your list have to be acquired by training.

3. Which facets of prior learning would be most beneficial to bring a novice operator up to operational status?

- Numeracy
    - Team work Management
    - IT skills
    - Data processing skills e.g. Matlab

    - Workshop engineering – Tech qualification

- **Electronics and software are key; without these basics, a person if of little value to us. We can teach the deck operations and normal procedures but the ability to troubleshoot a problem is paramount.**
- It depends on the individual and the circumstances. I have to be a competent 'Jack-of-all' but if the group is larger then specialist expertise is the way to go. At the very minimum one needs electrical technical skill and some software aptitude.

- From a pure operational perspective electrical (software and electrical), mechanical, acoustic and oceanography competencies would be core to a sound operator in my opinion.
- Graduate of a technical institute or a university in a technical program
- General electrical systems
- Robotic systems
- Computer systems and networks

4. Would it be advantageous to train skilled trades people versus university graduates?
   - **Good question; we've never considered this. A person with a trade degree might be quite useful but, so far, we have required a university degree.**

   - Doesn't make too much difference (as discussed above). Probably the real issue is who is available and what are you prepared to pay them.
   - A versatile technical background is necessary, a mix of technicians and engineers (for system and operation responsibility) is appropriate.

Training

1. Is the training that you provide specialized, generic or proprietary in nature?
   - Yes, yes, yes
     - Specialized e.g. the LonWorks operating system
     - Generic training in Matlab
     - Proprietary tends to be ad hoc or as the need arises, i.e. we train each other with respect to our jobs so that the skills are shared.
   - **Generic**
   - We provide generic training – common sense training in how to operate the AUV as well as specialized training that gets into proprietary information.
   - I am a research engineer who has responsibility over system / sub system development, and operation up to the point where an operator team takes over. Thus I would say my training is generic on underwater systems, navigation etc., than specific to our AUV's.

2. Does your training provide a comprehensive academic background?
   - I would say not
   - **No, not at all; it's very specific and hands on.**
   - Sara was trained by ISE, but her training experience fell woefully short and it was her general competency that enabled her to lead AUV operations capably.
   - Our training assumes a comprehensive academic background as in question 2.
   - PhD in robotics

3. Is there a minimum educational time frame or number of completed missions that should be completed before an operator is considered capable of deployment?
    - Depends on the complexity of the missions. I can't see why it should require more than a few missions before a pilot is capable of solo.
        - Due to the nature of what we do, we have never embarked on a training program. As our team has been loosely together for a long time.
    - **We work as a team so each new operator is transitioned gradually into positions of increasing responsibility.**
    - **In our training package, we involve the operator(s) in the planning and execution of 5 (minimum) to 10 (maximum) missions that are 3 to 4 hours in length. We expect that this would enable them to carry out simple missions of short duration and that they would probably conduct another 5 to 10 missions such as these before moving progressively on to more difficult work.**
    - **Typically 1 cruise with mean of 10 deployments for a person having already experience at sea.**

4. Since AUV systems are inherently varied by type and manufacturer, what common elements would be paramount in cross training operators to be capable of operating vehicles of various types or from different manufacturers?
    - Concepts of navigation
    - **Battery systems, network and communications, acoustic communications and navigation, deck operations.**
    - **The common (sense) parts are mostly to do with operations. However, all of the commercially available AUV's work in much the same way and we have found that operators experienced on one brand of AUV can very quickly appreciate and understand the way in which another functions.**
    - **All aspects representing the physical limits: communication, navigation, mapping, electronics; then autonomous systems, robotics, underwater connectors, underwater actuators; finally operational: vessel operations, deployment, maritime knowledge and experience.**
5. Does each trainee require complete training in all underwater vehicle components?
    - Depends on the size of the team. In General No.
    - **Eventually; at first we can fill in for deficiencies, but we like to have as much cross training as possible.**
    - **That is what we do.**
    - **There are numerous competences and few people on the team; put in another way: you'll need to have people with thorough (specialized) understanding in some fields, and rough knowledge in other fields.**
6. Do supervisors require more training than operators?
    - **We don't really have supervisors; we work as a team.**

- **Ideally, a supervisor will have spent time as an operator. When we are training teams, or trials manager will 'coach' the AUV supervisor.**
- **They only need more experience.**

7. How many 'live' deployments do you do in your current operator training courses including launch and recovery operations?
    - N/A we don't do courses
    - **It's all live; we do not have a separate training course.**
    - **Our AUV operators come from other systems (ROV, manned sub); 1 cruise with 10-20 deployments is good adaption to the AUV, completed with some lab work to learn the specific background.**

8. Is your training transferrable to other platforms?
    - N/A
    - **Inasmuch as there is a lot of overlap, yes, but there are limits.**
    - One cannot transition immediately to another platform. There are subtle differences that if unappreciated can result in significant problems. This is largely due to the higher stakes of AUV operations rather than the fundamental difference in technologies though

9. Have you had much experience cross-training personnel to operate your vehicles who were initially trained on other manufactures vehicles?
    - Some e.g. with license to subsea to develop their own AUV based on Autosub. They were ROV operators. The training was limited to a few days workshop.
    - **No, not yet.**
    - I have operated other AUV's products and there are similarities and differences. A little or casual mistake can really ruin a day.
    - **A little bit – one from Gavia vehicle and one from Autosub.**
    - **A trained operator will be efficient on another system in a few days, a supervisor a few weeks. These operators will work on any of our systems, in order to optimize human resources management over longer periods of time.**

Formal Training

1. What formalized training is available for AUV operators?
    - **None that I know of.**
    - I am not aware of formal training programs.
    - I don't know of any formalized training available with AUV platforms from either the manufacturer of the Memorial platform (ISE) or available institutionally.

- I do know that it is possible to get hire an experienced consultant in to put off a short course
- **We have a 10 to 15 day maintenance and operations course that we provide at our site using our ship, or at the clients site using his ship. We provide it to teams of between 3 and 10. We also provide a 5-day course in our software.**
- **Checklists, vehicle configurations, payload configurations, data control, vessel mobilization, maintenance.**

2. If a formal training environment were not available to train operators, what would be the best method to take advantage of their previous experiences and education to advance them to qualified operators?
   - **We use hands on; get new people involved as quickly as possible and see what they have to contribute.**
   - At this point in time we bridge gaps individual tutelage of new operators through informal methods (ie not class setting) and experience as alluded to above. I believe that it is a current risk management exercise on terms of entrusting operators with such valued equipment. An institution, organization or company assumes that the person they have in control of this type of asset has the ability and sensibility to run the gear and not beat it up.
   - I have no formal training for AUV operations, but I would recommend that approach for no one.
   - What I did do was ride shotgun here on some trials and spent time with other organizations operating the same model AUV. Our internal model for training has been very much on the job with a 'teacher to pupil' relationship.
   - I do not have an opinion on this.
   - Harbor training deployments = low cost. Training on the job (trainee operator or novice operator with 2 experienced colleagues).
3. Are there any current accredited AUV training centres other than those of the specific manufacturer?
   - **Not that I know of.**
   - **Not to my knowledge. Cybernetics in France is thinking about it.**
   - **We only train in house, essentially for cost and time constraints. Manufacturer training applies for new systems.**

On Job Training

1. What is the best vehicle to use for training? The actual vehicle operated in real-time or simulators along with 'bench top' components for illustrative purposes?

- Both needed –we don't have detailed enough simulators- but this would be very useful.

- **Remus is the simplest and the most user friendly; it's a good place to start.**
- Simulation of missions has a role to play. However the nature of AUV work is not like ROV deployments. The lack of continuous real time control means that mission simulation in a 'simulator' sense has no use. Where simulation is used is on various aspects of AUV performance and operations, as opposed to simulating an entire AUV mission or deployment. Simulation cannot replace hands on learning. Moreover, hands on experience is a tremendously evolving exercise. One mission doesn't 'learn you' an AUV.
- Really, one needs a lot of hours and some hard trouble shooting/fall on your face lessons to become a capable AUV operator.
- **The actual vehicle by a long shot.**
- **No simulator replaces sea conditions, work conditions and live n the vessel (work hours, logistics, environment etc.); we do not train on simulators, we do train on the real systems in the lab (background, engineering, maintenance, troubleshooting) and in harbor trials. Operational aspects are not trained, they are experience.**

2. Do you use on job training currently as your prime method to train operators?

- Yes
- **Yes**
- Yes
- **Yes. Typically a team of 3 can do with one novice operator. But lab training must be provided for the background, it's the balance of both kinds of training.**

3. Is apprenticeship training an appropriate method to develop AUV operators?

- Yes
- **I suppose so; the team is small enough that it isn't a consideration here.**
- **I don't know.**
- **If apprenticeship training means to have a student part time in our facilities or at sea, the answer is no. Other wise is (2)**

Refresher Training

1. At which interval do you recommend that operators complete refresher training?

- N/A
- **Every cruise is refresher training for us.**
- **Don't think this is necessary. The operators learn much more by being operators.**
- **After 1 year without cruise experience.**

2. Does the manufacturer notify you after hardware and software modifications have been completed so that you can incorporate them into your vehicle and then complete further training as required?

- N/A
- **Just the opposite; we develop new hardware and software and pass it back to them.**
- **Yes. We provide the details so they can update their knowledge themselves.**
- **Modifications come from:**
    - **In house developments**
    - **Manufacturer**
    - **Third party subsystems.**
- **We have procedures on updating the system and testing, in order to avoid inconsistency in system training, side effect problems and so on. Technical trials at sea are programmed once a year for validation of major modifications.**

Marine Specific

1. What marine specific training is paramount in safe AUV operations?

- Marine specific training is paramount for safe AUV operations
- **We do not operate at all in fresh water**
- **Common sense and seamanship.**
- **In our case it is experience with deploying underwater systems – vehicle operators receive marine skills and ship operators develop skills in vehicle deployment: untrained or unskilled ship operators can be a problem for AUV work.**

2. What level of marine navigation or chart work, either paper based charting or electronic charting is required of an AUV operator?

- We don't have formal qualifications. We always work off of a ship, and we take advice from the master in regard to safety at sea.
- **We use an eChart based planning and navigation system so basic charting ability is assumed.**
- **Familiarity with both paper and electronic charts is a good thing.**
- **The chief operator is the contact for the (scientific) end user. He has to understand and use chart material to translate the user requirements into an operational AUV mission. Our AUV mission programming software MIMOSA, has been developed to the requirement that it makes mission programming easy as possible, ideally free of vehicle specific technical details; thematic maps can be loaded as reference data t the AUV mission, scientists are able with this tool to build draft realistic AUV missions which need only to be revised and validated by the operator.**

3. Should operators be required to attain certificates in offshore safety and survival, first aid, and marine emergency duties?
- This is a requirement for our at sea work.
- **No.**
- **It wouldn't hurt and quite often, the operator requires it.**
- **They obtain the same safety instructions as any scientist on board.**

Specific Technical Skill Sets Required

1. In your opinion what type of training is mission critical for your operators/technicians to obtain?
- They should have competency in the relevant fields. Safety is paramount.
- **We use an eChart based planning and navigation system so basic charting ability is assumed.**
- **AUV system insight as navigation, acoustics, security system, batteries ... plus specific knowledge of payloads.**

2. Is knowledge of microcontrollers and embedded systems an essential AUV operator skill?
- No
- **Yes, definitely, including software and interfacing.**
- **No**
- **No**

3. What skill sets are required in addition to a Degree in an Engineering/Computer Science/Earth Science?
- A degree is not needed. Skills needed depend on the size of the team and the spares levels as explained in Background 2.
- **Software and interfacing.**
- **Electrical Engineering.**
- **Sea and underwater vehicle experience.**

Management Skills

1. What risk management and assessment training should be included in an operators training?
- Risk Management training is needed.
- **Common sense as applied to making the go/no-go decision as it applies to weather and equipment status.**

- There are huge risk management aspects of operations. Any decent operator should have the capability to continually assess the ongoing risks as part of any deployment. Frankly at times, these stakes can get quite high (ie not just $$ but lives). In some ways, it can be like skippering a ship. Training alone does not make a good operator - there is a personality aspect to it as well.
- **I would leave this out of a basic course.**
- **Insight to the technical risks, operational risks and risks related to end user mission achievement (a successful mission is only that which brings home a complete and consistent data set).**

2. Would courses in engineering management be considered essential for AUV operator training?

- Not essential.
- **No, not at all.**
- **Ability to maintain a good, accurate log of events.**
- **Not mandatory.**

Regulatory Bodies

1. What regulations currently exist which protect the integrity of the AUV industry?

- Don't know of any.
- **None that I know of.**
- No regulations are in place that I am aware of.
- **None. SUT is thinking about this sort of stuff.**
- **Not aware of any specific regulation.**

2. Are there any current AUV certifications, which would verify that an operator is trained in a particular area of AUV operations?

- I Don't think so.
- **None that I know of.**
- No.
- **Not aware.**

3. Is there a requirement for a regulatory body or international organization to oversee standardized training for AUV operators?

- I Don't think so.
- **No.**
- **There is not presently a formal requirement. The probability that one or more agencies may in the near term setup training courses for AUV operators and maintainers is relatively high. This will likely create the requirement, as operators will specify this training when they hire AUV personnel.**

- **This does not even exist for manned subs.**

Future Considerations

1. If you were to select a preferred worldwide location from which to conduct your AUV training centre where would that be?

- Near deep water, warm, sheltered. Eastern Med.
- **There is no one preferred site. It's important to have a variety of conditions, water depths, and terrain scales to deal with but you could find that just about anywhere.**
- **Somewhere with 365 days of ice free waters, in a place close (less than 1 hour by boat) to useful water depths (50 to 100 meters) where the wind is generally less than 10 knots and the sea heights less than 1-2 feet. Ideally, in a place where there is little boat traffic – especially pleasure boats and water skiers. And for sure a good pub nearby.**
- **Not realistic in my humble opinion. We go towards balanced operations by technicians where training must be cost-effective.**

2. What features, including simulated bottom features would this contain?

- Who said anything about simulated? Currents, and various density profiles.
- **Simulated? Not necessary. Go to the real thing; there is plenty of it around. It's very important to include rough weather operations at some point.**
- **A slope with an incline of 15 to 20 degrees would be nice.**
- **Not realistic, to many different vehicle types, mission types, depth/shallow, under ice / heavy traffic areas, environmental conditions etc.**

3. For training purposes would a sandy bottom be preferred to one comprised of rocks and coral?

- I suppose – safer – muddy might be better.
- **Rough terrain is essential; a sandy bottom isn't very useful except in the very early stages of training.**
- Yes.
- **Obviously start with the easy one, but then do canyons, under-ice, deep-water etc. ; again this does not seem realistic.**

4. Which type or class of vehicle would provide the best training environment for operator candidates while keeping in mind the benefits of cross training?

- Something you could afford to lose.
- **I think it would be better to train on the actual vehicle the person would use. Cross training is valuable but only after initial training on the project vehicle.**

- Right now, almost all AUV's are 'cruising' which means they have one thruster and cannot hover. They are intended for long-range survey operations.
- Train on the vehicle they will operate – cross training is a side effect, not to be over estimated. See cost-effectiveness. AUV's will be significantly used if operation does not require years of programming.

Appendix B Units

AUVROVACOU01

AUVROVCADD01

Course Information for VET AUV Operator ROV Pilot

Unit AUVROVCADD01

COURSE NUMBER:	MEM09002B
COURSE TITLE:	Interpret Technical Drawings
COURSE DESCRIPTION:	Students will learn to interpret technical drawing relating to any of the full range of engineering disciplines. Technical drawings may utilise perspective, exploded views or hidden view techniques. Interpretation may require guidance particularly in respect to any geometric tolerancing.
PREREQUISITES:	Nil
CO-REQUISITES:	Nil
COURSE HOURS:	54
SUGGESTED TEXT:	MEM 9.2A.1 Interpret Technical Drawings,
LEARNING RESOURCES:	Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. check and validate drawing against job requirements or equipment.
2. check and validate drawing version.
3. recognize components, assemblies or objects as required.
4. identify dimensions as appropriate to field of employment.
5. identify and follow instructions as required.
6. identify material requirements as required.
7. recognise symbols in the drawing as appropriate.

MAJOR TOPICS:

1.0 Selecting correct technical drawings
2.0 Technical drawing interpretation

LEARNING OBJECTIVES:

1.0 Selecting correct technical drawings

1.1 Describe the purpose of a technical drawing.
1.2 Check the drawing against job requirements/related equipment in accordance with standard operating procedures.
1.3 Explain the importance of using the most current version of a drawing.
1.4 Obtain the current version of the drawing in accordance with standard operating procedures.
1.5 Confirm the drawing version is the most current in accordance with standard operating procedures.

2.0 Technical drawing interpretation

2.1 Describe the type of sectional or pictorial view presented in a drawing.
2.2 Describe all objects represented in a presented drawing.
2.3 Explain the purpose of all symbols used in a presented drawing.
2.4 Read and interpret information on the drawing, written job instructions, specifications, standard operating procedures, charts, lists and other applicable reference documents.
2.5 List sources of clarification for technical drawings
2.6 Clarify, where necessary, task related information from a drawing.
2.7 State and calculate the limit and fit illustrated in a drawing.

2.8 Ensure units of measurement used in the preparation of the drawing are consistent.

2.9 Report on the actions undertaken in response to instructions.

2.10 Describe, from the drawing information, the materials from which the object(s) are made.

2.11 Describe any hazard and control measures associated with interpreting technical drawings, including housekeeping.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM09003B

COURSE TITLE: Prepare basic engineering drawing

COURSE DESCRIPTION: This unit covers identifying the drawing requirements, preparing or making changes to engineering drawings, preparing an engineering parts list and issuing the drawings.

PREREQUISITES: NIL

CO-REQUISITES: NIL

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

1.1 Requirements and purpose of drawing are determined from customer and/or work specification and associated documents.
1.2 All data necessary to produce the drawing is identified and collected.

1.3 Drawing requirements are confirmed with relevant personnel and timeframes for completion are established.
1.4 Drafting equipment is selected appropriate to the drawing method chosen.
1.5 Drafting principles are applied to produce a drawing that is consistent with standard operating procedures within the enterprise.
1.6 All work is undertaken safely and to prescribed procedure.
1.7 Completed drawing is approved in accordance with standard operating procedures.
1.8 Components parts are identified and organised by component type and/or in accordance with organisation/customer requirements.
1.9 Drawings and or parts lists records are completed in accordance with standard operating procedures.
1.10Approved drawings and or parts lists are copied and issued to relevant personnel in accordance with standard operating procedures.
1.11Approved drawings and or parts lists are stored and catalogued in accordance with standard operating procedures.

MAJOR TOPICS:

1.0 Identify drawing requirements
2.0 Prepare or make changes to engineering drawing
3.0 Prepare engineering parts list
4.0 Issue drawing

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

COURSE NUMBER: MEM09010C

COURSE TITLE: Create 3D models using computer aided design system

COURSE DESCRIPTION: This unit covers preparing the 3D CAD environment, creating and modifying 3D models, and producing output from the 3D model.

PREREQUISITES: Nil

CO-REQUISITES: Nil

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: This unit applies to the production of 3D models utilizing computer equipment. Operations at this level include, but are not limited to, the creation and manipulation of entities such as arcs and lines and primitives such as spheres, cones, cylinders and boxes using industrial software. The unit applies to the fields of mechanical, electrical/electronic, fabrication, and fluid power.

MAJOR TOPICS:

1.0 1. Prepare 3D environment
2.0 2. Create and modify 3D model
3.0 3. Produce output from 3D model

LEARNING OBJECTIVES:

1.0 Establish coordinate system to job requirement.
2.0 Establish orientation to job requirement.
3.0 Establish views to job requirement.
4.0 Create entities in 3D space to job requirement.
5.0 Manipulate entities in 3D space to job requirement.
6.0 Create surfaces in 3D space to job requirement including ruled and revolved.
7.0 Modify existing 3D model to job requirement.
8.0 Save file in various formats for retrieval as per standard operating procedures.
9.0 Extract physical properties to job requirement including volume, mass and centre of gravity.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

AUVROVCNTL01

COURSE NUMBER: MEM18060B

COURSE TITLE: Maintain, repair control instrumentation

COURSE DESCRIPTION: This unit covers determining control loop characteristics, monitoring and recording the operation of a control loop, localizing the fault condition, and replacing or repairing the faulty condition

PREREQUISITES:

MEM05001B Perform manual soldering/desoldering – electrical/electronic components

MEM09002B Interpret technical drawing

MEM12004B Perform precision electrical/electronic measurement

MEM12023A Perform engineering measurements

MEM18001C Use hand tools

MEM18002B Use power tools/hand held operations

MEM18054B Fault find, test, calibrate instrumentation systems and equipment

MEM18055B Dismantle, replace and assemble engineering

	MEM18057B Maintain/service analog/digital electronic equipment MEM18062B Install, maintain and calibrate instrumentation sensors, transmitters and final control elements
CO-REQUISITES:	Nil
COURSE HOURS:	Ninety (90)
SUGGESTED TEXT:	<u>MEM 18.6B Maintain, repair control instrumentation – single and multiple loop control systems</u>
LEARNING RESOURCES:	Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. Obtain and interpret relevant engineering specifications, technical information, software data, diagrams and drawings, historical records and documents pertaining to the system components and operational data.
2. Consult system operators and other relevant plant personnel with respect to the control loop characteristics.
3. Confirm function/malfunction of the system and/or its components.
4. Check operational characteristics of control devices, signal conversion instruments and final control elements for conformance to specification.
5. Identify faults/defects in control system.
6. Locate/read in-built fault indicators and error codes.
7. Obtain relevant pneumatic, electrical and electronic circuit diagrams.

8. Test and monitor the control loop for correct operation.
9. Monitor and record responses of the control system.
10. Use appropriate faultfinding and diagnostic techniques and procedures throughout the monitoring and testing process.
11. Compare collected data with the operational specifications of the control system.
12. Mark components for repair or replacement.
13. Dismantle/disassemble serviceable items.
14. Set up appropriate test and calibration equipment.
15. Set and adjust the controller modes.
16. Check the control instrumentation for correct zero, span and range.
17. Adjust the control system as required.
18. Complete all necessary reports including appropriate follow-up procedures.
19. Commission the control system.
20. Interpret trends from operational data.
21. Interpret information from in-built devices.
22. Calculate control loop characteristics.

MAJOR TOPICS:

1.0 Determining control loop operating characteristics
2.0 Monitoring and recording operation of a control loop
3.0 Localizing fault condition
4.0 Replacing or repairing faulty condition
5.0 Calibrating and adjusting control instrumentation
6.0 Completing service reports and recommissioning

LEARNING OBJECTIVES:

1.0 Determining control loop operating characteristics

1.1 Examine engineering specifications, technical information and historical trends for relevant data

1.2 Examine, read and interpret system specifications, operational data and other relevant data sources and relevant conclusions are noted

1.3 Carry out consultation with system operators and other relevant plant personnel and relevant data is extracted and documented by appropriate means

1.4 Observe operation of the system using knowledge of all control loopdevice characteristics, controller mode principles and adjustment methods

1.5 Use appropriate test equipment and testing procedures

1.6 Utilize fault finding and diagnostic techniques

1.7 Collect relevant data by appropriate means from all sources including maintenance records, fault indicators, charts, error codes operational symptoms, observation monitoring and consultation with appropriate personnel

2.0 Monitoring and recording operation of a control loop

2.1 Interpret pneumatic, electrical and electronic circuit diagrams

2.2 Test and monitor loop operation from the controller response to set point and manual output changes using knowledge of all control loop device characteristics, controller mode principles and calibration/adjustment methods, using correct test equipment, principles and procedures are

2.3 Interpret software configuration data for digital control systems

2.4 Monitor and record operational responses by appropriate means

2.5 Utilize fault finding and diagnostic techniques throughout checking and testing procedures including simple and multi-controller type control schemes

2.6 Analyse diagnostic results and conclusions against predetermined operational specifications

3.0 Localizing fault condition

3.1 Test circuits to the level necessary to identify and localize faults

3.2 Utilize drawings/diagrams and operational testing data in identifying and localizing fault conditions

3.3 Localize and verify fault condition to major component level using appropriate test equipment, principles and procedures

4.0 Replacing or repairing faulty condition

4.1 Dismantle components for repair or replacement using appropriate tools, equipment and procedures

4.2 Select replaceable items from manufacturers' catalogues, spare parts lists, or data sheets

4.3 Repair serviceable items using correct principles, tools, equipment and procedures

4.4 Reassemble repaired and replaced items using appropriate tools, equipment, techniques and procedures

5.0 Calibrating and adjusting control instrumentation

5.1 Calibrate and adjust panel mounted, split architecture single loop/multiple loop using correct calibration principles, equipment and methods for all devices according to manufacturers' instructions

5.2 Adjust controller modes and actions according to specifications

5.3 Undertake zero span and range checks using correct and appropriate configuration

5.4 Make final adjustments to control instrumentation using correct and appropriate procedures, techniques, tools and equipment

6.0 Completing service reports and recommissioning

6.1 Complete service reports to standard operating procedures

6.2 Adopt appropriate follow up procedures

6.3 Recommission control instrumentation to standard operating procedures

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM18062B

COURSE TITLE: Install, maintain and calibrate instrumentation sensors, transmitters and final control elements

COURSE DESCRIPTION: This unit covers selecting and installing appropriate sensors and signal transmitters, maintaining and diagnosing correct operation of sensors and signal transmitters, and completing fault documentation

PREREQUISITES:

AUVROVELTR01-MEM05001B Perform manual soldering/desoldering –electrical/electronic components

AUVROVCADD01-MEM09002B Interpret technical drawing

AUVROVELTR01-MEM12004B Perform precision electrical/electronic measurement

ROVAUVMECH01-MEM12023A Perform engineering measurements

AUVROVFABS01-MEM18001C Use hand tools

ROVWKSHOP001-MEM18002B Use power tools/hand held operations

AUVROVMODS01-MEM18055B Dismantle, replace and assemble engineering components

	AUVROVELTR01-MEM18057B Maintain/service analog/digital electronic equipment
CO-REQUISITES:	Nil
COURSE HOURS:	Ninety (90)
SUGGESTED TEXT:	MEM 18.62B Install, maintain and calibrate instrumentation sensors, transmitters and final control elements,
LEARNING RESOURCES:	Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this unit, the student will be able to select and install appropriate sensors and signal transmitters. Maintain and diagnose correct operation of sensors and signal transmitters and be capable of completing fault documentation.

1. Access relevant data sheets, circuit diagrams, engineering drawings, instructions, specifications, information and supplier catalogues and replacement components.
2. Select sensors, transmitters and final control elements.
3. Install and test sensors, transmitters and final control elements to specification.
4. Obtain and perform relevant scheduled/preventative maintenance schedules for sensors, transmitters and final control elements.
5. Determine correct function of sensors, transmitters and final control elements
6. Record test results.
7. Identify, localize, monitor and report/record faults in sensors, transmitters and final control elements.
8. Prepare sequential action plan to correct faults in sensors, transmitters and final control elements.
9. Apply procedures to sequential and loop testing test results.
10. Check sensors, transmitters and final control elements and marking for replacement, repair or overhaul.
11. Repair/overhaul faulty items for fitting and /or refitting.
12. Fit/ refit sensors, transmitters and final control elements.
13. Prepare fitted/refitted sensors, transmitters and final control elements for testing

and calibration.

14. Configure, calibrate, test, adjust, tune and validate system performance.

MAJOR TOPICS:

1.0 Selecting for installation appropriate sensors, transmitters and final control elements

2.0 Installing instrumentation sensors, transmitters and final control elements

3.0 Maintaining, diagnosing correctoperation of sensors, transmitters and final control elements

4.0 Completing faultdocumentation and plan corrective action

5.0 Analyzing control loopand localize faults

6.0 Repairing/replacing, overhauling sensors, transmitters and final control elements

7.0 Calibrating and testing instrumentation sensors, transmitters and final control elements

8.0 Returning sensors, transmitters and final control elements and control loops to service

LEARNING OBJECTIVES:

1.0 Selecting for installation appropriate sensors, transmitters and final control elements

1.1 Determine specification requirements from data sheets, circuit diagrams, engineering drawings

1.2 Interpret and define and knowledge of device characteristics and principles of operation, specification requirements

1.3 Select according to their device characteristics, principles of operation and measurement capabilities, in conformance to specifications measurement range, processes and environment, sensors, transmitters and final control elements

2.0 Install instrumentation sensors, transmitters and final control elements

2.1 Install sensors, transmitters and final control elements using sound working knowledge of installation principles, procedures, techniques, tools and test equipment, according to appropriate codes of practice, standards, safety and legislative requirements

2.2 Plan installation access for maintenance and mounting connections for power, signal, and process

2.3 Diagnose installed sensors, transmitters and final control elements for correct operation using appropriate test equipment and procedures. Results are assessed against specifications or manufacturers' technical data sheets

3.0 Maintaining, diagnosing correctoperation of sensors, transmitters and final control elements.

3.1 Apply preventative maintenance schedules and procedures using knowledge of device characteristics and principles of operation to maintain sensors, transmitters and final control elements in optimum condition

3.2 Clean and service sensing elements using knowledge of device characteristics and principles of operation, to maintain optimum operating condition particularly at the process interface, using correct principles, tools, test equipment, techniques and procedures

3.3 Determine correct operation or malfunction using appropriate test equipment and procedures, sensors, transmitters and final control elements which are diagnosed within the system or as individual devices

3.4 Monitor and assess against predetermined specification or manufacturers' technical data operation of sensors, transmitters and final control elements

3.5 Localize and monitor using appropriate test equipment/procedures, correct operation of sensors, transmitters and final control elements is checked or fault condition identified,

4.0 Completing fault documentation and plan corrective action

4.1 Document and report faults and malfunctions to standard operating procedures

4.2 Plan corrective action autonomously or in consultation with appropriate personnel and auctioned

5.0 Analyzing control loopandlocalize faults

5.1 Obtain and interpret engineering specifications and technical information, control device, signal transmission and final element specifications. Read and interpret system specifications, including operational data, and historical records and trends

5.2 Extract and document relevant data in consultation with system operators and other relevant plant personnel to standard operating procedures
5.3 Observe operation of the system is using sound knowledge of all external control device characteristics, controller modes, signal transmission, final control devices
5.4 Set up correct and appropriate signal transmission test equipment using appropriate technique
5.5 Test circuits and control lines to the level necessary to detect and localize fault

6.0 Repairing/replacing, overhaul sensors, transmitters and final control elements

6.1 Examine and verify sensors, transmitters and final control elements for replacement, repair overhaul using correct tools/test equipment and appropriate principles, techniques and procedures
6.2 Select replacement items from manufacturers' parts lists or catalogues to meet specifications
6.3 Obtain replacement items
6.4 Repair and overhaul faulty items using correct principles, techniques, tools, test equipment and procedures
6.5 Prepare repaired, overhauled and replacement items for refitting according to standard workshop procedures
6.6 Refit sensors, transmitters and final control elements using correct principles, tools, test equipment and procedures
6.7 Prepare refitted sensors, transmitters and final control elements for testing and calibration

7.0 Calibrating and testing instrumentation sensors, transmitters and final control elements

7.1 Calibrate sensors, transmitters and final control elements against appropriate physical standards using correct calibration devices, test equipment, techniques and procedures
7.2 Perform zero, span and range tests using correct calibration devices, test equipment, principles, techniques and procedures
7.3 Assess zero span and range results against manufacturers' instructions sheets
7.4 Repair and overhaul faulty items using correct principles, techniques,

tools, test equipment and procedures

7.5 Apply zero, span adjustments to align sensors, transmitters and final control elements to manufacturers' instruction sheets using correct calibration equipment, principles, techniques and procedures

8.0 Returning sensors, transmitters and final control elements and control loops to service

8.1 Put into service sensors, transmitters and final control elements on conformance to specifications with due regard to process requirements, safety, installation/commissioning procedures and sequence of operation

8.2 Controller modes and actions are adjusted according to specifications

8.3 Test electrical and pneumatic transmission lines and appropriate action is taken including the use of signal conditioning devices

8.4 Apply correct procedures in returning instrumentation to service, including configuring, calibrating, adjusting, tuning and validating system performance

8.5 Return system to service in accordance with standard operating procedures.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

Course Information for VET AUV Operator ROV Pilot

Unit AUVROVCNTL01

COURSE NUMBER:	MEM18067B
COURSE TITLE:	Tune control loops – multi controller or multi element systems
COURSE DESCRIPTION:	This unit covers determining and recording control loop characteristics, tuning control loops and completing service records
PREREQUISITES:	MEM05001B Perform manual soldering/desoldering – electrical/electronic components MEM09002B Interpret technical drawing MEM12004B Perform precision electrical/electronic measurement MEM12023A Perform engineering measurements MEM18001C Use hand tools MEM18002B Use power tools/hand held operations MEM18054B Fault find, test and calibrate instrumentation systems and equipment MEM18055B Dismantle, replace and assemble engineering components MEM18057B Maintain/service analog/digital electronic equipment MEM18060B Maintain, repair control instrumentation – single and multiple loop control

systems
MEM18062B Install, maintain and calibrate instrumentation sensors, transmitters and final control elements.

CO-REQUISITES: Nil

COURSE HOURS: Ninety (90)

SUGGESTED TEXT: MEM 18.67B Tune control loops – multi controller or multi element systems,

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. Calculate control loop characteristics.
2. Obtain and interpret relevant engineering specifications, technical information, software data, diagrams and drawings, historical records and documents pertaining to the system components and operational data.
3. Consult system operators and other relevant plant personnel with respect to the control loop characteristics.
4. Confirm function/malfunction of the system and/or its components.
5. Check operational characteristics of control devices, signal conversion instruments and final control elements for conformance to specification.
6. Identify faults/defects in control system components.
7. Locate/read in-built fault indicators and error codes.
8. Obtain relevant pneumatic, electrical and electronic circuit diagrams.
9. Determine corrective action and interpreting trends from operational data.
10. Test/monitor the controls loop for correct operation.
11. Monitor and record operational responses of the control system/loop.
12. Use appropriate faultfinding and diagnostic techniques and procedures throughout the monitoring and testing process.
13. Compare collected data with the operational specifications of the control system.
14. Mark components for repair or replacement.
15. Dismantle/disassemble serviceable items.
16. Set up appropriate test and calibration equipment.
17. Set and adjust the controller modes.

18. Check the control instrumentation for correct zero, span and range.
19. Adjust the control system as required.
20. Implement diagnostic techniques and procedures.
21. Tune the control loop.
22. Complete all necessary reports including appropriate follow up procedures.
23. Commission control system.

MAJOR TOPICS:

1.0 Determining control loop characteristics
2.0 Recording control loop responses
3.0 Tuning control loops
4.0 Completing service reports

LEARNING OBJECTIVES:

1.0 Determining control loop characteristics

1.1 Examine engineering specifications, technical information and historicalprocess, records and trends for relevant data
1.2 Consult with system operators and other relevant plant personnel and extract and document relevant data to standard operating procedures
1.3 Read programmed maintenance/service reports and note relevant data
1.4 Analyse data and ascertain control loop characteristics

2.0 Recording control loop responses

2.1 Using chart recorders and data loggers, recorded control loop responses in open and closed loop mode

2.2 Test unit for tuning using appropriate diagnostic techniques

2.3 Analyse diagnostic results against specifications

3.0 Tuning control loops

3.1 Using knowledge of control loop device characteristics, controller mode principles and adjustment methods, perform tuning operations using correct and appropriate techniques, procedures and equipment

3.2 Test and correct, where necessary, recording equipment used for monitoring and adjustment of control loop components during controller tuning operations

3.3 Apply step response – open loop tuning calculations to achieve specified loop characteristics

3.4 Use closed loop tuning methods including ultimate sensitivity and systematic trials to achieve specified loop characteristics

3.5 Use correct sequence of tuning on multi controllers and/or multi element systems to achieve specified characteristics

3.6 Tune control loops to optimum mode settings utilising correct and appropriate techniques, tools, test equipmentand procedures

4.0 Completing service reports

4.1 Complete service reports to standard operating procedures

4.2 Adopt appropriate follow up procedures

4.3 Recommission process control loop to specifications

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

AUVROVCOMM01

AUVROVCOMP01

AUVROVELTR01

Course Information for VET AUV Operator ROV Pilot

Unit*AUVROVELTR01*

COURSE NUMBER:	MEM18057B
COURSE TITLE:	Maintain/Service Analog/Digital Electronic Equipment
COURSE DESCRIPTION:	Students willmaintain/service analog/digital electronic equipment and carry out the testing and maintenance of electronic equipment and systems, where a series of checks and pre-determined tests is applied in accordance with workshop manuals, testing procedures etc. Checks, tests and calibrations apply to a wide range of electronic systems and sub-assemblies used in engineering environment including telecommunication, process control, computer systems, security monitoring and alarm systems, etc. This course also covers the replacement of faulty components identified during these tests.
PREREQUISITES:	AUVROVELTR01-MEM05001B Perform manual soldering/desoldering – electrical/electronic components AUVROVCADD01-MEM09002B Interpret technical drawing AUVROVELTR01-MEM 12004B Perform precision electrical/electronic measurement

AUVROVFABS01-MEM18001C Use hand tools

CO-REQUISITES: Nil

COURSE HOURS: 54

SUGGESTED TEXT: None

LEARNING RESOURCES: MEM 18.57 book_V1, MEM 18.57 book_V2, MEM 18.57 book_V3 (Instrumentation Texts), Instructor supplied materials

MAJOR TOPICS:

1.0 Undertaking Maintenance Checks and Routine Tests
2.0 Maintaining and/or Servicing Electronic Equipment
3.0 Returning Electronic Equipment to Service

LEARNING OBJECTIVES:

1.0 Undertaking Maintenance Checks and Routine Tests

1.1 Determine electronic equipment and functions by reference to circuit diagrams, equipment manuals and/or consultation with equipment operator where appropriate.

1.2 Describe electronic equipment and functions by reference to circuit diagrams, equipment manuals and/or consultation with equipment operator where appropriate.

1.3 Run equipment built-in test functions to standard operating procedures where appropriate.

1.4 Record results of equipment built-in test functions to standard operating procedures where appropriate.

1.5 Note and record built-in faults/status display to standard operating procedures.

1.6 Check equipment/sub-assemblies, components, connections, terminations etc. visually and with correct and appropriate test equipment and techniques.

1.7 Remove faulty components where appropriate.

1.8 Replace faulty components where appropriate.

1.9 Check all results for compliance with manufacturers' requirements or specification, and results are recorded to standard operating procedures.

2.0 Maintaining and/or Servicing Electronic Equipment

2.1 Isolate sub-assemblies according to standard operating procedures, where appropriate.

2.2 Adjust electronic equipment/sub-assemblies to specifications, manufacturers' requirements and/or standard operating procedures using correct and appropriate techniques, tools and test equipment.

3.0 Returning Electronic Equipment to Service

3.1 Return equipment/sub-assemblies into service utilizing correct and appropriate techniques and procedures.

3.2 Check equipment/sub-assemblies for operational compliance to specifications and/or manufacturers' requirements.

3.3 Carry out documentation requirements related to the checking of equipment/sub-assemblies to standard operating procedures.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Course Projects

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM12004B

COURSE TITLE: Perform precision electrical/electronic measurement

COURSE DESCRIPTION: This unit applies to the identification of measuring requirements, the selection of appropriate measuring devices and calibration and care of devices to obtain accurate, precision measurements.

PREREQUISITES: Nil

CO-REQUISITES:

COURSE HOURS: 36

SUGGESTED TEXT: MEM 12.4AA: Precision electrical/electronic measurement,

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. Interpret specifications accurately from drawings, instructions.
2. Select appropriate equipment to achieve specified outcome.
3. Use correct and appropriate measuring techniques.
4. Interpret readings and measurements correctly and accurately.
5. Set up equipment to specifications utilizing manufacturers' or standard operating techniques.
6. Adjust and maintain measuring equipment to required accuracy, utilizing manufacturers' specifications or standard operating techniques.
7. Undertake care and storage of equipment to manufacturers' specifications or standard operating procedures.

MAJOR TOPICS:

1.0 Using equipment for precision measurement
2.0 Setting measuring devices
3.0 Maintaining precision equipment

LEARNING OBJECTIVES:

1.0 Using equipment for precision measurement

1.1 List the sources of specifications for the circuitry and/or components that is to be tested.
1.2 Interpret drawings, specifications, data sheets and instructions.
1.3 Describe the applications where analog and digital meters, cathode ray oscilloscopes, bridges and potentiometers, wattmeters and digital probes would be used.
1.4 List the units of measurement used in conjunction with precision electrical/electronic measurement.
1.5 Describe the procedures/techniques for obtaining a range of electrical/electronic measurements.
1.6 Take measurements such as peak and transient voltages, transient frequencies, digital wave form analysis using precision electrical/ electronic measuring devices.

1.7 Interpret measurements for a range of precision electrical/electronic measuring devices including analog and digital meters, cathode ray oscilloscopes, bridges and potentiometers, wattmeters and digital probes.

2.0 Setting measuring devices

2.1 Describe the tools and equipment necessary in setting precision electrical/electronic measuring devices.
2.2 List the sources to find the specifications of the equipment to be set.
2.3 Describe the procedures for setting a range of precision electrical/electronic measuring devices used in your shop.
2.4 Set and adjust precision electrical/electronic measuring devices including analog and digital meters, cathode ray oscilloscopes, bridges and potentiometers, wattmeters and digital probes.
2.5 Describe the adjustments that can be made to a range of precision electrical/electronic measuring devices in your shop.
2.6 Describe the procedures for adjusting a range of precision electrical/electronic measuring devices

3.0 Maintaining precision equipment

3.1 Describe the procedures for maintaining a range of precision electrical/electronic measuring devices.
3.2 Describe the procedures for storing precision electrical/electronic measuring devices.
3.3 Maintain and store precision electrical/electronic measuring devices to manufactures specifications and following standard operating procedures.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests

2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER:	MEM05001B
COURSE TITLE:	Perform manual soldering/desoldering – electrical/electronic components
COURSE DESCRIPTION:	Students will learn to perform manual soldering/desoldering for the installation and fabrication of electrical/electronic components.
PREREQUISITES:	Nil
CO-REQUISITES:	Nil
COURSE HOURS:	54
SUGGESTED TEXT:	MEM 5.1AA Manual Soldering/Desoldering- Electrical/electronic components
LEARNING RESOURCES:	Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. follow verbal or writtenmaterial preparationinstructions.
2. prepare materials using correct tools, equipment, materials and procedures.
3. prepare materials to specifications using instruction or standard operating procedures.
4. select correct soldering techniques, procedures, materials and soldering tools.
5. joint, mount, and shape materials to specification using standard operating procedures.
6. apply solder using correct and appropriate techniques.
7. where appropriate, remove excess material using correct tools and techniques.
8. observe procedures for the protection of components according to standard operating procedures.
9. undertake inspection procedures to standard operating procedures.
10. report/record inspection results to standard operating procedures as required.
11. select correct and appropriate techniques, procedures, desoldering tools and equipment for given task.
12. desolder materials/components using correct procedure minimising damage to materials/ components.
13. remove and clean material/components to specifications using standard operating procedures.

MAJOR TOPICS:

1.0 Prepare materials for soldering
2.0 Solder materials
3.0 Inspect solder joints
4.0 Undertake desoldering

LEARNING OBJECTIVES:

1.0 Prepare materials for soldering

1.1 Read and interpret routine information on written job instructions, specifications and standard operating procedures
1.2 Follow oral instructions
1.3 Describe cleaning solutions, their properties and cleaning procedures

related to soldering

1.4 Describe the appropriate personal protective equipment for manual soldering/desoldering
1.5 Describe methods of joint preparation
1.6 Describe the types of, and reasons for, flux used in your shop
1.7 Undertake material preparation

2.0 Solder materials

2.1 Describe hazard control practices in your shop when using soldering/desoldering equipment
2.2 Describe the procedure for preventing electrostatic discharge damage
2.3 Perform routine soldering
2.4 Performing desoldering

3.0 Inspect solder joints

3.1 Describe how to test and inspect soldered joint
3.2 Perform an inspection of a soldered joint

4.0 Undertake desoldering

4.1 Describe the procedure and precautions to desolder a finished component
4.2 Desolder a finished component

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

AUVROVFABS01

Course Information for VET AUV Operator ROV Pilot

Unit AUVROVFABS01

COURSE NUMBER:	MEM05001B
COURSE TITLE:	Perform manual soldering/desoldering – electrical/electronic components
COURSE DESCRIPTION:	Students will learn to perform manual soldering/desoldering for the installation and fabrication of electrical/electronic components.
PREREQUISITES:	Nil
CO-REQUISITES:	Nil
COURSE HOURS:	54
SUGGESTED TEXT:	MEM 5.1AA Manual Soldering/Desoldering-Electrical/electronic components
LEARNING RESOURCES:	Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. follow verbal or writtenmaterial preparationinstructions.
2. prepare materials using correct tools, equipment, materials and procedures.
3. prepare materials to specifications using instruction or standard operating procedures.
4. select correct soldering techniques, procedures, materials and soldering tools.
5. joint, mount, and shape materials to specification using standard operating procedures.
6. apply solder using correct and appropriate techniques.
7. where appropriate, remove excess material using correct tools and techniques.
8. observe procedures for the protection of components according to standard operating procedures.
9. undertake inspection procedures to standard operating procedures.
10. report/record inspection results to standard operating procedures as required.
11. select correct and appropriate techniques, procedures, desoldering tools and equipment for given task.
12. desolder materials/components using correct procedure minimising damage to materials/ components.
13. remove and clean material/components to specifications using standard operating procedures.

MAJOR TOPICS:

1.0 Prepare materials for soldering
2.0 Solder materials
3.0 Inspect solder joints
4.0 Undertake desoldering

LEARNING OBJECTIVES:

1.0 Prepare materials for soldering

1.1 Read and interpret routine information on written job instructions, specifications and standard operating procedures.

1.2 Follow oral instructions.

1.3 Describe cleaning solutions, their properties and cleaning procedures related to soldering.

1.4 Describe the appropriate personal protective equipment for manual soldering/desoldering.

1.5 Describe methods of joint preparation.

1.6 Describe the types of, and reasons for, flux used in your shop.

1.7 Undertake material preparation.

2.0 Solder materials

2.1 Describe hazard control practices in your shop when using soldering/desoldering equipment.

2.2 Describe the procedure for preventing electrostatic discharge damage.

2.3 Perform routine soldering.

2.4 Performing desoldering.

3.0 Inspect solder joints

3.1 Describe how to test and inspect soldered joint.

3.2 Perform an inspection of a soldered joint

4.0 Undertake desoldering

4.1 Describe the procedure and precautions to desolder a finished component.

4.2 Desolder a finished component

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

Course Information for VET AUV Operator ROV Pilot

Unit AUVROVFABS01

COURSE NUMBER:	MEM18001C
COURSE TITLE:	Use Hand Tools
COURSE DESCRIPTION:	Students will develop basic hand skills that are the foundation for becoming a mechanical technician. They will complete shop projects using metal cutting tools, holding tools, striking tools, and assembling tools. The course will help students develop knowledge and skill in tool identification, tool selection, tool maintenance and tool use
PREREQUISITES:	MEME13014A Apply principles of occupational health and safety in the work environment
CO-REQUISITES:	MEME14004A Plan to undertake a routine task
COURSE HOURS:	54
SUGGESTED TEXT:	MEM 18.1C : Use Hand Tools,
LEARNING RESOURCES:	Fitting and Machiningby TAFE Publications

ISBN 0 7241 3819 6

Videos: 160103a Millwright Bench work (Non-Cutting Hand Tools), 160103b Bench work (Hand-Held Cutting Tools), AB Apprenticeship and Training –Millwright – First Period – ISBN-07785-4321-8,

Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. Identify and select appropriate hand tools to complete a given task.
2. Demonstrate the correct use of hand tools to complete a given task.
3. Demonstrate safe working practices when using hand tools.
4. Identify, label and report hand tools which are in an unsafe or faulty condition.
5. Maintain hand tools, including sharpening, using correct standard operating procedures, principles and techniques.
6. Safely store hand tools in appropriate locations according to standard operating procedures and manufacturer's recommendations.

MAJOR TOPICS:

1.0 Hand tools identification and selection
2.0 Safe hand tools usage
3.0 Hand tools maintenance
4.0 Hand tools storage

LEARNING OBJECTIVES:

1.0 Hand tools identification and selection

- 1.1 Identify tools as presented in the shop
- 1.2 Describe the use for which the tool is designed
- 1.3 Select the correct tools to:
  - 1.3.1.1 Secure
  - 1.3.2 Measure
  - 1.3.3 Mark out
  - 1.3.4 Cut
  - 1.3.5 Shape
  - 1.3.6 Finish
  - 1.3.7 Disassemble and assemble

2.0 Safe hand tools usage

- 2.1 Discuss the need for correct personal protective equipment in a shop environment.
- 2.2 Demonstrate the proper use of personal protective equipment in a shop environment.
- 2.3 Describe examples of, and rationale for, proper techniques and control measures when using a tool to complete a task.
- 2.4 Demonstrate proper techniques and control measures when using a required tool to complete a task.

3.0 Hand tools maintenance

- 3.1 Describe standard operating procedures for reporting hand tools that are identified to be unsafe or faulty.
- 3.2 Identify and report hand tools that are in an unsafe or faulty condition.
- 3.3 Describe the need for routine maintenance of the hand tools in the shop.
- 3.4 Demonstrate the correct maintenance procedures of the hand tools in the shop.

4.0 Hand tools Storage

4.1 Discuss the need to safely store hand tools according to manufacturers' recommendations and standard operating procedures of the shop.

4.2 Demonstrate the correct and safe storage of hand tools.

FORMAL ASSESSMENT TOOLS:

1. **Knowledge Based Tests**
2. **Practical exercises**
3. **Unit Projects**

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM18003C

COURSE TITLE: Use tools for precision work

COURSE DESCRIPTION: Thisunit involves using a variety of tools, instruments and power equipment to perform precision tasks on a range of metallic and non-metallic materials. The types of precision work covered by this unit could include:

- scraping machine beds to precise tolerances
- broaching a tapered keyway
- hand reaming the bore of a spigot or bush to a positive transition fit with shaft
- core drilling (finishing) a blind locating hole to receive a mating pin
- lapping a mechanical seal to fine finish
- filing complex angles and mating edges
- precision grinding using flex-drive attachment or similar

PREREQUISITES:

18001 Use hand tools

18002 Use power tools/hand held operations

12023 Perform engineering measurements

CO-REQUISITES: None

COURSE HOURS: 36

SUGGESTED TEXT: MEM18.3A Resource Book: Use tools for precision work

MEM18.3A Trainee WorkBook: Use tools for precision work

LEARNING RESOURCES: Fitting and Machiningby TAFE Publications

ISBN 0 7241 3819 6

Instructor supplied handouts

MAJOR TOPICS:

1.0 Determining job requirements
2.0 Preparing tools and tooling to produce precision outcome
3.0 Using toolsto produce work to precise specifications

LEARNING OBJECTIVES:

1.0 Determining job requirements

1.1 Determine task requirements and specifications from drawings, specification documentation instruction or work orders
1.2 Clarify, where necessary, task requirements and specifications with appropriate persons
1.3 Select processes/techniques such as cutting out, drilling, fitting, filing, reaming, lapping, broaching, burnishing, scraping, polishing, hand held grinding, or chiselling appropriate to task, specifications and material

2.0 Preparing tools and tooling to produce precision outcome

2.1 Select tools, accessories and consumables appropriate to task, specifications and material
2.2 Where applicable, use engineering principles to determine any necessary cutting tool modifications such as shape, rake angle and clearance angles required to produce specified outcomes
2.3 Prepare and modify tools/tooling as required

3.0 Using tools to produce work to precise specifications

3.1 Describe hazards and control measures associated with the work area, tools and equipment in your shop area
3.2 Prepare the work area to ensure safe conditions prior to commencing work
3.3 Prepare and secure the work piece using appropriate method for selected operations
3.4 Use tools according to acceptable engineering principles, methods, applications and procedures to produce specified outcome to the required accuracy
3.5 Inspect tools and equipment for safe and proper working order before, during and after use
3.6 Identify, repair where appropriate, or mark for repair and/or disposal unserviceable tools/equipment according to prescribed procedure
3.7 Check condition of all tools and equipment for conformance to specifications and safe and proper operation prior to storage
3.8 Maintain tools/equipment to ensure serviceability
3.9 Store tools/equipment in appropriate locations

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

AUVROVHYDR01

AUVROVLOGS01

AUVROVMISP01

AUVROVMODS01

Course Information for VET AUV Operator ROV Pilot

Unit AUVROVMODS01

COURSE NUMBER:	MEM18055B
COURSE TITLE:	Dismantle, replace and assemble engineering components
COURSE DESCRIPTION:	This unit covers dismantling and identifying faulty components, selecting replacements, and assembling engineering components into assemblies or sub-assemblies in accordance with standard operating procedures.
PREREQUISITES:	AUVROVCADD01-MEM09002B Interpret Technical Drawing AUVROVMECH01-MEM12023A Perform Engineering Measurements AUVROVFABS01-MEM18001C Use Hand Tools ROVWKSHOP001MEM18002B Use Power Tools/Hand Held Operations
CO-REQUISITES:	Nil
COURSE HOURS:	54

SUGGESTED TEXT: MEM 18.55A A Dismantle, replace and assemble engineering components

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. analyse engineering components and inspect task requirements.
2. select appropriate tools and equipment and prepare component/s for dismantling.
3. dismantle components using standard operating procedures, tools and equipment.
4. clearly mark engineering components to aid reassembly.
5. Obtain, interpret and understand specifications for components from appropriate sources.
6. assess damaged or faulty components against specifications according to standard operating procedures.
7. identify faulty components for repair, replacement or adjustment according to standard operating procedures.
8. select where applicable, replacement and/or repaired parts for reassembly according to standard operating procedures.
9. apply appropriate techniques in the preparation, assembly and adjustment of components using fastening equipment and methods which ensure conformance to specifications, operational performance, quality and safety of the completed assembly according to standard operating procedures.
10. select and apply correct lubrication, packing, sealing materials correctly in conformance to job specifications.
11. inspect, test and adjust final component assembly as necessary for compliance with operational specifications and returned to use according to standard

operating procedures.

MAJOR TOPICS:

1.0 Dismantle engineering components
2.0 Identify faulty components
3.0 Select replacement components
4.0 Assemble engineering components into assemblies or sub-assemblies

LEARNING OBJECTIVES:

1.0 **Dismantle engineering components**
- 1.1 Explain why tasks need to be performed in accordance with standard operating procedures.
- 1.2 Describe potential hazards and control measures in place in your shop for dismantling and assembling engineering components, including housekeeping.
- 1.3 Describe specialty tools and equipment used to dismantle components.
- 1.4 Prepare component for dismantling.
- 1.5 Dismantle components using appropriate techniques, tools and equipment.
- 1.6 Mark component parts appropriately for identification purposes.
- 1.7 Obtain and interpret all relevant instructions, standard operating procedures, drawings and specifications.

2.0 Identify faulty components
- 2.1 Describe how to check components for conformance to specifications.
- 2.2 Explain where specifications of the components can be found.
- 2.3 Check components visually and dimensionally for conformance to specification.
- 2.4 Where appropriate, mark faulty parts for repair, replacement or adjustment.

3.0 **Select replacement components**
- 3.1 Describe features and/or dimensions upon which replacement parts are to be selected.

3.2 Describe the process of identifying replacement parts from "third party" suppliers' catalogues.
3.3 Select and confirm replacement parts to specifications.
3.4 Obtain and use all relevant supplier catalogues for assemblies in your shop.

4.0 Assemble engineering components into assemblies or sub-assemblies

4.1 Describe the procedures for assembling two component assemblies in your shop.
4.2 Prepare and assemble components using appropriate techniques in accordance with standard operating procedures.
4.3 Explain why specifications, operational performance, quality and safety are important when assembling components.
4.4 Describe two procedures for lubricating component assemblies in your shop.
4.5 Where appropriate, apply lubricants correctly to the assembly in accordance with specifications and standard operating procedures.
4.6 Describe all checks to be undertaken during inspection of the final assembly.
4.7 Inspect and check the final assembly for conformance to specification.
4.8 Describe the procedures for returning components/assemblies into use.
4.9 Where appropriate, return the final assembly to use.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM18058C

COURSE TITLE: Modify electronic equipment

COURSE DESCRIPTION: This unit covers undertaking modifications to electronic system(s) including the testing and evaluating the modified system.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

1. 1.1 Determine modification requirements as understood by reference to schematics, circuit diagrams, documentation and/or consultation with appropriate authority.
2. 1.2 Analyze appropriate, maintenance reports and system output information to confirm to the need and nature of modification.
3. 1.3 Confirm the scope and nature of modifications as determined by standard operating procedures and with appropriate authority.
4. 2.1 Carry out modifications using correct and appropriate techniques, tools and procedures.
5. 2.2 Amend documentation including all reports and circuit drawing etc. using standard operating procedures.
6. 3.1 Check, test and evaluate modifications for compliance with desired outcome or specification using correct and appropriate techniques, tools and test equipment.
7. 3.2 Recommend any additional modification changes, if required using standard operating procedures.

MAJOR TOPICS:

1.0 1.0 Determine modification
2.0 2.0 Undertake modifications
3.0 3.0 Test and evaluate modified electronic systems

LEARNING OBJECTIVES:

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

AUVROVOCNG01

ROVAUBPOSS01

AUVROVPROP01

AUVROVRISK01

AUVROVSAFE01

COURSE NUMBER: MEM11011B

COURSE TITLE: Undertake manual handling

COURSE DESCRIPTION: This unit covers lifting and moving materials manually and/or using basic manual handling equipment in a wide range of environments.

PREREQUISITES: None

CO-REQUISITES: None

COURSE HOURS: 6

SUGGESTED TEXT: None

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. determine material weightcorrectly utilising most appropriate technique (scales or signage).
2. assess risks associated with lifting.
3. undertake lifting techniques to standard operating procedures individually and as a team. Types of movement, methods, storage, height and position are considered. .
4. select appropriate equipment where required.
5. place material safely and securely on moving equipment.
6. relocate material ensuring safety of personnel and security of material.
7. unload material from moving equipment and place in a safe and secure manner.

MAJOR TOPICS:

1.0 Lifting materials manually
2.0 Moving/shifting materials manually

LEARNING OBJECTIVES:

1.0 Lifting materials manually

1.1 Describe the procedure for lifting materials of various weights and sizes according to standard operating procedures
1.2 Describe the potential hazards of using incorrect handling techniques
1.3 Assess the weight of material using scales, signage and/or written or oral information
1.4 Assess the risk of manually handling the material
1.5 Demonstrate proper techniques for lifting materials of various weights and sizes both individually and as a team
1.6 Where necessary select the appropriate lifting equipment for the material

2.0 Moving/shifting materials manually

2.1 Place material safely and securely on various types of moving equipment
2.2 Relocate material ensuring safety of personnel and security of material
2.3 Unload material from moving equipment and place in a safe and secure manner

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MSAPMOHS200A

COURSE TITLE: WORK SAFELY

COURSE DESCRIPTION: On completion of this unit, the worker will be able to identify Occupational Health and Safety (OHS) hazards, and assess risk, as well as follow instructions and procedures in the workplace with minimal supervision. The worker will also be capable of participating in and contributing to OHS management issues.

PREREQUISITES: Nil

CO-REQUISITES: Nil

COURSE HOURS: 18

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: At the end of the course the student will be able to:

1. Identify hazards in the work area before and during work.
2. Assess risks for the identified hazards.
3. Identify controls for these hazards from procedures.
4. Review effectiveness of controls within the scope of authority
5. Identify and report remaining risk
6. Control risks when working under minimal supervision by following workplace procedures.
7. Select, use and maintain relevant personal protective equipment (PPE).
8. Recognise emergency situations.
9. Take appropriate initial emergency action.
10. Follow procedures for dealing with a range of emergencies

MAJOR TOPICS:

1.0 Identify hazards and assess risk.
2.0 Follow procedures for risk control.
3.0 Follow emergency procedures.
4.0 Initiate suggestions to enhance task/job-specific safety.
5.0 Apply knowledge of OHS legislation and the organization OHS policies and procedures.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

AUVROVSENS01

Course Information for VET AUV Operator ROV Pilot

Unit AUVROVSENS01

COURSE NUMBER:	MEM18062B
COURSE TITLE:	Install, maintain and calibrate instrumentation sensors, transmitters and final control elements
COURSE DESCRIPTION:	This unit covers selecting and installing appropriate sensors and signal transmitters, maintaining and diagnosing correct operation of sensors and signal transmitters, and completing fault documentation
PREREQUISITES:	AUVROVELTR01-MEM05001B Perform manual soldering/desoldering –electrical/electronic components AUVROVCADD01-MEM09002B Interpret technical drawing AUVROVELTR01-MEM12004B Perform precision electrical/electronic measurement ROVAUVMECH01-MEM12023A Perform engineering measurements AUVROVFABS01-MEM18001C Use hand tools ROVWKSHOP001-MEM18002B Use power tools/hand held operations AUVROVMODS01-MEM18055B Dismantle, replace and assemble engineering components

AUVROVELTR01-MEM18057B Maintain/service analog/digital electronic equipment

CO-REQUISITES: Nil

COURSE HOURS: Ninety (90)

SUGGESTED TEXT: MEM 18.62B Install, maintain and calibrate instrumentation sensors, transmitters and final control elements

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. Access relevant data sheets, circuit diagrams, engineering drawings, instructions, specifications, information and supplier catalogues and replacement components.
2. Select sensors, transmitters and final control elements.
3. Install and test sensors, transmitters and final control elements to specification.
4. Obtain and perform relevant scheduled/preventative maintenance schedules for sensors, transmitters and final control elements.
5. Determine correct function of sensors, transmitters and final control elements
6. Record test results.
7. Identify, localize, monitor and report/record faults in sensors, transmitters and final control elements.
8. Prepare sequential action plan to correct faults in sensors, transmitters and final control elements.
9. Apply procedures to sequential and loop testing test results.
10. Check sensors, transmitters and final control elements and marking for

replacement, repair or overhaul.

11. Repair/overhaul faulty items for fitting and /or refitting.
12. Fit/ refit sensors, transmitters and final control elements.
13. Prepare fitted/refitted sensors, transmitters and final control elements for testing and calibration.
14. Configure, calibrate, test, adjust, tune and validate system performance.

MAJOR TOPICS:

1.0 Selecting for installation appropriate sensors, transmitters and final control elements
2.0 Installing instrumentation sensors, transmitters and final control elements
3.0 Maintaining, diagnosing correctoperation of sensors, transmitters and final control elements
4.0 Completing faultdocumentation and plan corrective action
5.0 Analyzing control loopand localize faults
6.0 Repairing/replacing, overhauling sensors, transmitters and final control elements
7.0 Calibrating and testing instrumentation sensors, transmitters and final control elements
8.0 Returning sensors, transmitters and final control elements and control loops to service

LEARNING OBJECTIVES:

1.0 Selecting for installation appropriate sensors, transmitters and final control elements

1.1 Determine specification requirements from data sheets, circuit diagrams, engineering drawings

1.2 Interpret and define and knowledge of device characteristics and principles of operation, specification requirements

1.3 Select according to their device characteristics, principles of operation and measurement capabilities, in conformance to specifications measurement range, processes and environment, sensors, transmitters and final control elements

2.0 Install instrumentation sensors, transmitters & final control elements

2.1 Install sensors, transmitters and final control elements using sound working knowledge of installation principles, procedures, techniques, tools and test equipment, according to appropriate codes of practice, standards, safety and legislative requirements

2.2 Plan installation access for maintenance and mounting connections for power, signal, and process

2.3 Diagnose installed sensors, transmitters and final control elements for correct operation using appropriate test equipment and procedures. Results are assessed against specifications or manufacturers' technical data sheets

3.0 Maintaining, sensors, transmitters & final control elements

3.1 Apply preventative maintenance schedules and procedures using knowledge of device characteristics and principles of operation to maintain sensors, transmitters and final control elements in optimum condition

3.2 Clean and service sensing elements using knowledge of device characteristics and principles of operation, to maintain optimum operating condition particularly at the process interface, using correct principles, tools, test equipment, techniques and procedures

3.3 Determine correct operation or malfunction using appropriate test equipment and procedures, sensors, transmitters and final control elements which are diagnosed within the system or as individual devices

3.4 Monitor and assess against predetermined specification or manufacturers' technical data operation of sensors, transmitters and final control elements

3.5 Localize and monitor using appropriate test equipment/procedures, correct operation of sensors, transmitters and final control elements is checked or fault condition identified,

4.0 Completing fault documentation and plan corrective action

4.1 Document and report faults and malfunctions to standard operating procedures

4.2 Plan corrective action autonomously or in consultation with appropriate personnel and auctioned

5.0 Analyzing control loopandlocalize faults

5.1 Obtain and interpret engineering specifications and technical information, control device, signal transmission and final element specifications. Read and interpret system specifications, including operational data, and historical records and trends

5.2 Extract and document relevant data in consultation with system operators and other relevant plant personnel to standard operating procedures

5.3 Observe peration of the system is using sound knowledge of all external control device characteristics, controller modes, signal transmission, final control devices

5.4 Set up correct and appropriate signal transmission test equipment using appropriate technique

5.5 Test circuits and control lines to the level necessary to detect and localize fault

6.0 Repairing/replacing sensors, transmitters & final control elements

6.1 Examine and verify sensors, transmitters and final control elements for replacement, repair overhaul using correct tools/test equipment and appropriate principles, techniques and procedures

6.2 Select replacement items from manufacturers' parts lists or catalogues to meet specifications

6.3 Obtain replacement items

6.4 Repair and overhaul faulty items using correct principles, techniques, tools, test equipment and procedures

6.5 Prepare repaired, overhauled and replacement items for refitting according to standard workshop procedures

6.6 Refit sensors, transmitters and final control elements using correct principles, tools, test equipment and procedures

6.7 Prepare refitted sensors, transmitters and final control elements for testing and calibration

7.0 Calibrating and testing sensors, transmitters & final control elements

7.1 Calibrate sensors, transmitters and final control elements against appropriate physical standards using correct calibration devices, test equipment, techniques and procedures

7.2 Perform zero, span and range tests using correct calibration devices, test equipment, principles, techniques and procedures

7.3 Assess zero span and range results against manufacturers' instructions sheets

7.4 Repair and overhaul faulty items using correct principles, techniques, tools, test equipment and procedures

7.5 Apply zero, span adjustments to align sensors, transmitters and final control elements to manufacturers' instruction sheets using correct calibration equipment, principles, techniques and procedures

8.0 Returning sensors, transmitters and final control elements to service

8.1 Put into service sensors, transmitters and final control elements on conformance to specifications with due regard to process requirements, safety, installation/commissioning procedures and sequence of operation

8.2 Controller modes and actions are adjusted according to specifications

8.3 Test electrical and pneumatic transmission lines and appropriate action is taken including the use of signal conditioning devices

8.4 Apply correct procedures in returning instrumentation to service, including configuring, calibrating, adjusting, tuning and validating system performance

8.5 Return system to service in accordance with standard operating procedures

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

AUVROVSONR01

COURSE NUMBER: UEENEEH040B

COURSE TITLE: Diagnose and rectify faults in sonar apparatus and systems

COURSE DESCRIPTION: This unit covers faultfinding and the repair of faults in sonar apparatus and system. The unit encompasses safe working practices, interpreting diagrams, applying logical diagnostic methods and knowledge of sonar system components, rectifying faults, safety and functional testing and completing the necessary service documentation.

PREREQUISITES: Nil

CO-REQUISITES: Nil

COURSE HOURS: 24

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: Upon completion of this unit the student will be able to diagnose and rectify faults in sonar apparatus and systems.

MAJOR TOPICS:

1.0 Prepare to diagnose and rectify faults.
2.0 Diagnose and rectify faults.
3.0 Complete and report fault diagnosis and perform rectification activities.

LEARNING OBJECTIVES:

1.0 Prepare to diagnose and rectify faults.

1.1 Obtain and understand OHS procedures for a given work area.
1.2 Follow established OHS risk control measures in preparation for the work.
1.3 Determine the extent of faults from reports and other documentation.
1.4 Consult with appropriate personnel to ensure the work is coordinated effectively with others involved on the work site.
1.5 Obtain the tools, equipment and testing devices needed to diagnose faults.

2.0 Diagnose and rectify faults.

2.1 Follow OHS risk control measures and procedures for carrying out the work.
2.2 Isolate all circuits/machines/plant where necessary in strict accordance OHS requirements and procedures.
2.3 Apply logical diagnostic methods to diagnose sonar apparatus and system faults employing measurements and estimations of system operating parameters referenced to system operational requirements.
2.4 Test suspected fault scenarios as being the source of system problems.
2.5 Identify competency required to rectify fault and contact other sources where appropriate when it is out side the scope of electronics.
2.6 Rectify faults in the electronic components of the system to raise sonar apparatus and system to its operation standard.
2.7 Test system is tested to verify that the system operates as intended and to specified requirements.
2.8 Make decisions to deal with unexpected situations are from discussions with appropriate persons and job specifications and requirements.
2.9 Select a method for dealing with unexpected situations from a basis of safety and work outcomes.
2.10 Carry out diagnostic and rectification activities efficiently without waste of materials or damage to apparatus and the surrounding environment.

3.0 Complete and report fault diagnosis and perform rectification activities.

3.1 Make work site safe in accordance with established safety procedures.

3.2 Rectification of faults is documented in accordance with established procedures.

3.3 Record and notify appropriate people that the system faults have been rectified in accordance with established procedures.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

AUVSWDESIG01

COURSE NUMBER: UEENEEH015B

COURSE TITLE: Develop software solutions in microcontroller based systems

COURSE DESCRIPTION:

This unit covers developing, implementing and testing programming solutions in microcontroller based systems. It encompasses following development brief, using appropriate development software, writing code, applying problem solving procedures, testing and modifying of program.

PREREQUISITES: Nil

CO-REQUISITES: Nil

COURSE HOURS: 30

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: Upon completion of this unit the student will be able to develop computer code for embedded architecture ensuring key features of the programming language are used and applied to develop and test solutions. Key features may include use of registers, addressing modes, assembler instructions, subroutines and flags.

MAJOR TOPICS:

1.0 Code development preparations.
2.0 Code development.
3.0 Code testing and documentation.

LEARNING OBJECTIVES:

1. Determine the extent of code development work from performance specifications.
2. Plan activities to meet scheduled timelines.
3. Select appropriate development kit and software based on specified requirements.
4. Carry out proper implementation strategies for programming.
5. Use of correct syntax when developing code.
6. Use of key features of the programming language to develop and test solutions.
7. Use an analytical approach to provide most effective solutions.
8. Meet standards for quality of work when monitored against established organizational or professional standards.
9. Develop testing procedures to analyze code.
10. Rectify problems in code and track outstanding issues.
11. Ensure specifications are met.
12. Write intermediate and final work reports in accordance with professional standards.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

ROVAUVELEC01

COURSE NUMBER: MEM10003B

COURSE TITLE: Install and Test Electrical Wiring and Circuits up to 1000 volts a.c. and 1500 volts d.c.

COURSE DESCRIPTION: Students will cover theinstallation of electrical wiring/systems and/or enclosures, including specialist cables, using the full range of installation materials and techniques to any wiring circuits which are directly or indirectly connected to a power supply system. The scope of work includes electrical installation work and electrical equipment work.

PREREQUISITES:

09002 Interpret technical drawing
10002 Terminate and connect electrical wiring
12002 Perform electrical/electronic measurement
12023 Perform engineering measurements
18001 Use hand tools
18002 Use power tools/hand held operations
18049 Disconnect/reconnect fixed wired equipment (up to 1000 volts a.c. and 1500 volts d.c.)

CO-REQUISITES:

COURSE HOURS: 108

SUGGESTED TEXT: MEM 10.3A A Install and Test Electrical Wiring and Circuits up to 1000 volts a.c. and 1500 volts d.c

LEARNING RESOURCES:

MAJOR TOPICS:

1.0 Planning the Installation
2.0 Preparing for Electrical Installation
3.0 Installing the Wiring/Enclosures and/or Support Systems
4.0 Commissioning and Testing the Installed Wiring System
5.0 Performing Emergency First Aid

LEARNING OBJECTIVES:

1.0 Planning the installation

1.1 Plan electrical installation work and electrical equipment work utilizing a range of methods, tools and equipment appropriate to the work.
1.2 Determine special work, hazard and safety requirements.
1.3 Incorporate special work, hazard and safety requirements in the plan of installation.
1.4 Devise work plan/strategy in accordance with legislative and regulatory requirements and standard operating procedures.
1.5 Confirm work plan/strategy in accordance with legislative and regulatory requirements and standard operating procedures.

2.0 Preparing for electrical installation

2.1 Undertake all work safely and to workplace procedures, and legislative requirements.
2.2 Check materials for correct specifications.

3.0 Installing the wiring/enclosures and/or support systems

3.1 Install to specifications using correct, appropriate techniques, tools and equipment
all types of cables/conductors such as single insulated, thermoplastic insulated and sheathed, flat and circular, MIMS, steel wire armoured, flexible cords and cables, copper and aluminium, catenary systems, shielded.

3.2 Install metallic and non-metallic conduit/enclosures to specifications using correct, appropriate techniques, tools and equipment.

3.3 Install trunking, ducting, cable tray/ladder, catenarysupport systemsto specifications using correct, appropriate techniques, tools and equipment.

3.4 Mark or label cabling for identification and to specification.

4.0 Commissioning and testing the installed wiring system

4.1 Test all completed wiring/systems and enclosures for compliance with specifications, regulations, and legislative requirements, utilising appropriate test procedures and equipment.

4.2 Energize the installation for compliance with specifications, where appropriate.

4.3 Test the installation for compliance with specifications, where appropriate.

4.4 Rectify faults to specification.

4.5 Complete documentation such as including forms, short reports requiring comments etc., according to regulatory requirements and to required specifications.

5.0 Performing emergency first aid

5.1 Assess situation to identify points of danger to the injured person and potential rescuer, including the assessment of electrical hazards.

5.2 Isolate electrical hazards in accordance with established procedures for electrical rescue.

5.3 Undertake rescue/recovery of injured person, or assistance to injured person, in accordance with recognized standards/procedures.

5.4 Describe the procedure for contacting appropriate medical and rescue authorities.

5.5 Record details of first aid given.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Course Projects

RECOMMENDED EVALUATION:

Skill Assessment

Knowledge Assessment

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER:	MEM18046B
COURSE TITLE:	Fault find and or repair electrical equipment/ a nd components up to 1000 volts a.c./1500 volts d.c.
COURSE DESCRIPTION:	Studentswilllocate and rectify faults in equipment and components using up to 1000 volts a.c./1500 volts d.c. single and multi-phase power where these are disconnected from the electrical supply. This course includes basic mechanical disconnection, dismantling and re-assembly of equipment components, enclosures, drives etc.
PREREQUISITES:	09002 Interpret technical drawing 10002 Terminate and connect electrical wiring 12002 Perform electrical/electronic measurement 12023 Perform engineering measurements 18001 Use hand tools 18002 Use power tools/hand held operations
CO-REQUISITES:	
COURSE HOURS:	126
SUGGESTED TEXT:	None

LEARNING RESOURCES: Instructor supplied resources.

MAJOR TOPICS:

1.0 Locating fault
2.0 Rectifying fault(s)

LEARNING OBJECTIVES:

1.0 Locating fault

1.1 determine function of the following equipment/components by reference to circuit diagrams, schematics, manual and/or consultation with technical adviser:

1.2 Single and multi phase motor drive and heating appliances, relays, coils, transformers, thermostats, gauges, illuminating devices, switches, circuit fuses and breakers, etc. using up to 1000 volts a.c.1500 volts d.c. power supplies on non-interconnected circuits.

1.3 Brushes, armatures, windings, contactors, relays, programmable controllers or other electronic switching devices, switches, fuses, circuit breakers, relays, transformers, semi-conductor devices, regulators, and motors.

1.4 Examine built-in fault indicators and error codes to standard operating procedures.

1.5 Interpret built-in fault indicators and error codes.

1.6 Record results of built-in fault indicators and error codes, where appropriate.

1.7 Isolate equipment correctly from power supply, where required.

1.8 Check and test equipment/component using correct and appropriate techniques,such as testing for voltage, current, frequency, polarity, phase, circuit continuity, insulation resistance, and earth continuity, following standard operating procedures.

1.9 Check and test equipment/component using tools and test equipment such as continuity testers, ammeters, voltmeters, multimeters, tong testers, wattmeters, and cathode ray oscilloscopes.

1.10 Check and test results, where required, are interpreted and verified to specification.

1.11 Identify and localize equipment/component fault.

1.12 Ensure equipment/component fault/s are correctly recorded to standard operating procedures.

2.0 Rectifying fault(s)

2.1 Repair, equipment/component/s using correct and appropriate techniques, procedures, tools and equipment to specifications or manufacturers' requirements.

2.2 Replace equipment/component/s using correct and appropriate techniques, procedures, tools and equipment to specifications or manufacturers' requirements.

2.3 Adjust equipment/component equipment/component/s using correct and appropriate techniques, procedures, tools and equipment to specifications or manufacturers' requirements.

2.4 Check and test equipment/components using correct and appropriate techniques, procedures, tools and equipment for compliance with site or manufacturers' specifications.

2.5 Record rectifications report to standard operating procedures, where appropriate.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Course Projects

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER:	MEM10002B
COURSE TITLE:	Terminate and connect electrical wiring
COURSE DESCRIPTION:	This unit applies to the connection of wiring and includes termination and connection of all types of cords and cables, excluding specialist cables. All testing is undertaken on completed circuits where these are not connected to main supply, using appropriate methods such as continuity and resistance checks. Specifications are obtained from electrical/electronic circuit drawings and data sheets.
PREREQUISITES:	MEME09002B, MEME12002A, MEME18001C
CO-REQUISITES:	Nil
COURSE HOURS:	108

SUGGESTED TEXT: MEM 10.2A A Terminate and connect electrical wiring

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. undertake all work safely and to workplace procedures and State regulations and legislative requirements.
2. checked materials for correct specifications.
3. undertake or check/inspect preparation of work for correct specifications and locations such as cable trays, brackets, and trenches.
4. make terminations/connections to specifications, manufacturers' requirements and to safety and State regulations and legislative requirements.
5. adjust and fix all brackets, clamps, holders etc. to specifications.
6. mark/tag and label all cables, wires, conductors and connections etc. to specification.
7. test all completed wiring and connections for compliance with specifications.
8. complete correctly all reports and documentation to required specifications.

MAJOR TOPICS:

1.0 Prepare for electrical wiringtermination and connection
2.0 Connect electrical wiring

LEARNING OBJECTIVES:

1.0 Prepare for electrical wiringtermination and connection

1.1 Discuss safety hazards associated with the termination and connection of electrical wiring.
1.2 Describe where to find statutory and regulatory requirements associated with the termination and connection of electrical wiring.
1.3 Check materials for conformance to specifications.

1.4 Check existing and new installation site for correct location and specification.
1.5 Read and interpret routine information on written job instructions, specifications, drawings and standard operating procedures.
1.6 Discuss relevant manufacturer requirements for connecting and terminating electrical wiring and circuits.
1.7 Describe specific personal protective equipment used when terminating and connecting electrical wiring.

2.0 Connect electrical wiring

2.1 Describe the types of wiring support.
2.2 Adjust and fix wiring supports.
2.3 Discuss protection requirements and regulations under which you work.
2.4 Describe the methods for terminating different materials.
2.5 Make terminations/connections to specification, manufacturer and regulatory requirements.
2.6 Compare two wiring support techniques and discuss where each be more benficial.
2.7 Discuss marking, tagging and labelling requirements for cables, wires, conductors and connections.
2.8 Mark, tag and label cables, wires, conductors and connections to specification.
2.9 Describe techniques used to test wiring connections.
2.10 Undertake testing of wiring and connections for conformance to specification.
2.11 Use language and literacy skills to complete short reports and required documentation.
2.12 Use measurements to check connections and components.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

COURSE NUMBER:	MEM12002B
COURSE TITLE:	Perform Electrical/electronic measurement
COURSE DESCRIPTION:	This unit applies to the measurement of voltage, current, resistance, power, frequency etc. on a.c. and d.c. circuits up to 1000 volts, using appropriate measuring devices and for a range of general applications.
PREREQUISITES:	MEME13014A Apply principles of occupational health and safety in the work environment
CO-REQUISITES:	Nil
COURSE HOURS:	72
SUGGESTED TEXT:	MEM 12.2: Electrical Measuring Instruments
LEARNING RESOURCES:	Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. select appropriate device or equipment (analogue/digital multi meters, clip-on meter, oscilloscopes, potentiometers) and setting to obtain required measurement.
2. make appropriate connections to obtain required measurement according to standard operating procedure.
3. obtain, interpret readings correctly and convert, where necessary, into the required units of measurement.
4. undertake routine care such as zero and linear adjustments, inspection, checks for serviceability and safe operation and storage of devices to manufacturer's specifications or standard operating procedures.

MAJOR TOPICS:

1.0 Using electro-measuring devices to measure variables
2.0 Maintaining electro devices

LEARNING OBJECTIVES:

1.0 Using electro-measuring devices to measure variables

- 1.1 Define terminology and discuss concepts relating to electrical/electronic measurement.
- 1.2 Describe any relevant State legislative and regulatory requirements, industry standards, and code of practice necessary to safely complete required tasks.
- 1.3 Select appropriate measuring devices for specific applications within the scope of this unit.
- 1.4 Describe where to find specifications of the electro-measuring devices in your shop.
- 1.5 Locate specifications of the electro-measuring devices in your shop.
- 1.6 Describe how to apply the settings on each electro-measuring device.
- 1.7 Apply the settings on each electro-measuring device.
- 1.8 Describe the procedures for connecting electro-measuring devices to circuitry.
- 1.9 Connect electro-measuring devices to circuitry.
- 1.10 Describe situations where the scale for each setting on the electro-measuring device would be different.
- 1.11 Describe the scale factor needed to be applied to readings taken from each electro-measuring device.
- 1.12 Apply any required scale factors when using the device.
- 1.13 Describe potential hazards and control measures associated with

electrical/electronic measurement in your shop.

1.14 Demonstrate any control measures associated with electrical/electronic measurement in your shop.

1.15 Describe the appropriate personal protective equipment to be used depending on the task.

1.16 Use appropriate personal protective equipment for the task.

1.17 Read and, where necessary, interpret information on standard operating procedures.

1.18 Describe the procedures for obtaining electrical/electronic measurements with the devices in your shop.

1.19 Obtain electrical/electronic measurements with the devices in your shop.

1.20 Obtain and interpret specified electrical measurements.

1.21 Perform arithmetic operations required to convert measurements into appropriate units of measurement.

2.0 Maintaining electro devices

2.1 Describe maintenance and storage requirements for a range of electro-measuring devices.

2.2 Maintain and store electro-measuring devices to industry standard.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

ROVAUVFIBR01

COURSE NUMBER: ICTTC015C

COURSE TITLE: Locate and identify cable system faults

COURSE DESCRIPTION: This unit teaches methods to locate and identify fibre optic and cable system faults.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: Upon completion of this unit the student will be qualified to identify faults in fibre optic cables and recommend means to rectify the fault.

MAJOR TOPICS:

1.0 Identify and clarify nature of fault
2.0 Recommend means to rectify fault
3.0 Establish context and background information
4.0 Determine and rank likely causes of fault
5.0 Apply simple checks and tests
6.0 Obtain suitable tools and equipment to test fault if required
7.0 Apply fault finding methodology

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: ICTTC065C

COURSE TITLE: Splice optic fibre cable

COURSE DESCRIPTION: This unit applies to all telecommunications applications including telephony, data, video and multi media.

PREREQUISITIES:
CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: By the end of this unit the student will learn how to correctly splice, terminate and test fibre optic cables. Special emphasis will be placed on underwater applications of fibre use.

MAJOR TOPICS:

1.0 Prepare for splicing
2.0 Verify optical fibre cable placement
3.0 Secure optical fibre cable
4.0 Splice optical fibre cable

5.0 Install optical fibre termination connectors
6.0 Complete splicing operation
7.0 Complete installation administration

LEARNING OBJECTIVES:

1. Use safety equipment to protect self and public in accordance with enterprise guidelines and occupational health & safety practices.

2. Read and interpret installation plan and physical conditions at site to determine layout of job.

3. Locate and identify adjoining services in accordance with enterprise guidelines and occupational health & safety practices.

4. Test for presence of dangerous gases in accordance with enterprise guidelines.

5. Undertake approved alterations to the design in accordance with enterprise guidelines.

6. Verify that cable installation is in accordance with the installation plan.

7. Check cable visually for signs of possible sheath damage.

8. Maintain bend ratios to manufacturer's and regulation requirements.

9. Use correct securing methods to avoid damage to cable and / or sheath.

10. Verify operation of power meters and light sources before use.

11. Strip cable end to expose optical fibres in accordance with splicing method in use.

12. Handle optical fibre cable in a safe manner to avoid risk of injury.

13. Clean optical fibres by removing all coatings from fibre to remove all possible contaminants.

14. Prepare connection ends to a smooth flat surface to ensure no optical path redirection from join.

15. Splice fibres using manufacturer's tool in accordance with enterprise guidelines.

16. Test joint for signal strength to manufacturer's and design requirements.

17.Select connector to match terminating frame to design specifications.

18. Fit connector without damage to fibre or thread.

19. Fibre is affixed within connector to manufacturer's specifications.

20. Test connection for signal strength to manufacturer's and design specifications.

21. Place cables in enclosure and lay up in accordance with manufacturer's instructions and enterprise guidelines.

22. Remove waste and debris from worksite and disposed of in accordance with environmental requirements and to maintain safe worksite conditions.

23. Maintain tools in accordance enterprise guidelines.

24. Complete reports in accordance with enterprise policy.

25. Document changes by noting alterations to plans using appropriate symbols.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

ROVAUVHRAL01

COURSE NUMBER: MEM18019B

COURSE TITLE: Assist in search and rescue operations

COURSE DESCRIPTION: This unit covers undertaking preventive maintenance checks/adjustments on pneumatic systems, and fault finding, replacing, repairing or overhauling, and recommissioning pneumatic systems.

PREREQUISITES:
CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

1. Identify and prepare system components, assemblies or sub-assemblies for inspection/preventative maintenance.
2. Carry out visual inspection and testing with appropriate test equipment according to fluid power principles, procedures and safety requirements.
3. Perform scheduled preventative maintenance tasks including obvious repairs and adjustments according to manufacturers' specification using fluid power techniques/practices.
4. Identify and carry out a visual inspection of designated pneumatic system components for the collection of fault-finding data.

5. Consult the system operator where appropriate and collect additional data.
6. Check maintenance reports and preventative maintenance schedules for additional fault finding data.
7. Undertake fluid power principles, checks and tests using appropriate test equipment and techniques.
8. Identify and verify faults and malfunctions.
9. Document and report faults and malfunctions or reported to designated personnel and actioned.
10. Discharge system or sub-assembly in isolated safety and discharge residue pressure in accordance with prescribed procedures or checked for correct isolation.
11. Ensure isolated system or sub-assembly is tagged according to designated means.
12. Ensure component or sub-assembly is removed from system using correct removal principles and techniques.
13. Ensure components or sub-assemblies are dismantled, examined and verified for replacement, overhaul or repair, using correct and appropriate techniques and procedures. 3.5 Identify replacement items and select them from manufacturers' catalogues to meet specifications
14. Ensure faulty items are repaired/replaced/overhauled, using correct and appropriate principles, techniques and procedures.
15. Make sure component or sub-assembly items are refitted to equipment and tested for correct operation assessed against specifications. 4.1 System or sub-assembly is recommissioned according to prescribed procedures and specifications.
16. Verify using fluid power principles and system application techniques, that the system is working correctly.
17. Ensure appropriate follow-up procedures are instigated.
18. Update all maintenance records/service reports and ensure they are completed by appropriate designated means.

MAJOR TOPICS:

1.0 Undertake preventative maintenance checks/adjustments on pneumatic systems
2.0 Undertake fault finding on pneumatic systems
3.0 Repair and/or overhaul pneumatic power system
4.0 Recommission pneumatic system

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM18021B

COURSE TITLE: Maintain hydraulic systems

COURSE DESCRIPTION: This unit covers undertaking preventive maintenance checks/adjustments on hydraulic systems, and fault finding, repairing, rectifying or overhauling, and recommissioning hydraulic systems.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

1. Prepare system components, assemblies for inspection/preventative maintenance.
2. Carry out visual inspection and testing with appropriate test equipment using fluid power principles, procedures and safety requirements.
3. Perform scheduled preventive maintenance tasks including obvious repairs and adjustments according to manufacturers' specifications.
4. Identify designated hydraulic system components and perform a visual inspection of

the system to collect faultfinding data.
5. Consult system operator where appropriate and collect additional data.
6. Check maintenance reports and preventative maintenance schedules for additional fault finding data.
7. Perform checks and tests using fluid power principles and appropriate equipment and techniques.
8. Identify and verify faults and malfunctions.
9. Document faults and malfunctions by appropriate means.
10. Tag isolated system or sub-assembly by designated means.
11. Remove components or sub-assembly from system using correct removal principles and techniques.
12. Dismantle, examine and verify Components or sub-assemblies for replacement, overhaul or repair, using correct and appropriate techniques and procedures.
13. Select replacement items from manufacturers' catalogues to meet specifications.
14. Rectify faulty items using correct and appropriate principles, techniques and procedures.
15. Connect component or sub-assembly items to equipment and test for correct operation against specifications.
17. Investigate appropriate follow-up procedures.
18. Update maintenance records/service reports by appropriate designated means.

MAJOR TOPICS:

1.0 Undertake preventative maintenance checks/adjustments on hydraulic systems
2.0 Undertake fault finding on hydraulic systems
3.0 Repair and/or rectify hydraulic system
4.0 Recommission hydraulic system

LEARNING OBJECTIVES:

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

ROVAUVLARS01

COURSE NUMBER:	MEM18006B
COURSE TITLE:	Repair and fit engineering components
COURSE DESCRIPTION:	Thisunit covers fault finding, repairing faulty components, manufacturing new parts/components, and fitting mechanical engineering components into assemblies or sub-assemblies.
PREREQUISITES:	18001 Use hand tools 18002 Use power tools/hand held operations 18003 Use Tools for precision work 12023 Perform engineering measurements 9002 Interpret technical drawings 18055 Dismantle, replace and assemble engineering components
CO-REQUISITES:	None
COURSE HOURS:	54

SUGGESTED TEXT: Nil

LEARNING RESOURCES: Fitting and Machiningby TAFE Publications

ISBN 0 7241 3819 6

Instructor supplied handouts

MAJOR TOPICS:

1.0 Identifying scope of repair and/or fit required
2.0 Repairing/replacing faulty components
3.0 Manufacturing parts/components
4.0 Fitting engineering components into assemblies or subassemblies
5.0 Checking operation of repaired components/unit

LEARNING OBJECTIVES:

1.0 Identifying scope of repair and/or fit required

- 1.1 List possible sources of operational specifications for components.
- 1.2 Obtain operational specifications for components from appropriate source(s).
- 1.3 Interpret operational specifications for components or request, where necessary, clarification from your supervisor.
- 1.4 Discuss the purpose of using gland packing, jointing or gasket materials.
- 1.5 Discuss the importance of applying different types of lubricants and the consequences of using inappropriate or no lubricant.
- 1.6 Describe how to assess operation and condition of components against specifications.
- 1.7 Describe possible of out of specification indicators.
- 1.8 Assess operation and condition of components against specifications.
- 1.9 Identify faulty/worn components.
- 1.10 Determine causes of faults using appropriate engineering

principles, techniques, procedures, tools and equipment.

1.11 Determine repair, replacement, adjustment or manufacture requirements.

2.0 Repairing/replacing faulty components.

2.1 Where applicable, determine appropriate method of repair.

2.2 Describe possible types of adjustment of faulty components.

2.3 Select correct tools and equipment to be used to dismantle the components.

2.4 Where applicable, repair or adjust faulty components to conform to specifications.

2.5 Where applicable, selected replacement parts from manufacturers' cataloguesand assess against specifications.

3.0 Manufacturing parts/components

3.1 List possible sources of parts/component specifications.

3.2 Determined parts/component specifications from appropriate source.

3.3 Select materials to meet specification requirements.

3.4 Produce new components in conformance to specifications using appropriate workshop practices such as drilling, scraping, filing, reaming, tapping or threading.

3.5 Inspect completed components for compliance with dimensions/specifications.

3.6 Where appropriate, mark component parts for identification prior to assembly.

4.0 Fitting engineering components into assemblies or subassemblies

4.1 Determine fitting requirements and sequence of assembly.

4.2 Apply appropriate fitting principles and techniquesin the preparation and assembly of component parts using fastening equipment and methods which ensures conformance to specifications, operational performance, quality and safety.

4.3 Using acceptable engineering practices, select and apply correct gland packing, jointing/gasket materials correctly in conformance to specifications and operational requirements.

4.4 Determine correct lubrication requirements by appropriate means and attend to where applicable.

Perform final adjustments on component assembly to meet operational specifications using acceptable engineering principles, fitting techniques and procedures.

5.0 Checking operation of repaired components/unit

5.1 Check components/unit under operational conditions for compliance to operational specifications using acceptable engineering principles to standard operating procedures.

5.2 Discuss the need to have approval for out of specification modifications.

5.3 Ensure out of specification modification/alterations are approved by appropriate authority.

5.4 Discuss the need for recording and documenting out of specification modification/alterations.

5.5 Record and document out of specification modification/alterations to standard operating procedures.

5.6 Discuss applicable "return to service" procedures conducted in your work place.

5.7 Commission and return to service final component assembly according to standard operating procedures.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: TDMMR3301A

COURSE TITLE: Perform rigging and lifting operations on board a vessel

COURSE DESCRIPTION: This unit covers the proper use of ropes, knots, hitches and bends, using fiber and synthetic ropes and wire to ensure safe can correct operations aboard a vessel in support of rigging and lifting operations.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: On successful completion of the course the student will be able to:

1. Recognize the correct material to use for lashing and lifting.
2. Apply appropriate knots, hitches and bends in fiber and synthetic ropes.
3. Fabricate eye splices and short splices in fiber and synthetic rope in accordance with established nautical practice.
4. Maintain rope, wire and cables in accordance with company and manufacturer's instructions.

5. Identify and isolate and report defective lifting gear.
6. Correctly rig a load using appropriate gear according to safety procedures.
7. Ensure maximum lifting load is not exceeded.
8. Perform safety checks on lifting gear.
9. Recognize the proper use of PPE
10. State required equipment for work aloft practices
11. Use appropriate safety precautions when working aloft or over the side.
12. State and demonstrate the appropriate use of safety chairs, stages, safety harnesses in accordance with shipboard practices.
13. Effectively and safely use a portable ladder.
14. Correctly maintain all lifting and rigging gear.
15. Identify faulty lashing techniques.
16. Correctly lash cargo.

MAJOR TOPICS:

1.0 Use and maintenance of ropes and wires
2.0 Operation of lifting gear
3.0 Rigging and maintenance of access ways
4.0 Lifting and lowering considerations
5.0 Proper lashing and storage of cargo

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

ROVAUVMANT01

COURSE NUMBER: MEM18065B

COURSE TITLE: Diagnose and repair digital equipment and components

COURSE DESCRIPTION: This unit covers locating faults in digital electronic equipment or sub-assemblies and replacing faulty components.

PREREQUISITES:
CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

1. Reference equipment manuals and circuit diagrams so that the system/equipment functions and principles are determined and understood.
2. Run built-in test functions, and check fault indicators error codes and review appropriate maintenance records.
3. Using appropriate fault finding techniques reproduce and verify fault symptoms.
4. Isolate and remove faulty equipment from system, using appropriate tools and

techniques.
5. Check and test equipment using correct and appropriate test equipment and faultfinding techniques.
6. Identify faulty component/s and/or locate the fault cause.
7. Remove faulty component as required using correct and appropriate tools and techniques.
8. Repair faulty component in accordance with manufacturers' recommended procedures or to standard operating procedures.
9. Fit repaired/replacement components in accordance with manufacturers' recommended procedure or to standard operating procedures using correct and appropriate tools and techniques.
10. Check and test system equipment for correct operational compliance to specifications using correct and appropriate test procedures and equipment.

MAJOR TOPICS:

1.0 Locate fault

2.0 Repair/replace faulty components

LEARNING OBJECTIVES:

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: TDMMR2301A

COURSE TITLE: Operate and maintain batteries, starter motors and power distribution systems

COURSE DESCRIPTION: On completion of this unit the student will be able to operate and monitor electrical machinery, power distribution systems and batteries.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

On successful completion of this course the student will be able to:

1. Operate and monitor batteries, starter motors and power distribution systems in accordance with manufacturer's instructions.
2. Correctly operate and maintain shore power.
3. Identify poor performance and faults in power distribution systems using established faultfinding techniques.
4. Isolate faulty or malfunctioning batteries and starter motors.
5. Isolate faulty or malfunctioning power distribution systems.
6. Perform repairs on damaged and faulty equipment, and replace if required
7. Silence and reactive alarms as required
8. Effective coordinate repairs with established procedures
9. Keep records on the operation, testing, repair and maintenance of equipment

□

MAJOR TOPICS:

1.0 Operate and monitor electrical machinery and electronic equipment
2.0 Repair faults in electrical machinery and electronic equipment
3.0 Complete maintenance and repair documentation
4.0 Follow safety and hazard control procedures

LEARNING OBJECTIVES:

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

ROVAUVMECH01

COURSE NUMBER:	MEM07001B
COURSE TITLE:	Perform operational maintenance of machines/equipment
COURSE DESCRIPTION:	This unit covers carrying out programmed safety and maintenance checks on machines/equipment including manual, semi-automatic and automatic machines of a stand-alone continuous production or process nature.
PREREQUISITES:	MEMM13014A Apply principles of occupational health and safety in the work environment MEMM11011B Undertake Manual Handling
CO-REQUISITES:	
COURSE HOURS:	36
SUGGESTED TEXT:	Nil
LEARNING RESOURCES:	Fitting and Machiningby TAFE Publications

ISBN 0 7241 3819 6

Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. undertake programmed safety and maintenance checks to prescribed procedure
2. record status/report on proforma or report orally.
3. follow instructions and undertake removal/replacement of consumable components such as air filters, oil wipers, grease containers, tool tips, indicator globes, fluids and lubricants, guides and limit switch actuators to prescribed procedure.
4. replace and/or top up fluids and lubricants to prescribed schedule.

MAJOR TOPICS:

1.0 Programmed safety and maintenance checks
2.0 Programmed maintenance

LEARNING OBJECTIVES:

1.0 Programmed safety and maintenance checks

1.1 Explain the difference between 'programmed' and 'operational' maintenance checks

1.2 Explain the difference between 'programmed' and 'operational' safety checks

1.3 Explain why programmed maintenance checks and safety checks are necessary

1.4 Explain why operational maintenance checks and safety checks are necessary

1.5 Describe potential hazards associated with the machines/equipment in your workshop

1.6 Describe the measures used to control potential hazards in your workshop associated with machines/equipment

1.7 Describe how you record and report results of maintenance checks and safety checks in your workshop

1.8 Describe the programmed maintenance check and safety check procedures for machines in your workshop

1.9 Conduct the programmed maintenance checks and safety checks on machines in your workshop

1.10 Record and report results of programmed maintenance checks and safety checks in your workshop

2.0 Programmed maintenance

2.1 Describe examples of operational maintenance on machines/equipment in your workshop

2.2 Conduct any required operational maintenance such as replacing and or topping up comsumable components on machines/equipment in your workshop

2.3 Record and report results of operational maintenance in your workshop

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM12023A

COURSE TITLE: Perform Engineering Measurements

COURSE DESCRIPTION: Students will use a variety of measuring tools and measuring techniques appropriate and necessary to make non-precision and precision measurements in either imperial or metric standard in a range of manufacturing, engineering and related environments. It includes, where required, adjustment of measuring devices through simple means and typically includes zeroing or scale adjustment.

PREREQUISITES: MEME13014A Apply principles of occupational health and safety in the work environment

CO-REQUISITES: MEME15002

MEME12024 Practical assessment only

COURSE HOURS: 72

SUGGESTED TEXT: MEM 2.5C11: Measure with graduated devices, Commonwealth of Australia 2002

LEARNING RESOURCES: Fitting and Machiningby TAFE Publications

ISBN 0 7241 3819 6

Videos: 160102a Measurement Basics, 160102b Measuring Tools, 160102c Layout, 160102d Precision Measuring Tools, AB Apprenticeship and Training –Millwright – First Period – ISBN-07785-4321-8,

Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. determine measurement requirements from specifications of drawings, sketches, schematics, diagrams and technical manuals.
2. select appropriate device or equipment according to standard operating procedures to achieve required outcome.
3. use correct and appropriate measuring technique.
4. obtain accurate measurements such as length, squareness, flatness, angle, roundness, and clearances using analog, digital and other devices.
5. determine or verify dimensions using basiccalculations, where required.
6. undertake routine care and storage of devices to manufacturers' specifications or standard operating procedures.
7. make and check routine adjustments such as zeroing in and scale adjustment to devices.
8. record measurements accurately, where required.
9. prepare freehand sketches which depict required information, such as dimensions, base line or datum pints, as required.

MAJOR TOPICS:

1.0 Selection of appropriate device or equipment
2.0 Obtaining measurements using a range of measuring devices
3.0 Maintaining measuring devices
4.0 Communicating measurements

LEARNING OBJECTIVES:

1.0 Selection of appropriate device or equipment
- 1.1 Identify basic measuring tools used in the shop.
- 1.2 Describe terms associated with measuring such as zero line, zero error, tolerance, clearance, scale, range, variation, datums, limits, allowance and fit.
- 1.3 Convert between metric and imperial measures.
- 1.4 Convert between fractions and decimals.
- 1.5 Describe vernier instruments and their uses.
- 1.6 Describe the types of micrometers and their uses.
- 1.7 Select the correct measuring device for a given measuring task

2.0 Obtaining measurements using a range of measuring devices
- 2.1 List ways of obtaining and clarifying measurements.
- 2.2 Assess the effect of temperature change on the dimensions of various materials being measured.
- 2.3 Describe how to validate a measuring instrument by conducting "zeroing in" and scale adjustment.
- 2.4 Record measurements using the finest graduation of the following measuring devices: protractors, combination squares, set squares, dial protractors, thermometers, tape measures, rulers, micrometers and vernier scaled instruments.
- 2.5 Check measurements for conformance to specifications.

3.0 Maintaining measuring devices
- 3.1 Discuss why proper storage of measuring devices is important.
- 3.2 Maintain measuring devices according to standard operating procedures or manufacturer's specifications.

4.0 Communicating measurements
- 4.1 List ways of communicating measurements
- 4.2 Communicate accurate measurements using drawings where necessary.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM18005B

COURSE TITLE: Perform fault diagnosis, installation and removal of bearings

COURSE DESCRIPTION: This unit covers performing routine bearing checks during operations and non-operation, diagnosing bearing faults, identifying bearing requirements for replacement or installation, and removing and installing bearings.

PREREQUISITES:

9002 Interpret technical drawing

12023 Perform engineering measurements

18001 Use hand tools

18002 Use power tools/hand held operations

18003 Use tools for precision work

18006 Repair and fit engineering components

18055 Dismantle, replace and assemble engineering components

CO-REQUISITES: Nil

COURSE HOURS: 45

SUGGESTED TEXT: MEM 18.5A A Bearings – Fault diagnosis installation and removal

LEARNING RESOURCES: Instructor supplied handouts

MAJOR TOPICS:

1.0 Performing routine bearing checks during operation and non-operation
2.0 Diagnosing bearing faults
3.0 Identifying bearing requirements for replacement or installation
4.0 Removing bearings
5.0 Installing plain bearings
6.0 Installing anti-friction bearings

LEARNING OBJECTIVES:

1.0 Performing routine bearing checks during operation and non-operation

1.1 Determine task requirements and inspect bearing installation by the most appropriate means.
1.2 Check bearing installation during operation using standard procedures of listening, feeling, observing and with test equipment appropriate to the installation.
1.3 Check seal condition for seal and wear leaks using correct and appropriate means.
1.4 Check lubricating devices for correct operation using tools and techniques appropriate to the task.
1.5

2.0 Diagnosing bearing faults

2.1 Perform a visual and sensory inspection of bearing arrangement.
2.2 Test bearings for correct operation and malfunction using manufacturers' specification and diagnostic equipment appropriate to the task.
2.3 Identify faulty bearings for replacement using relevant engineering principles.
2.4 Identify causes of failure using techniques and equipment appropriate to the task.

2.5 Determine, where necessary, corrective action to avoid recurrences.

3.0 Identifying bearing requirements for replacement or installation

3.1 Inspect bearing installation and determine task requirements.

3.2 Determine operational function of bearings to be installed or replaced using bearing and engineering principles.

4.0 Removing bearings

4.1 Determine tools and bearing removal techniques for the task.

4.2 Remove bearings from shafts or bearing housings with minimal damage to components.

4.3 Inspect serviceable items using measuring and test equipment appropriate to the task.

4.4 Repair serviceable items using engineering techniques, tools and equipment appropriate to the task.

5.0 Installing plain bearings

5.1 Select standard replaceable items for plain, wrapped, flanged, split bush and thrust bearings from manufacturers' parts lists, catalogues or engineering drawings.

5.2 Select tools and installation techniques appropriate to the task.

5.3 Size bearings to correct clearance.

5.4 Ensure lubrication requirements are catered for to meet specification and/or application requirements.

5.5 Fit bearings correctly.

5.6 Tension down and run bearings according to standard operating procedures or manufacturers' recommendations.

5.7 Check final clearance, adjustments and lubrication and take corrective action if necessary.

6.0 Installing anti-friction bearings

6.1 Select standard replaceable ball and roller anti-friction bearings from manufacturers' catalogues, spare parts lists or from interpretations of engineering drawings.

6.2 Determine inside/outside bearing diameters from specifications or manufacturers' catalogue.

6.3 Check inside/outside bearing diameters using measuring instruments appropriate to the task.

6.4 Check housings size and shafts for correct fit and clearances.

6.5 Select installation techniques appropriate to the task.

6.6 Fit bearings to shafts or housing using engineering principles and tools, equipment, techniques fitted appropriate to the task.

6.7 Bearings are sealed and, where required, capped to specifications.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER:	MEM18013B
COURSE TITLE:	Perform gland packing
COURSE DESCRIPTION:	Thisunit covers inspecting glands and gland packing, and removing and replacing or topping up gland packing. The unit applies to, but is not limited to, packing for high or low temperatures and pressures, solids, gases, liquids.
PREREQUISITES:	18001 Use hand tools 12023 Perform engineering measurements
CO-REQUISITES:	None
COURSE HOURS:	36
SUGGESTED TEXT:	MEM18.13A A resource book,
LEARNING RESOURCES:	Fitting and Machiningby TAFE Publications

ISBN 0 7241 3819 6

Instructor supplied handouts

MAJOR TOPICS:

1.0 Inspecting glands and gland packing
2.0 Removing gland packing
3.0 Replacing or topping up gland packing

LEARNING OBJECTIVES:

1.0 Inspecting glands and gland packing

1.1 Describe the principles of gland packing
1.2 Describe the various types of gland packing
1.3 Discuss the reasons for selecting gland packing over other methods of sealing
1.4 Inspect stuffing box assembly and gland packing to determine job requirements

2.0 Removing gland packing

2.1 Describe the tools/equipment used to remove gland packing
2.2 Discuss the techniques used to remove gland packing
2.3 Extract or remove gland packing using appropriate engineering techniques, tools and equipment

3.0 Replacing or topping up gland packing

3.1 Select correct and appropriate gland packing to conform with application and/or specifications
3.2 Describe the methods of cutting gland packing
3.3 Cut gland packing to size and shape to conform with application and/or specifications
3.4 Fill the stuffing box with appropriate packing material such as carbon, hemp, rubber, leather, teflon, felt, and neoprene that are flat, ribbon, square, round, moulded, dry and lubricated using standard operating procedures or manufacturers' recommended procedures
3.5 Describe control measures, including housekeeping and permits, used when reassembling gland

3.6 Reassemble the gland using standard operating procedures or manufacturers' recommended procedures

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER: MEM18018C

COURSE TITLE: Maintain pneumatic system components

COURSE DESCRIPTION: This unit covers checking pneumatic system components, and identifying and repairing or replacing faulty components. Pneumatic system components are identified, inspected and assessed using fluid power principles to predetermined specifications interpreted from data sheets and circuits diagrams. Correct operational function of equipment components is confirmed and commissioned in conformance with specification, using standard operating procedures.

PREREQUISITES:

09002 Interpret technical drawing

12023 Perform engineering measurements

18001 Use hand tools

18002 Use power tools/hand held operations

18003 Use tools for precision work

18006 Repair and fit engineering components

18055 Dismantle, replace and assemble engineering components

CO-REQUISITES:

COURSE HOURS: 72

SUGGESTED TEXT: MEM 18.18A2: Pneumatic system components

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. correctly identify pneumatic system components such as static and dynamic seals, linear and semi-rotary actuators, pressure control valves, directional control valves, flow control valves, normally open and closed timers, counters, pneumatic motors, and fluid conductors.
2. demonstrate an understanding of the characteristics and operational function of each system component.
3. inspect and test the operational function of each component.
4. assess correct operation of each component against specifications.
5. localise faulty system components and confirm malfunction by inspection and testing using fluid power principles, procedures and safety requirements.
6. dismantle and repair faulty system components to manufacturers'/site specifications.
7. select replacement parts from manufacturers' catalogue according to required specifications.
8. reassemble and verify system components for correct operation and test against specifications.
9. confirm correct operation of the pneumatic system to standard operating procedures.
10. adopt appropriate follow-up procedures according to standard operating procedures.
11. complete, where appropriate, service reports using standard operating procedures.

MAJOR TOPICS:

1.0 Check pneumatic system components (as described in outcome section)

2.0 Identify, repair orreplace faulty pneumatic system components

LEARNING OBJECTIVES:

1.0 Check pneumatic system components (as described in outcome section)

- 1.1 List the individual components within the pneumatic system in your shop
- 1.2 Describe characteristics/operational function of each component
- 1.3 Explain where to find the specifications of each pneumatic system component
- 1.4 Obtain, interpret and follow written job instructions, specifications, standard operating procedures, charts, lists, drawings, relevant data sheets and other applicable reference documents
- 1.5 Plan and sequence testing operations
- 1.6 Check and clarify task-related information
- 1.7 Describe the equipment to test pneumatic system components
- 1.8 Describe the procedures for inspecting and testing pneumatic system components
- 1.9 Check individual components within the pneumatic system for correct operation
- 1.10 Inspect and test pneumatic system components to specifications

2.0 Identify, repair orreplace faulty pneumatic system components

- 2.1 Discuss potential hazard and control measures associated with maintaining pneumatic system components, including housekeeping
- 2.2 Follow safe work practices and procedures
- 2.3 Describe characteristics of faulty system components
- 2.4 Describe the potential causes of faulty pneumatic components
- 2.5 Describe the safety procedures for working on pneumatic components
- 2.6 Describe the procedure for repairing pneumatic system components
- 2.7 Select replacement parts from manufacturers'/suppliers' catalogues

2.8 Dismantle and repair faulty system components following procedures
2.9 Assemble pneumatic system components as per standard operating procedures
2.10 Describe the procedures for checking the repaired pneumatic system operation
2.11 Check repaired/replaced pneumatic system components for correct operation
2.12 Check the operation of the repaired/replaced pneumatic system for conformance to specification
2.13 Describe the reporting/recording procedures associated with identifying, repairing or replacing system components
2.14 Complete service reports, where necessary

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

ROVAUVOPER01

ROVAUVROBS01

COURSE NUMBER: MEM07039A

COURSE TITLE: Write programs for industrial robots

COURSE DESCRIPTION: This unit covers planning and writing computer programs for robot operations.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: This unit applies to the writing of programs to achieve operating specifications. Programs are in accordance with manufacturers' operating procedures, manufacturer specific language and the functional parameters of the robot.

MAJOR TOPICS:

1.0 Identify robot requirements

2.0 Plan robot program

3.0 Write basic program

4.0 Trial program

LEARNING OBJECTIVES:

1.0 Identify robot requirements

- 1.1 Identify Robot features and specifications.
- 1.2 Identify Robot language.
- 1.3 Identify Robot safety features.
- 1.4 Interpret manufacturer's operating procedures and engineering drawings to define robot function and tool path geometry.
- 1.5 Determine required operations for robot and end effectors in conjunction with appropriate technical experts or other technical reference sources.

2.0 Plan robot program

- 2.1 Identify programming requirements.
- 2.2 Calculate coordinates for tool path or robot functions.
- 2.3 Select programming method.
- 2.4 Develop program plan.

3.0 Write basic program

- 3.1 Prepare Robot and computer equipment.
- 3.2 Write program in required language and in accordance with standard operating procedures.
- 3.3 Incorporate safety features a in robot program.
- 3.4 Prepare operation sheet.

4.0 Trial program

- 4.1 Operate Robot in manual mode to test program, in conjunction with operator as appropriate.
- 4.2 Verify program performance against required specifications and with

appropriate technical experts or other technical reference sources.

4.3 Edit program if necessary to adjust operation as required.

4.4 Check components for conformance to specifications as required.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

Course Information for VET AUV Operator ROV Pilot

UnitROVAUVROBS01

COURSE NUMBER: MEM18061B

COURSE TITLE: Maintain/calibrate complex control systems

COURSE DESCRIPTION: This unit covers determining system specification and control loop characteristics, and testing, monitoring and recording system operation.

This unit applies to localizing the fault condition; repairing or replacing faulty condition; calibrating, configuring and adjusting complex control systems; and decommissioning the system.

It extends to the use of pneumatic analog and digital test and recording equipment for the calibration, configuration and testing of multiple loop control systems including pneumatic, analog electronics, distributed PLC and computer-based control systems which include supervisory mode.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES:

1. Examine engineering specifications, technical information and historical records and trends and ensure relevant data is documented.
2. Obtain read and interpret system specifications and operational data including those for multiple loop control systems and devices.
3. Obtain read and interpret Circuit and logic diagrams and configuration data
4. Carry out consultation with system operators and other relevant plant personnel and extract relevant data and documented by appropriate means.
5. Obtain appropriate work clearances are obtained for monitoring and testing the system.
6. Ensure relevant data is collected by appropriate means from all sources including maintenance records, chart recorders, data loggers, fault indicators, error codes, operational symptoms, tests and observation monitoring.
7. Identify that fault detection and diagnostic data are analysed against predetermined operational specifications, and conclusions are documented.
8. Observe system operation using knowledge of all individual/multiple element loop device characteristics, controller mode principles, testing, calibration and adjustment methods.
9. Choose and setup appropriate test equipment.
10. Carry out appropriate tests using standard operating procedures.
11. Ensure that signal transmission test equipment is set up and used where applicable.
12. Determine if any adjustment/maintenance needs are required through interpretation and analysis of pneumatic, electrical, electronic, logic diagrams and configuration data for all control system devices.
13. Connect appropriate field instrumentation to test system configuration.
14. Connect field instrumentation and test for selected control operation, and performance is monitored against specifications.
15. Carry out diagnostics checks to ensure correct operation.
16. Carry out fault finding and diagnostic using correct equipment, techniques and procedures to detect faulty control system components or elements.
17. Devise a plan to adequately test the system to the level necessary to detect and localise fault condition.
18. Localize and verify the fault condition using appropriate test equipment, principles and processes.
19. Dismantle faulty items for repair or replacement using appropriate tools, equipment and procedures according to manufacturers' recommendations.
20. Select replaceable items from manufacturers' catalogues, spare parts lists, or data sheets.
21. Follow correct maintenance procedures using manufacturers' handbooks, for faulty items.
22. Ensure faulty items and/or conditions are repaired using correct maintenance procedures and equipment.

23. Reassemble repaired and replaceable items using appropriate principles, tools, and equipment, techniques and test procedures.
24. Carry out diagnostic checks to ensure correct operation of system, taking appropriate corrective action as necessary.
25. Select the appropriate and correct calibration and test equipment to enable calibration to manufacturers' specifications.
26. Perform mechanical alignment of control devices where applicable.
27. Ensure the system is configured using appropriate programming tools and techniques.
28. Ensure relevant alignment procedures are performed for optimum control and in accordance with specifications.
29. Apply the correct sequence of alignment is used on multiple control loops and multi-element systems.
30. Make sure correct recording equipment is set up for adjustment and monitoring during alignment.
31. Perform calibration and adjustment function on multi-loop devices, multi-element control loops, controller modes and actions according to operational specifications using correct principles and methods applicable to the type of control loop being serviced.
32. Make on-line changes to parameters in the system to meet specified requirements. 5.10 Field instrumentation is connected for selected control operation and system is operated to a satisfactory level of control.
33. Undertake final adjustments to align system operation to operational specifications including process and optimum control efficiencies.
34. Apply correct procedures in return to service including configuring, calibrating, adjusting, tuning and final validation of system performance in accordance with specifications.
35. Return system to service.
36. Complete service reports to standard operating procedures.

MAJOR TOPICS:

1.0 Determine system specifications and control loop characteristics

2.0 Test, monitor and record system operation

3.0 Localize fault condition

4.0 Replace faulty items or repair faulty condition

5.0 Calibrate, configure, adjust complex control systems

6.0 Return system to service

LEARNING OBJECTIVES:

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

ROVAUVSUBC01

ROVMANIPS001

ROVWKSHOP001

COURSE NUMBER: MEM08015B

COURSE TITLE: Apply protective coatings (advanced)

COURSE DESCRIPTION: This unit applies to spraying pre-treatments and protective coatings including conventional, two pack, and plural component.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: At the end of this unit the student will be able to:

1. Determine work requirements from job sheet, instructions, drawings or visual inspection.
2. Identify required protective coating materials according to job specification.
3. Identify required protective coating system according to materials.
4. Prepare worksite for coating process.
5. Inspect surface condition for readiness for application of protective coating.
6. Identify unsuitable work surfaces and defects.
7. Mask components that do not require protective coating.
8. Identify overspray conditions
9. Assemble coating material and supplies.
10. Select PPE.
11. Follow instructions for mixing chemicals.
12. Apply a thin test coat.
13. Monitor coating application and curing process.
14. Clean equipment.
15. Store faulty equipment in accordance with policy.
16. Document the process.
17. Check pieces for tolerance.
18. Inspect work and document findings according to SOP.

MAJOR TOPICS:

1.0 Determine job requirements.

2.0 Setup equipment.

3.0 Inspect surface prior to cleaning.

4.0 Prepare surfaces using abrasive blasting.

5.0 Inspect prepared surface.

LEARNING OBJECTIVES:

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

COURSE NUMBER:	MEM18002B
COURSE TITLE:	Use Power tools/hand held operations
COURSE DESCRIPTION:	Students will develop basic hand skills that are the foundation for becoming a mechanical technician. They will complete shop projects using power hand and pedestal tools, such as drills, grinders and saws used in industrial applications. The course will help students develop knowledge and skill in tool identification, tool selection, tool maintenance and tool use.
PREREQUISITES:	MEME13014A Apply principles of occupational health and safety in the work environment
CO-REQUISITES:	MEME15024A Apply quality procedures
COURSE HOURS:	36
SUGGESTED TEXT:	MEM 18.2AA : Use Power Tools/Hand held operations,

LEARNING RESOURCES: Fitting and Machining by TAFE Publications

ISBN 0 7241 3819 6

Videos: 160105a Grinders, 160105b Power Saws, 160106a Drilling, AB Apprenticeship and Training –Millwright – First Period – ISBN-07785-4321-8

Instructor supplied handouts

COURSE AIMS/OUTCOMES:

Upon successful completion of this course, the student will be able to:

1. Identify and select appropriate power tools to complete a given task.
2. Demonstrate the correct use of power tools to complete a given task.
3. Demonstrate safe working practices when using power tools.
4. Identify, label and report power tools which are in an unsafe or faulty condition.
5. Maintain power tools, including sharpening, using correct standard operating procedures, principles and techniques.
6. Safely store power tools in appropriate locations according to standard operating procedures and manufacturer's recommendations.

MAJOR TOPICS:

1.0 Power tools identification and selection
2.0 Safe hand tools usage
3.0 Power tools maintenance
4.0 Power tools storage

LEARNING OBJECTIVES:

1.0 Power tools identification and selection

1.1 Identify power tools and parts as presented in the shop
1.2 Describe the use for which the tool is designed
1.3 Select the correct tools to mark out, shape, finish and drill.

2.0 Safe hand tools usage

2.1 Discuss the need for correct personal protective equipment in a shop environment.

2.2 Demonstrate the proper use of personal protective equipment in a shop environment.

2.3 Describe examples of, and rationale for, proper techniques and control measures when using a tool to complete a task.

2.4 Demonstrate proper techniques and control measures when using a required tool to complete a task.

2.5 Demonstrate proper techniques for the replacement of power tool attachments such as blades, bits and wheels.

3.0 Power tools maintenance

3.1 Describe standard operating procedures for reporting power tools that are identified to be unsafe or faulty.

3.2 Identify and report power tools that are in an unsafe or faulty condition.

3.3 Describe the need for routine maintenance of the power tools in the shop.

3.4 Demonstrate the correct maintenance procedures of the power tools in the shop.

4.0 Power tools Storage

4.1 Discuss the need to safely store power tools according to manufacturers' recommendations and standard operating procedures of the shop.

4.2 Demonstrate the correct and safe storage of power tools.

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

Course Information for VET AUV Operator ROV Pilot

UnitROVWKSHOP001

COURSE NUMBER: TDMMB1301A

COURSE TITLE: Carry out shipboard fabrication and repair operations

COURSE DESCRIPTION: On completion of this unit the student will be able to locate, isolate and effectively repair defective equipment using the shipboard workshop and supplied tools.

PREREQUISITES:

CO-REQUISITES:

COURSE HOURS:

SUGGESTED TEXT:

LEARNING RESOURCES: Instructor supplied handouts

COURSE AIMS/OUTCOMES: On completion of the unit the student will be able to:

1. Carry out inspections of vessel structures and components in accordance with vessel's survey requirements.
2. Investigate damaged, faulty or deteriorated structures and components in accordance with sound engineering practice.
3. Recognize and report damaged and faulty equipment
4. Take Appropriate action is taken in consultation with the responsible engineer to

prevent further damage in accordance with vessel's planned maintenance system or procedures, established marine engineering practice, safety regulations and manufacturer's instructions

5. Notify senior engineer prior to carrying out repairs.

6. Work safely with others during the manufacturing process.

7. Identify, select and use appropriate tools to effect the repair.

8. Fabricate and repair vessel structures, components and fittings are conducted in accordance with safety regulations and company procedures in consultation with the responsible engineer

9. Maintain records concerning any identified structural or component faults or deterioration and related fabrication and repair operations

MAJOR TOPICS:

1.0 Detect, identify and investigate faulty and deteriorated structures and components

2.0 Fabricate and repair faulty and deteriorated structures and components

3.0 Follow safety and hazard control procedures

4.0 Complete maintenance and repair documentation

FORMAL ASSESSMENT TOOLS:

1. Knowledge Based Tests
2. Practical exercises
3. Unit Projects
4. Holistic Projects spanning several units of competency

RECOMMENDED EVALUATION:

Skill Assessment	70%
Knowledge Assessment	30%

DATE DEVELOPED: February 2010

REVISION NUMBER: **DATE REVISED:**

Appendix C MATE KSG

Knowledge and Skill Overview Chart for Remotely-Operated Vehicle (ROV) Technicians

JOB FUNCTION	*TASK AREAS*					
A. Operate equipment	A1 Operate vehicle functions	A2 Operate cameras (video and still)	A3 Operate acoustic positioning system	A4 Operate sonar	A5 Operate manipulators (robotic arms)	A6 Operate LARS (launch and recovery systems)
B. Pilot the ROV	B1 Evaluate environmental conditions and hazards	B2 Dock/undock from TMS (tether management system)	B3 Navigate the ROV by acoustics, sonar and visual (video)			
C. Perform maintenance/ repairs on equipment	C1 Maintain/repair electronics	C2 Maintain/repair hydraulics	C3 Maintain/repair mechanics	C4 Use test equipment	C5 Calibrate and align equipment	C6 Perform general housekeeping and corrosion control
D. Maintain communications	D1 Maintain good customer relations	D2 Coordinate/ integrate with ship's crew	D3 Coordinate/ integrate with fellow crew members	D4 Write reports	D5 Maintain records	
E. Use seamanship skills	E1 Perform basic rigging	E2 Possess working knowledge of survival skills				
F. Integrate system modifications (advanced skills)	F1 Design, build, and interface electrical systems	F2 Design, build, and interface hydraulic systems	F3 Maintain technical documentation	F4 Design and construct mounting systems		

Knowledge and Skill Overview Chart for (ROV) Technicians

Critical work function A: Operate equipment

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
A1. Operate vehicle functions	• Vehicle is operated in a timely, safe, and successful manner. • Vehicle functions respond as expected. • Assigned tasks are completed in a timely, safe, and successful manner. • Customers are satisfied.	• Knowledge of vehicle systems, including deck handling equipment (LARS) and tether management systems (TMS), and their applications • Ability to operate all vehicle functions (e.g., lighting, cameras, altimeters, depth transducers, vehicle controls, auto functions, hydraulic valves) • Basic knowledge of computers • Ability to use spreadsheets, word processing, and databases • Ability to use operating systems and OEM (original equipment manufacturer) software • Ability to comprehend hardware and software manuals
A2. Operate cameras (video and still)	• Desired images are obtained. • Images are clear. • The appropriate camera is used for the desired results.	• Knowledge of and ability to operate cameras and video equipment • Knowledge of different camera types • Knowledge of video distribution systems • Knowledge of lighting and how it affects video images • Knowledge of environmental conditions (e.g., turbidity, sediment)
A3. Operate acoustic positioning system	• ROV arrives at destination in a safe and timely manner. • Customer items are positioned correctly. • ROV is tracked successfully. • Environmental parameters are measured correctly.	• Ability to operate acoustic equipment • Knowledge of and ability to apply principles of acoustic positioning • Knowledge of OEM-specific acoustic equipment • Knowledge of environmental conditions (e.g., salinity, temperature) and how to measure these parameters (e.g., using XBTs)
A4. Operate sonar	• Vehicle is deployed and recovered safely and without injury.	• Knowledge of sonar (theory and equipment) and ability to select proper settings • Ability to interpret images • Ability to locate target(s) • Ability to recognize and avoid obstacles
A5. Operate manipulators (robotic arms)	• Dock/undock is successful. • ROV arrives safely and without damage. • Telemetry is maintained during operations. • All environmental factors are considered properly.	• Ability to use manipulators and cameras • Ability to manipulate the position of the ROV • Ability to demonstrate hand-eye coordination and spatial awareness (3D interpretation of 2D images) • Knowledge of manipulator specifications and limitations • Ability to avoid collateral damage
A6. Operate LARS (launch and recovery system)	• ROV is launched and recovered successfully (without damage to ROV and/or vessel). • Safety is maintained during launch and recovery. • Environmental conditions are measured and considered properly.	• Ability to operate site-specific handling systems (e.g., winch and A-frame, knuckle boom crane) • Knowledge of and ability to implement all safety requirements

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function B: Pilot the ROV

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
B1. Evaluate environmental conditions and hazards	• ROV arrives at destination in a safe and timely manner. • Target is located correctly. • Obstacles are avoided. • Sonar is operated properly.	• Knowledge of safe operating parameters (sea state limitations, weather, currents) • Knowledge of weather and currents • Ability to interpret sea state
B2. Dock/undock from TMS (tether management system)	• Desired manipulator task is completed safely and in a timely manner. • No collateral damage is sustained.	• Knowledge of tether management system • Ability to demonstrate hand-eye coordination and spatial awareness • Ability to measure environmental conditions and react properly
B3. Navigate the ROV by acoustics, sonar and visual (video)	• ROV arrives at destination in a safe and timely manner. • Customer items are positioned correctly. • ROV is tracked successfully. • Environmental parameters are measured correctly.	• Ability to fly the ROV • Ability to demonstrate hand-eye coordination and spatial awareness • Ability to read charts and maps • Knowledge of longitude and latitude • Ability to use various mapping systems • Ability to read a compass • Ability to calculate vectors

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function C: Perform maintenance/repairs on equipment

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
C1. Maintain/repair electronics	• Electrical safety is maintained. • Electrical failures are minimized. • Electrical systems demonstrate increased reliability. • Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • Diagnostic programs are used properly. • Measurement data are accurate.	• Knowledge of basic electronics • Knowledge of electrical system safety (lockout, tagout) • Ability to inspect equipment (e.g., for corrosion, wear, damage, ground faults) • Ability to use diagnostic programs within the system • Knowledge of system layout • Ability to solder • Ability to replace faulty components
C2. Maintain/repair hydraulics	• Hydraulic safety is maintained. • Hydraulic failures are minimized. • Hydraulic systems demonstrate increased reliability. • Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • There are no environmental mishaps. • Diagnostic programs are used properly. • Measurement data are accurate.	• Knowledge of basic hydraulics and principles • Knowledge of hydraulic system safety (lockout, tagout) • Ability to inspect equipment (e.g., corrosion, wear, damage, leaks) • Ability to use diagnostic programs (e.g., flow monitors) within the system • Knowledge of system layout • Knowledge of basic physics
C3. Maintain/repair mechanics	• Mechanical safety is maintained. • Mechanical failures are minimized. • Mechanical systems demonstrate increased reliability. • Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • Diagnostic programs are used properly. • Measurement data are accurate.	• Knowledge of hydraulic system safety (lockout, tagout) • Ability to inspect equipment (e.g., corrosion, wear, damage, leaks) • Ability to use diagnostic programs (e.g., flow monitors) within the system • Knowledge of system layout • Knowledge of basic physics

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function C: Perform maintenance/repairs on equipment (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
C4. **Use test equipment**	• Test equipment is used properly to accomplish required task(s). • Tests are conducted in a safe manner. • Correct instruments are chosen for each task. • Test and measurement data are used to troubleshoot and resolve problems successfully.	• Ability to determine the proper equipment for the test • Ability to operate various test and measurement instruments (e.g., oscilloscope, megohmeter, TDR, OTDR, multimeter) in a safe manner
C5. **Calibrate and align equipment**	• Equipment and instruments function accurately within manufacturer's specifications. • Calibration and alignment procedures are followed.	• Knowledge of equipment operations • Ability to calibrate and align instruments and equipment (e.g., CTD) per manufacturer specifications and procedures
C6. **Perform general housekeeping and corrosion control**	• Work environment is neat and orderly. • Cleaning materials are used, stored, and disposed of properly. • Hazardous materials are stored and/or disposed of properly. • Equipment damage due to corrosion is minimized.	• Ability to maintain a clean and efficient work environment • Knowledge of sanitation and hygiene procedures • Knowledge of HAZMAT storage and disposal • Knowledge of galvanic corrosion, seawater chemistry and how different metals behave under different conditions

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function D: Maintain Communications

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
D1. **Maintain good customer relations**	• Information is recorded accurately and legibly. • Logs and other records are current, correct, and well-documented. • Customer is satisfied.	• Ability to communicate verbal and written information clearly • Ability to solve problems • Ability to demonstrate good customer relations skills
D2. **Coordinate/ integrate with ship's crew**	• Briefing accomplishes objective(s). • Miscommunications are minimal. • Hand signals are used properly. • Debriefing provides good, positive feedback. • Mission is successful.	• Ability to conduct a briefing/debriefing (e.g., communicate mission and clarify terminology) • Knowledge of chain of command • Knowledge of ship's procedures • Ability to use hand signals
D3. **Coordinate/ integrate with fellow crew members**	• Team goals are accomplished. • Crew performance increases/improves. • Crew is content and happy. • Mission is successful.	• Ability to focus on team goals • Ability to get along with fellow members for extended periods of time and in cramped quarters

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function D: Maintain Communications (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
D4. **Write reports**	• Records are current. • Information is recorded accurately and legibly. • Logs are current, correct, and well-documented.	• Ability to write information in a clear concise manner • Ability to format documents
D5. **Maintain records**	• Records are current. • Information is recorded accurately and legibly. • Logs are current, correct, and well-documented.	• Knowledge and ability to perform record-keeping • Knowledge of logs (e.g., pilot, maintenance, inventory, finance, video, customer)

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function E: Use seamanship skills

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
E1. **Perform basic rigging**	• Knots, gear, and rigging equipment are used properly. • Rigging is accomplished safely, correctly, and in a timely manner. • Items are moved or secured safely and without damage. • Hand signals are used properly.	• Knowledge of rigging equipment (e.g., shackles, eyes, snatch blocks, bridles, slings) • Knowledge of and ability to tie knots • Knowledge of salvage gear • Knowledge of trigonometry • Knowledge of physics • Knowledge of deck safety • Ability to use hand signals
E2. **Possess working knowledge of survival skills**	• Personal flotation devices (PFDs) and survival suits are used properly. • Life boats are accessed and used properly. • CPR/first aid certifications are current. • Environmental concerns are addressed adequately. • Overhead loads and other hazards are assessed properly.	• Ability to use PFDs and survival suits properly • Ability to use life boats • Knowledge of CPR/first aid • Ability to assess environmental conditions and react properly • Ability to be alert and look for danger at all times when on a moving and working deck

Knowledge and Skill Guidelines for (ROV) Technicians

Critical work function F: Integrate system modifications (advanced skills)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
F1. **Design, build, and interface electrical systems**	• Design and fabrication of electrical systems to meet the intent of the project. • Electrical systems are built and interfaced properly (with other peripherals or pieces of equipment). • Instrumentation works and receives proper data.	• Ability to design and fabricate electrical systems • Knowledge of protocols and ability to interchange subsystems, tools and sensors • Knowledge of analog signal data
F2. **Design, build, and interface hydraulic systems**	• Design and fabrication of hydraulic systems meet the intent of the project. • Hydraulic systems are built and interfaced properly (with other peripherals or pieces of equipment). • Circuitry is modified properly. • Operation of added equipment is successful.	• Ability to design and fabricate hydraulic systems • Ability to add components and modify circuitry as necessary • Ability to read blueprints/schematics
F3. **Maintain technical documentation**	• Documentation allows new personnel to understand changes. • Changes are communicated effectively. • Tools (e.g., CAD) are used properly.	• Ability to maintain and update technical documentation • Ability to communicate effectively, both orally and in writing • Knowledge of CAD • Ability to create and print a schematic
F4. **Design and construct mounting system**	• Test equipment is used properly to accomplish required task(s). • Design and fabrication of mounting systems meet the intent of the project. • Mounting system works. • Proper materials are used. • CAD is used properly.	• Ability to design and fabricate mounting systems • Knowledge of CAD • Knowledge of proper materials to use

Knowledge and Skill Overview Chart for Marine Technicians who Work aboard Research Vessels

Job description: Individuals who apply basic seamanship, science, computer, and engineering skills to the marine environment – including the open ocean, coastal regions, estuaries, rivers, swamps, and lakes. They may work aboard ships or other vessels, directly underwater (e.g., diving, in submarines), remotely underwater (e.g., ROVs), in a marine laboratory or onshore support facility, or in any number of other marine and coastal settings.

JOB FUNCTIONS	*TASK AREAS*					
A. **Use equipment/ instrumentation**	A1 #1 Operate equipment/ instrumentation	A2 #2 Maintain equipment/ instrumentation	A3 #5 Repair equipment/ instrumentation	A4 #10 Install equipment/ instrumentation	A5 #13 Verify equipment/ instrumentation calibration records	*A6 #19 Design and fabricate equipment/ instrumentation*
B. **Collect data**	B1 #9 Collect physical and oceanographic data	B2 #14 Collect ship's underway data	*B3 #20 Collect geo-physical data*	*B4 #23 Collect atmospheric and meteorological data*	*B5 #24 Collect biological data*	*B6 #25 Collect geochemical data*
C. **Manage and maintain computers and networks**	C1 #11 Use software programs	C2 #17 Perform system administration	*C3 #26 Perform scripting/ programming*			
D. **Direct deck operations**	D1 #3 *Maintain safety*	D2 #6 Launch and retrieve sampling equipment	D3 #8 Mobilize/de-mobilize scientific equipment	D4 #18 Store/ handle hazardous materials	*D5 #22 Operate small boats*	
E. **Perform ancillary duties**	E1 #4 Interface between scientists and crew	E2 #7 *Inventory, evaluate, and order equipment and supplies*	E3 #12 Facilitate pre- and post-cruise logistics	E4 #15 Provide training	E5 #16 Write reports and recommendations	*E6 # 21 Satellite communication/ radio communication*

The tasks in regular font were considered to be important to the majority of technicians. *The tasks in italics are important to specialized technicians.* The numbers in the upper right hand corner of each task box indicate how the technicians ranked the importance of this task.

(#1 = highest, #26 = lower, but still very important to specialized technicians)

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function A: Use equipment/instrumentation

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What marine technicians need to know and/or be able to do in order to perform this task well
A1. Operate equipment/ instrumentation	• Equipment/instrumentation is operated safely and according to guidelines. • Equipment/instrumentation obtains results that are within expected limits. • Results meet quality control standards. • Results meet expectations of principal investigator. • Data are properly collected, stored, and delivered to user in a timely manner. • Log book is current and correct. • Correct calibration standards are used.	• Knowledge of equipment specifications • Ability to operate CTDs, sonars, echo-sounders, current profilers, corers, nets, winches, air guns, GPS, telecommunications equipment, underwater cameras, XBTs, salinometers, etc. • Ability to apply computer skills • Ability to read, follow, and understand technical manuals and written procedures • Knowledge of parameters being measured, such as salinity or wind speed • Ability to recognize valid data • Ability to communicate clearly, both orally and in writing
A2. Maintain equipment/ instrumentation	• Equipment/instrumentation maintenance is performed on schedule. • Equipment/instrumentation operates with high reliability. • Equipment/instrumentation functions within specifications. • Log book is current. • Customers are satisfied.	• Ability to schedule maintenance events • Knowledge of equipment specifications • Knowledge of and ability to apply basic electronic and mechanical skills • Ability to use and care for cables and connectors • Ability to use and care for tools • Ability to read, follow, and understand technical manuals and written procedures • Knowledge of parameters being measured, such as salinity or wind speed • Ability to write clear, concise log entries

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function A: Use equipment/instrumentation (continued)

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What marine technicians need to know and/or be able to do in order to perform this task well
A3. **Repair equipment/ instrumentation**	• Relevant repairs are coordinated with manufacturer. • Lock out/tag out procedures are followed. • Log book is current. • Equipment is returned to working condition.	• Knowledge of electronic and mechanical test equipment • Ability to troubleshoot systems • Ability to use computer diagnostics • Ability to perform relevant computer, electronic, and mechanical repairs on equipment • Ability to read schematics and mechanical drawings • Ability to apply time management skills • See A1 and A2.
A4. **Install equipment/ instrumentation**	• Placement is correct and equipment is secured properly. • Equipment/instrumentation operates to required specifications. • Equipment/instrumentation meets American Bureau of Shipping, Code of Federal Regulations, OSHA, USCG, Naval INSURV, UNOLS, and RVOC Safety Standards and state and local policies. • Log book is initiated.	• Knowledge of basic wiring – what equipment draws and how to get power to it • Ability to locate and comply with relevant standards, policies, applicable laws, and regulations • Ability to interface equipment • Ability to secure equipment safely • See A3.

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function A: Use equipment/instrumentation (continued)

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What marine technicians need to know and/or be able to do in order to perform this task well
A5. **Verify equipment/ instrumentation calibration records**	• Equipment/instrumentation functions within manufacturer's specifications. • Equipment/instrumentation complies with current calibration standards. • Calibration records are complete, current, and documented. • Log book is current.	• Familiarity with calibration procedures and standards • Maintain calibration records • Ability to apply computer skills • Basic understanding of scientific notation • Knowledge of the scientific method • Knowledge of and ability to apply mathematical skills, including statistics, algebra, and geometry • Mechanical aptitude and dexterity • Ability to communicate clearly, both orally and in writing
A6. **Design and fabricate equipment/ instrumentation**	• Equipment/instrumentation meets installation requirements. • Equipment/instrumentation meets the needs of the project. • Documentation is current, proper, and understandable.	• Knowledge of current technologies available • Ability to create basic schematics and mechanical drawings • Ability to outline and communicate a given design to others in oral and written form • See A2.

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function B: Collect data

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What marine technicians need to know and/or be able to do in order to perform this task well
B1. Collect physical and oceanographic data	• Samples are collected properly. • Quality control standards are met. • Scientific sampling objectives are met. • Replicate and/or check samples agree. • Data have no gaps. • Data are stored and delivered to user in a timely manner. • Documentation is complete; log book is current and correct. • Data meet expectations of the principal investigator. • Customers are satisfied.	• Ability to operate sampling equipment • Ability to operate deck gear (e.g., winches, tuggers, A-frames) • Knowledge of basic physical oceanography, including wind and waves, salinity, acoustics, bathymetry, and ocean circulation • Knowledge of quality control procedures • Knowledge of trigonometry and geometry • Ability to write clear, concise log entries • Ability to gather required data, to the customer's satisfaction
B2. Collect ship's underway data	• Samples are collected properly. • Quality control standards are met. • Scientific sampling objectives are met. • Replicate and/or check samples agree. • Data have no gaps. • Data collected correlate with ship's position. • Data are stored and delivered to user in a timely manner. • Documentation is complete; log book is current and correct. • Data meet expectations of the principal investigator. • Customers are satisfied.	• Ability to operate sampling equipment • Ability to operate deck gear (e.g., winches, tuggers, A-frames) • Knowledge of basic physical oceanography, including wind and waves, salinity, acoustics, bathymetry, and ocean circulation • Ability to understand and use GPS • Knowledge of navigation (theory and equipment) • Ability to read charts • Ability to apply computer skills • Knowledge of quality control procedures • Ability to write clear, concise log entries • Ability to gather required data, to the customer's satisfaction

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function B: Collect data (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What marine technicians need to know and/or be able to do in order to perform this task well
B3. Collect geophysical data	• Samples are collected properly. • Quality control standards are met. • Scientific sampling objectives are met. • Replicate and/or check samples agree. • Data have no gaps. • Data are stored and delivered to user in a timely manner. • Documentation is complete; log book is current and correct. • Data meet expectations of the principal investigator. • Customers are satisfied.	• Ability to operate sampling equipment • Ability to operate deck gear (e.g., winches, tuggers, A-frames) • Knowledge of basic physical oceanography, including wind and waves, salinity, acoustics, bathymetry, and ocean circulation • Knowledge of marine geology, including bathymetry, magnetics, and gravity • Ability to use equipment such as pipe dredges, rock dredges, piston cores, box cores, air guns, seismic systems, and sound sources • Knowledge of quality control procedures • Ability to write clear, concise log entries • Ability to gather required data, to the customer's satisfaction
B4. Collect atmospheric and meteorological data	• Samples are collected properly. • Quality control standards are met. • Scientific sampling objectives are met. • Replicate and/or check samples agree. • Data have no gaps. • Data are stored and delivered to user in a timely manner. • Documentation is complete; log book is current and correct. • Data meet expectations of the principal investigator. • Customers are satisfied.	• Ability to operate sampling equipment • Ability to operate deck gear (e.g., winches, tuggers, A-frames) • Knowledge of basic physical oceanography, including wind and waves, salinity, acoustics, bathymetry, and ocean circulation • Knowledge of atmospheric and meteorological disciplines, including weather patterns, solar radiation, wind patterns, sea state, and cloud cover • Knowledge of basic math, such as trigonometry and geometry • Knowledge of quality control procedures • Ability to write clear, concise log entries • Ability to gather required data, to the customer's satisfaction

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function B: Collect data (continued)

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What marine technicians need to know and/or be able to do in order to perform this task well
B5. Collect biological data	• Scientific sampling objectives are met. • Samples are collected properly. • Quality control standards are met. • Replicate and/or check samples agree. • Data have no gaps. • Data are stored and delivered to user in a timely manner. • Documentation is complete; log book is current and correct. • Data meet expectations of the principal investigator. • Customers are satisfied. • Dive plan is followed (if appropriate).	• Ability to operate sampling equipment • Ability to operate deck gear (e.g., winches, tuggers, A-frames) • Knowledge of basic physical oceanography, including wind and waves, salinity, acoustics, bathymetry, and ocean circulation • Knowledge of biological disciplines, including basic biology, primary productivity, and marine animals • Ability to use equipment such as nets, trawls, dredges, acoustic profilers, PAR sensors, and fluorometers • Knowledge of basic lab procedures • Ability to assist with quantitative sampling and understand scientists' instructions • Knowledge of quality control procedures • Ability to write clear, concise log entries • Ability to gather required data, to the customer's satisfaction • Ability to obtain SCUBA certification at appropriate level
B6. Collect geochemical data	• Scientific sampling objectives are met. • Samples are collected properly. • Quality control standards are met. • Replicate and/or check samples agree • Data have no gaps. • Data are stored and delivered to user in a timely manner. • Documentation is complete; log book is current and correct. • Data meet expectations of the principal investigator. • Customers are satisfied.	• Ability to operate sampling equipment • Ability to operate deck gear (e.g., winches, tuggers, A-frames) • Knowledge of basic physical oceanography, including wind and waves, salinity, acoustics, bathymetry, and ocean circulation • Knowledge of geochemical disciplines, including salinity, trace metals, nutrients, gases, and oceanographic tracers (e.g., CFCs) • Knowledge of clean lab techniques • Knowledge of quality control procedures • Ability to write clear, concise log entries • Ability to gather required data, to the customer's satisfaction

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function C: Manage and maintain computers and networks

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What marine technicians need to know and/or be able to do in order to perform this task well
C1. Use software programs	• Appropriate software is selected for each task. • Desired end product is produced efficiently.	• Ability to use software such as databases, spreadsheets, word-processing, communication (e-mail), ARC-View, and Power Point • Ability to process, reduce, display, and store data
C2. Perform system administration	• System functions within specifications. • System operates with high reliability. • Maintenance is performed on schedule. • Log books are current and legible. • Multiple systems are interfaced successfully. • Scientific data are recorded, backed up, and made accessible. • Customers are satisfied.	• Knowledge of and ability to install and maintain operating systems, software, hardware, and networks • Knowledge of and ability to troubleshoot/repair operating systems, software, hardware, and networks • Ability to write clear, concise log entries • Knowledge of incremental back-up techniques • Knowledge of storage media (e.g., CD, diskette, Zip, FTP)
C3. Perform scripting/ programming	• Program performs planned tasks. • Program is well-documented. • Source code is provided.	• Knowledge of scripting languages, including PERL, C-Shell, Korne Shell, Boune Shell, Tcl/TK, and Awk/gawk/nawk • Familiarity with programming languages such as C, C++, Fortran, Visual Basic, and Lab-View • Ability to document program/source code in clear, concise language

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function D: Direct deck operations

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What marine technicians need to know and/or be able to do in order to perform this task well
D1. Maintain safety	• Safety procedures are in place and implemented. • All persons are familiar with safety procedures. • Safety briefings are well-documented. • Workers' compensation claims are minimized.	• Knowledge of and ability to implement ship's safety procedures • Ability to conduct a safety briefing
D2. Launch and retrieve sampling equipment	• Sampling equipment is launched safely and effectively. • Sampling equipment is retrieved without damage. • Sampling efforts are successful.	• Ability to operate launch and recovery equipment (e.g., pelican hooks, happy hooker ring) • Ability to manipulate winches, cranes, and frames safely • Ability to operate a forklift • Knowledge of seamanship and rigging • Knowledge of hand signals • Understanding of and ability to apply underway deck safety protocol • Ability to recognize unsafe conditions and react properly

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function D: Direct deck operations (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What marine technicians need to know and/or be able to do in order to perform this task well
D3. Mobilize/ de-mobilize scientific equipment	• Equipment arrives at/departs from destination in good working order. • Equipment is safely crane-lifted on and off vessel. • Equipment is stowed and secured properly for sea-going conditions.	• Ability to pack, secure, install, and ship equipment/instrumentation • Ability to operate winches, cranes, and frames • Ability to operate a forklift • Understanding of seamanship and rigging • Knowledge of shipboard layouts • Ability to obtain SCUBA certification at appropriate level
D4. Store/handle hazardous materials	• MSDS sheets are readily available. • Materials are properly stored, per regulations. • Materials are properly inventoried, per regulations. • Appropriate containment procedures are in effect. • Safety protocol is in place. • Spills are cleaned up quickly and properly. • Chain of custody forms is complete.	• Ability to read MSDS sheets • Knowledge of and ability to apply appropriate state, federal, institutional, and international regulations, such as DOT, OSHA, and IAT • Ability to respond to accidents • Knowledge of basic chemistry and hazardous materials • Knowledge of basic radioisotope safety, such as lab procedures and isolation
D5. Operate small boats	• Small boats are operated safely. • Assigned mission is completed satisfactorily. • Compliance with state, federal, institutional, and international regulations is maintained.	• Knowledge of and ability to apply seamanship skills • Knowledge of and ability to use outboard engines • Knowledge of and ability to use navigation tools, such as GPS and Loran • Ability to use radios, including knowledge of communication protocols • Ability to use basic survival skills • Knowledge of and ability to apply appropriate state, federal, institutional, and international regulations

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function E: Perform ancillary duties

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What marine technicians need to know and/or be able to do in order to perform this task well
E1. Interface between scientists and crew	• Communications are clear and concise. • Scientists are well-informed as to the capabilities and limitations of the vessel. • All parties are informed of plan of action, time line, and individual roles. • Crew has been briefed on scientific mission.	• Ability to communicate clearly, both orally and in writing • Knowledge of and ability to use good customer relations skills • Ability to solve problems
E2. Inventory, evaluate, and order equipment and supplies	• Adequate equipment and supplies are on hand. • Equipment and supplies are ordered in a timely manner. • Proper inventory of equipment and supplies is maintained.	• Ability to maintain an inventory of equipment and supplies • Knowledge of inventory systems • Knowledge of equipment consumption rates • Ability to locate and contact vendors and manufacturers • Knowledge of purchasing procedures • Ability to use the Internet, web browsers, and search engines • Ability to use written, oral, customer relations, and communication skills •
E3. Facilitate pre- and post-cruise logistics	• Perform operations properly, with minimal assistance and oversight. • Perform tasks correctly and efficiently. • Crew members are properly briefed. • Operations are performed with maximum safety. • Data and equipment integrity are maintained. • Necessary equipment is identified, secured, and returned after cruise.	• Ability to communicate clearly, both orally and in writing • Knowledge of shipping procedures and time lines • Knowledge of customs requirements

Knowledge and Skill Guidelines for Marine Technicians who Work aboard Research Vessels

Critical work function E: Perform ancillary duties (continued)

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What marine technicians need to know and/or be able to do in order to perform this task well
E4. Provide training	• Trainees perform tasks correctly and efficiently. • Trainees perform operations properly, with minimal assistance and oversight. • Crew members are properly briefed. • Operations are performed with maximum safety. • Data and equipment integrity are maintained.	• Knowledge of training procedures • Ability to assess trainees' skills • Knowledge of safety procedures • Ability to conduct a safety briefing • Ability to communicate clearly, both orally and in writing • Ability to maintain data and equipment in good condition
E5. Write reports and recommendations	• Complete and well-written reports are on hand when requested. • Reports are completed on time.	• Ability to communicate clearly, both orally and in writing • Knowledge of technical terms • Ability to meet deadlines
E6. Satellite communication/ radio communication	• Messages get through. • Customer billing is handled without problems.	• Knowledge of communication systems, including Inmarsat and e-mail procedures • Ability to communicate clearly, both orally and in writing • Knowledge of and ability to use good customer relations skills • Ability to solve problems

Knowledge and Skill Overview Chart for Hydrographic Survey Technicians

Job description: To assist with logistics, data acquisition, recording, imaging, and processing of various physical parameters relating to applications in the marine environment.

JOB FUNCTIONS	*TASK AREAS*							
A. **Conduct pre-cruise logistics and survey planning**	A1 Obtain required equipment	A2 Assist in vessel audit	A3 Evaluate power requirements	A4 Assist in design and layout of survey	A5 Evaluate known environmental parameters			
B. **Conduct field operations**	B1 Troubleshoot field equipment	B2 Provide survey navigation	B3 Deploy and recover equipment	B4 Establish or recover horizontal and vertical control	B5 Operate equipment	B6 Maintain field logs	B7 Maintain quality of raw data	B8 Assist with ship operations
C. **Manage data**	C1 Manage data acquisition	C2 Format data	C3 Organize files	C4 Store/back up data	C5 Process data to project specifications	C6 Contribute to cruise reports		
D. **Maintain equipment**	D1 Prepare equipment for shipment and storage	D2 Set up, maintain, and configure computer hardware and software	D3 Maintain equipment and consumables inventory	D4 Maintain equipment maintenance and calibration records	D5 Perform preventative maintenance	D6 Troubleshoot hardware and software		

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function A: Conduct pre-cruise logistics and survey planning

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
A1. Obtain required equipment	• Appropriate equipment is procured. • Equipment is ready and available for use. • Required equipment is aboard work platform in working order well in advance of survey. • Equipment is secured for at-sea conditions.	• Ability to select appropriate equipment for a specific job • Ability to check and calibrate equipment prior to shipment • Ability to prepare equipment for shipment • Ability to install and test equipment aboard survey platform • Ability to store equipment properly/secure equipment before and after use • Knowledge of methods for securing sensitive equipment for sea
A2. Assist in vessel audit	• All safety guidelines, including Coast Guard standards, are met. • Equipment is properly handled aboard ship. • Ship capacities are not exceeded. • Vessel acoustics are evaluated and considered appropriately. • Platform-specific considerations are appropriately planned for.	• Knowledge of pertinent safety guidelines • Knowledge of equipment ergonomics • Knowledge of equipment space requirements • Knowledge of berthing capacity • Knowledge of basic marine architecture and ship capacities • Knowledge of potential vessel acoustic effects on survey • Ability to select equipment appropriate to the platform at hand.
A3. Evaluate power requirements	• Power requirements for specific projects are correctly planned for and met. • Electrical power requirements are evaluated completely and correctly. • Power requirements/adjustments are coordinated with shipboard personnel. • Safety is maintained at all times.	• Knowledge of basic electricity, electronics, power systems, and wiring • Knowledge of international wiring and power standards • Knowledge of power requirements for a specific project, including knowledge of ship's power • Ability to understand instruction manuals and diagrams. • Knowledge of safety requirements (e.g., ground fault protection)

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function A: Conduct pre-cruise logistics and survey planning (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
A4. Assist in design and layout of survey	• Survey is correctly laid out. • Survey design is appropriate to the project and expected results. • Line files are correct. • CAD/GIS plots are clear, accurate, and complete. • Planning/test files are transferred among formats correctly and appropriately. • Pre-cruise charts are accurate, clear, and complete	• Ability to read nautical charts • Knowledge of geodesy • Knowledge of cartography • Knowledge of coordinate systems • Ability to communicate with customer • Ability to create a line file • Understanding of and ability to use basic CAD • Knowledge of various file formats (e.g., ASCII) and ability to transfer among formats • Knowledge of basic mathematics, including geometry, trigonometry, and geomatics • Knowledge of permits and regulatory issues; ability to acquire specific permits
A5. Evaluate known environmental parameters	• Base station is properly set up. • Environmental hazards (e.g., high seas) are assessed and planned for. • Harbor and traffic information is considered in planning. • Literature searches produce useable, relevant information (e.g., previous surveys, channel locations, acoustic information). • Expected weather conditions are researched and included in plans.	• Ability to set up a base station • Ability to assess environmental hazards • Ability to gather and analyze harbor and traffic information • Ability to analyze past survey data • Ability to perform a literature search • Knowledge of basic geomorphology

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function B: Conduct field operations

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
B1. Troubleshoot field equipment	• Equipment functions properly throughout survey. • Ready supply of back-up components is maintained on survey platform. • Time lost due to equipment outage is minimized. • Gauges and indicators are checked periodically for accuracy. • Accurate data are collected.	• Knowledge of troubleshooting techniques • Knowledge of and ability to use computer operating systems, networks, and specialized software efficiently • Knowledge of basic electronics (e.g., AC and DC circuitry, digital electronics, fiber optics) • Knowledge of basic hydraulics • Ability to contact and communicate well with technical support • Ability to integrate equipment • Ability to read schematics and instruction manuals • Ability to maintain spares inventory
B2. Provide survey navigation	• Survey navigation is delivered correctly, appropriately, and on time. • Navigation systems interface is appropriate and used correctly. • Hazards to navigation are identified.	• Knowledge of navigation systems • Understanding of ship handling • Understanding of navigation system interfaces • Knowledge of local area – local terrain (e.g., shoals, pinnacles)
B3. Deploy and recover equipment	• Equipment is appropriately handled while onboard ship. • Crane and boom operations are efficient and safe and result in no equipment damage. • All deployed sensors are recovered safely. • Cutting and welding is completed to project needs and specifications. • Safety procedures are followed and no unsafe practices or accidents result from deployment and recovery. • Survey is completed efficiently.	• Ability to use survey equipment correctly • Knowledge of crane and boom equipment, operation, and procedures • Knowledge of hand signals • Ability to use mechanical tools • Ability to cut and weld • Understanding of and ability to implement safety and health rules in accordance with permits (e.g., OSHA) • Knowledge of proper storage, packaging, and shipping procedures • Knowledge of shipboard layouts

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function B: Conduct field operations (continued)

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
B4. Establish or recover horizontal and vertical control	• Survey and GPS equipment is used correctly to obtain desired results. • Tide gauges are installed properly. • Database queries are relevant to the need and provide useful data. • Elevation is assessed properly. • Pitch, roll, and heave are compensated and filtered.	• Ability to operate GPS equipment • Knowledge of traditional land survey equipment (e.g., transits and levels) • Knowledge of geodesy/GIS • Knowledge of multiple mapping data sets • Ability to install tide gauges • Ability to perform database queries • Knowledge of and ability to use the Internet (e.g., search NOS, NIMA databases)
B5. Operate equipment	• Equipment is operated safely and according to guidelines. • Equipment performance is monitored while in operation. • Equipment is inspected frequently. • Equipment produces high quality survey data.	• Knowledge of operational characteristics of equipment • Ability to read and understand operating instructions • Knowledge of data quality assurance thresholds • Ability to assess the effects of vessel acoustics on survey data
B6. Maintain field logs	• Logs are maintained properly. • Writing is clear, complete, concise, and sequential. • Appropriate computer formats are used to maintain logs. • Computerized logs are backed up frequently.	• Ability to write clear, concise log entries • Ability to annotate records • Ability to follow accepted formats • Knowledge of and ability to use common spreadsheets and database programs

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function B: Conduct field operations (continued)

TASK	**Performance Indicators** How do we know when the task is performed well?	**Technical Knowledge and Skills** What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
B7. Maintain quality of raw data	• Prescribed procedures are followed and attention is paid to detail. • Raw data are monitored continuously; modifications are made when data stray from acceptable limits. • Appropriate data format is used.	• Ability to follow prescribed procedures • Ability to work in multiple data formats • Understanding of the intended use of data • Ability to recognize data relevant to specific job parameters • Ability to identify and take corrective action when data stray from acceptable thresholds
B8. Assist with ship operations	• Basic seamanship practices are followed. • Shipboard safety is maintained. • Small boats are employed safely and efficiently. • Appropriate responses are made to changing situations.	• Knowledge of seamanship, basic rigging, and deck equipment • Knowledge of ship safety procedures • Ability to pilot small boats • Ability to assess changes in environmental conditions

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function C: Manage data

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
C1. Manage data acquisition	• All relevant protocols and procedures are followed (e.g., bar check). • Raw data are collected according to survey plan. • Samples are processed properly	• Knowledge of data logs and protocols • Ability to monitor, back up, and archive data • Knowledge of sample handling procedures
C2. Format data	• Data are formatted according to customer specifications. • Record keeping is accurate, complete, timely, and organized. • Specialized software is used correctly and successfully.	• Ability to format data • Ability to use bookkeeping and organizational skills • Knowledge of specialized software
C3. Organize files	• Files are clearly organized and accessible. • Survey data requirements are met. • File naming convention is intuitive and documented.	• Ability to apply organizational skills • Knowledge of survey requirements • Ability to think logically • Ability to categorize • Knowledge of basic mathematics

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function C: Manage data (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
C4. Store/back-up data	• Raw data are backed up. • Compression methods are used to store data efficiently. • Storage media are properly handled and data are stored safely.	• Knowledge of storage media (e.g., CD, diskette, Zip, FTP) • Knowledge of incremental back-up techniques • Knowledge of compression programs • Ability to protect data from environmental hazards (e.g., moisture, dust)
C5. Process data to project specifications ***(May require advanced knowledge)***	• Specialized software is used properly and successfully. • Data are interpreted correctly. • Mathematical manipulation of data is completed correctly, according to customer specifications. • Processed data are verified for accuracy and completeness. • Processing errors are identified and corrected.	• Knowledge of specialized software (e.g., Promax, Isis, Caris, Winfrog, GIS, ArcInfo, Hypack, Hysweep, and Microstation) • Knowledge of mathematical/display software (e.g., Surfer, Matlab) • Basic ability to interpret data (e.g., side-scan sonar imagery, seismic reflection and refraction profiles, and bathymetry) • Ability to recognize and correct processing errors
C6. Contribute to cruise reports	• Written reports are clear, complete, timely, and well-organized. • Deviation from survey plan is explained in writing. • Lessons learned (e.g., lessons on platform- or survey site-specific issues) are documented.	• Ability to use word processing software and apply specific formatting • Ability to perform technical writing • Ability to summarize • Knowledge of specific project requirements • Ability to analyze the importance of specific events

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function D: Maintain equipment

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
D1. Prepare equipment for shipment and storage	• Equipment is properly prepared for shipment to and from job site/platform. • Equipment arrives at/departs from destination undamaged and on time. • Equipment is safely crane-lifted on and off survey platform.	• Ability to pack sensitive electronic equipment for shipment • Knowledge of shipping procedures • Knowledge of crane operations
D2. Set up, maintain, and configure computer hardware and software	• Instructions are followed. • Peripherals interface successfully with computer. • Necessary software is installed, upgraded, and uninstalled. • System back-ups are performed.	• Ability to read and understand instruction manuals • Knowledge of computer hardware and peripherals • Knowledge of Internet protocols and connectivity • Knowledge of common operating systems
D3. Maintain equipment and consumables inventory	• Inventory is maintained adequately. • Inventory systems and procedures are followed. • Consumables are ordered well in advance of reaching critical shortages. • Ordering of parts is accomplished smoothly and in a timely manner.	• Ability to maintain an inventory of consumables • Knowledge of inventory systems • Knowledge of procurement systems/procedures • Knowledge of equipment consumption rates • Knowledge of part nomenclature

Knowledge and Skill Guidelines for Hydrographic Survey Technicians

Critical work function D: Maintain equipment (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What hydrographic survey technicians need to know and/or be able to do in order to perform this task well
D4. Maintain equipment maintenance and calibration records	• All logs are completed appropriately. • Routine maintenance and calibration is performed on time. • Inoperable equipment is properly tagged and scheduled/shipped for repair.	• Knowledge of equipment and calibration logs • Ability to follow prescribed procedures • Ability to pay attention to detail • Knowledge of basic mathematics • Ability to convert units of measure • Ability to schedule maintenance and calibration events
D5. Perform preventative maintenance	• Routine preventative maintenance procedures are followed, developed, and refined. • Equipment is maintained in working condition. • Equipment is maintained to the maximum life span. • Potential malfunctions are identified prior to failure. • Time lost due to inoperable hardware is minimized.	• Ability to follow detailed directions • Knowledge of electronic hardware, tools, and maintenance methods • Ability to identify signs of wear and misuse • Ability to complete complex, scheduled tasks
D6. Troubleshoot hardware and software	• Problems with hardware and software are isolated for repair in a timely manner. • Malfunctioning hardware is shipped for repair when necessary. • Repair solutions with external vendors are sought. • Data loss is minimized. • Steps are taken to salvage important data when problems arise. • Technical support personnel are consulted for software solutions. • Maintenance agreements are updated and replaced when necessary.	• Knowledge of hardware and software troubleshooting techniques • Knowledge of common operating systems • Knowledge of computer components and peripherals • Ability to work with external vendors/technical support • Knowledge of basic electronics • Knowledge of electrical safety procedures • Knowledge of shipping procedures for electronic equipment