immerse

Subsea Technology:
The challenge of working below the oceans

Western Australian Museum – Maritime TEG 2011

Exhibition Brief

Report — Department of Maritime Archaeology, Western Australian Museum No. 262
2011

CONTENTS

1. EXHIBITION SUMMARY

People have been pioneering ways in which to explore and ultimately utilise the resources found on and below the sea-bed. Helmet and corselet or 'hard-hat' diving was introduced to the Shark Bay pearling industry in the 1860s and since then Western Australians have been at the forefront of subsea technological innovation. There are many uses of technology underwater, many of which relate to the oil and gas sector. It is also emphasised that the technologies and skill sets developed here can be utilised in other industries as well as for specific scientific endeavours; from the searching for historically significant shipwrecks such as HMAS *Sydney*, investigating the flora and fauna of the world's oceans, to finding a renewable source of energy offshore. This exhibition serves to showcase the clever ways in which humans work underwater and the technology they have designed which allows them to do so.

This would be the first Australian exhibition to publicly showcase the subsea industry. It provides a unique opportunity to tell for the first time, the story of Western Australian marine utilisation. The exhibition aims to inspire young people to continue technical and marine-related subjects in education, including consideration of a career in subsea technology; to raise community awareness by platforming the technology used within the industry with a focus on Western Australian innovations and contexts; and provide a historical overview. There is a very low level of community awareness about the world-class subsea technologies that are developed for, or deployed off our coastline, or the workings of the offshore energy and petroleum industry.

The proposed key themes for the exhibit include:

- The underwater world
- Working and living in an underwater environment
- Underwater robots
- Ping: Acoustic technology for discovering the seafloor
- Below the Seabed: The story of oil and gas exploration and utilisation
- Sustainability and the future
- Careers in underwater technology

The opening date is scheduled for 27 October 2011. Following the initial display (from 6-12 months) at the Western Australian Museum—Maritime (WAM) at Victoria Quay, Fremantle, it is anticipated that a number of modules will be toured intra-state and nationally. Suggested locations include WA Museum, Geraldton, WA Museum, Albany, Karratha and Broome Visitor Centres, National Maritime Museum, Darling Harbour, National Museum of Australia, Canberra, Museum Victoria's Science Works, Melbourne. It is anticipated that this exhibit while at the Fremantle site will be free entry.

2. EXHIBITION OBJECTIVES

- To create a ‘cutting edge’ interactive temporary exhibit. This includes highlighting work undertaken by industry as well as academia (including WAM) in subsea technology and related fields. There are no pure or applied science displays at any of the WAM sites;
- To change the public perception of WAM—Maritime as a venue for static, past-focused exhibits. To date, WAM has specialised in natural and social history themes;
- Achieve credibility with stakeholder and sponsors as a competitive and relevant exhibition venue;
- To be in step with current political, social and scientific research issues;
- To provide a safe forum for contentious ideas;
- To raise the profile of Western Australia as an innovative state;
- To encourage repeat and new visitation to the WAM—Maritime sites;
- To contribute to the refurbishment of WAM—Maritime. It is anticipated that parts of this exhibit can be retro-fitted into the long-term display (for example, the story of finding HMAS *Sydney* can be included in the Naval Gallery at Victoria Quay).

3. EXHIBITION BACKGROUND

This exhibition concept was first raised between members of the Society of Underwater (SUT) Perth Branch. A project sub-committee was then formed in February, 2009. In the early stages of discussion, the exhibit ideas revolved around an interactive display targeted for children. The themes discussed by the sub-committee soon proved much wider and the Western Australian Museum was considered a more appropriate venue. Similarly, the role of WAM, with the finding of HMAS *Sydney* and the wish to have this data on public display, led to the request for collaboration. The initial focal points for this display were:

1. An HMAS *Sydney* Interactive Display using C3D & C4D Seabed Visualisation-courtesy DOF Subsea and Finding Sydney Foundation.
2. A working observation-class ROV in a purpose-built tank.

A Memorandum of Understanding was entered into by the WAM and the SUT in January 2010 for the development of a temporary exhibition (working title: Subsea technology: the challenge of working below) for the Travelling Exhibition Gallery (TEG), WA Museum–Maritime at Victoria Quay, Fremantle. This set out a scope of works and responsibilities entered into by both parties for the concept development, of which this brief, is the first obligation.

4. STORYLINE

4.1. NARRATIVE AND DISPLAY VISION

Immerse seeks to plunge the visitor into an alien environment and experience what it is like to work, and at times live, below the ocean. The description of technology used to explore and make use of resources below the seabed is brought to life by recreating the underwater environment itself. *Immerse* aims to be contemporary and 'cutting edge' in not only content, but with the mediums chosen for display. The manipulation of sound, light and space combined with the use of state-of-the-art audiovisual equipment will transport the visitor offshore and then down to the sea-bed. The entrance to the Temporary Exhibition Gallery from the Museum foyer will act as a portal, transferring the visitor to a virtual offshore working Diver Support Vessel (DSV). Sounds of their arrival helicopter fill this space as they look down at the giant 'H' of the helipad they now stand on. They are greeted by offshore diver, 'Jim', who will serve as their guide throughout the exhibition (Jim is displayed as a motion-sensor activated hologram or televised on plasma screens—for more detail refer to Section 10.2). The exhibit is broken up into modules (described in detail below) and linked by our guiding character 'Jim', who describes his work as well as his interests, such as shipwrecks and marine life, at strategic points in the exhibit. The exhibit may be arranged physically in the form of a 'hub and spokes', with each module forming a loop off the deck of the vessel. The other primary link in the exhibit is the recreation of a gas pipeline which snakes it's way though, and is interpreted in each of the various modules. The pipeline will be installed at different heights in the gallery to demonstrate that the sea-bed is neither flat nor uniform. This positioning of the pipeline will also allow the display of a number of subsea tools, which perform various functions on pipelines. The size of some of the objects on display (actual and replica) will be overwhelming—a sensation which will be capitalised on in order to convey the feats of engineering required in subsea technology. The centrepiece of the display is a working observation class ROV in a purpose-built tank and an ROV simulator. The gallery will be a dark and watery world in which the visitor can soon learn to explore, with the assistance of the subsea technology on display.

4.2. THEMATIC MODULES

A) The underwater world

This theme introduces basic oceanographic principles and an historical summary of undersea exploration. It will provide context and background information prior to the introduction of specific examples of subsea technology. It is anticipated that the medium for display in this area will be text and image based, including AV. There is also an option to use models in the explanation of physical processes.

<u>Module 1: Oceanography (underwater environment and oceanographic processes)</u>

The ocean environment, as the setting for the subsea equipment will be introduced at the beginning of the exhibit. Basic definitions of oceanographic processes will be explained including atmospheric circulation, currents, wind patterns, wave and sediment processes. The ocean bottom and its geological context including the continental shelf, the continental slope, and the deep ocean basin will be introduced. The module is primarily descriptive and will focus on interesting and lesser-known facts about the ocean environment. While the objective is to provide context for the exhibition, it is also an opportunity to amaze visitors about the 'underwater world'. For example: Did you know that the Earth's longest mountain range is underwater? The Mid-Ocean Ridge system comprising hundreds of active volcanoes that occupy the floor of a rift valley with 1,000 metre high cliffs on either side. Technological developments have been an imperative part of our exploration of this unique environment.[1]

In particular this module will convey a sense of how deep the waters off our continental shelf are, and how rough the ocean gets during tropical cyclones which thrash our north-western coast.

This module is anticipated to include physical exhibits and explanations of oceanographic research, emphasising the role of the Australian Integrated Marine Observing System (funded by the Commonwealth Government with some support from State Governments), of which the West Australian Integrated Marine Observation System (WAIMOS) is a node. This program is monitoring our boundary currents and our shelf waters for changes in their physical (temperature, salinity, currents), chemical (nutrients) and biological (plankton, top predators) characteristics. This is achieved by using state-of-the-art technology such as ocean gliders, moorings, floats, and satellite imagery, integrated with high resolution models of Australia's oceans.[2]

Module 2: Western Australian Museum: Understanding the ocean and safeguarding this shared resource

WAM has been involved in a number of marine biodiversity projects, from taxonomic surveys in the shallow coastal environs to exploration of deep-sea hydrothermal vents for signs of life. WAM in conjunction with other academic institutions and industry have explored much of offshore Western Australia and made a number of exciting species discoveries, many of which are endemic to WA only:

1. WAM Kimberley Woodside Collection project: The project explores the marine biodiversity of the inshore Kimberley and associated continental shelf coral atolls from both a desktop analyses of historic collections and newly acquired data from project fieldwork undertaken in 2009 and 2010.
2. WAM Southwest Deepwater Survey (in conjunction with CSIRO, Museum of Victoria, Queensland Museum, Museum and Art Gallery of NT, Australian Museum).

[1] Macdonald, K., 2010, Exploring The Global Mid-Ocean Ridge: A Quarter-Century of Discovery *Oceanus* Magazine Woods Hole Institution http://www.whoi.edu/oceanus/viewArticle.do?id=2512&archives=true accessed 17/05/10

[2] Pattiaratchi, C., 2009, Integrated Marine Observing System (IMOS) in *Western Australia in Monitoring for Action: Understanding Western Australia's changing marine and coastal environments symposium abstracts.* 24 November 2009. WAMSI

Recognising that no single organisation has the capacity to undertake high cost, large-scale marine research programs, the Western Australian Marine Science Institution (WAMSI) is a collaboration of sixteen State federal, industry and academic organisations working together to provide independent marine research, Through WAMSI, marine scientists, specialist project teams and cutting edge technology unite to undertake research in climate change, marine life, ocean geology, weather patterns, storms, large-scale ocean movements, fishing, coral reefs, medical compounds, biodiversity and social issues.

Module 3: Underwater physics (including principles for working at depth and diving physiology)

The effects of diving on the human body are caused by the operation of certain physical laws, in particular the physical properties possessed by liquids and gases. The human body under water is operating in a completely different environment, in which it is exposed to much greater pressures than it experiences at the surface. Historical and personal connections will be drawn by highlighting the discovery of the causes of 'caisson disease' by Haldane after the building of the Eads and Brooklyn Bridges in the US, and the 'bends' experienced by early pearl divers. Key concepts include definitions of force, pressure and density; explanation of gas and buoyancy laws, physical properties of light and sound underwater.

Module 4: Biological phenomena of the sea

This module will provide an introduction to marine biology, illustrated with specimens from WAM's aquatic zoology collection. This information will link to later modules that describe equipment used to monitor marine life or alternatively equipment and situations offshore that may be adversely impacted by the sea's inhabitants. ROV captured footage collected from Australia and overseas showing a range of unusual marine animals and their encounters with deep sea infrastructure will also be displayed. Key concepts include: definition and description of benthic communities, requirements for biological communities, biological productivity and biomass.

Module 5: History of why people went underwater (utilisation of resources, scientific curiosity).

This module will be a summary of the first human encounters with the sea-bed and the equipment designed to assist in these early endeavours. Beginning with the prophetic imaginings of Jules Verne for the crew of the *Nautilus* with their *aérophores* (air-carriers), this module will look at specific equipment designed for sampling and exploring the sea-bed prior to the present era. This will include a display of the first type of instruments and methods used to investigate the sea bottom including sounding weights deployed from ships; the process of creating the first bathymetric chart by the U.S. Navy (Maury 1858);[3] the results of the HMS *Challenger* expedition (1872-1876) which is credited with providing the first real view of

[3] Maury, M.F., 1859, *The Physical Geography of the Sea*. Sampson Low, Son, and Co., London.

major seafloor features such as the deep ocean basins. Early diving experiences in Australia will also be featured, such as pearl diving and salvage.

B) Working and living in an underwater environment

This theme introduces the visitor to examples of equipment designed to sustain life and enable humans to work at depth. The subject will be explored using a linear/chronological progression of various types of diving equipment used both overseas and in Australia.

Module 1: Diving technology

This module, illustrated with text and objects functions as a time-line progression of manned diving equipment. Beginning with an overview of the initial ideas and inventions presented by Aristotle and Da Vinci as well as examples of the first diving suits (used to salvage the wreck of the *Royal George* in the United Kingdom in 1783), this module focuses on the invention and utilisation of 'open dress' and self contained underwater breathing equipment (SCUBA) (Siebe, 1819; Lemaire d'Augerville, 1820; James, 1825; Siebe, 1837; Rouquayrol & Denayrouze, 1865; Davis & Fleuss, 1902; Le Prieur, 1925; Commeinhes, 1939; Cousteau & Gagnan, 1943).[4]

Module 2: Australia's 'Father of SCUBA'

While Jacques Cousteau is credited with the invention of SCUBA, Australian engineer Ted Eldred was the inventor of the single hose regulator used by divers today.[5] The Eldred invention, named the 'Porpoise', first appeared on the market in 1952 after four years of development in workshops in North Melbourne and Fitzroy, in Victoria. It proved to be more efficient than the twin-hose regulator, known as the Aqua-Lung, and was chosen as the standard diving equipment for the Royal Australian Navy a year later. This achievement is not well known as, after struggling to raise capital to afford a patent, Eldred and his partner sold their company to French firm Air Liquide, which owned the patent to Aqua-Lung.
This module will focus on the little-known Australian contributions to diving technology. It will be primarily object based with accompanying text.

Module 3: Commercial diving

This module focuses specifically on commercial diving. Following the introduction of the 'hard-hat' and later SCUBA, the development of related equipment was either for the commercial or recreational market. The zenith of commercial diving equipment is the atmospheric diving suit (ADS). These self-contained, articulated suits maintain an internal pressure of one atmosphere, removing the need for the diver to decompress. The pioneer models Campos (1949), Tritonia (1935) were superseded by the JIM™ suit

[4] Norton, T., 1999, *Stars Beneath the Sea*. Century, London.

[5] Maynard, J., 2002, *Divers in Time: Australia's Untold History*. Glenmore Productions, Yarraville, Victoria.

(1970), NEWTSUIT™ (1986) and most recently the HARDSUIT™ (1996-present). They are used for oil-field platform structural repairs and a variety of search and recovery operations.[6]

The beginnings of commercial diving can be traced to the shipwreck salvage ventures of divers in the United Kingdom. The transfer of this technology was achieved through a combination of entrepreneurial copying, dispersion through Royal Navy dockyards and vessels throughout the British Empire, sale of equipment and the emigration of divers themselves. Marine civil engineering, and the maritime operations of two World Wars also contributed to growth of the commercial diving market.[7]

In the Australian context, this section will look at commercial diving's early development in the pearling industry,[8] North-west shelf and even inland, when standard diving dress was used to rescue an 'entombed miner' from the partially flooded Westralia Mine in Bonnievale, near Coolgardie in Western Australia, in 1907.[9]

Text panels and displays of diving equipment will be supplemented with AV comprising the colourful oral histories of commercial diving, from the divers themselves.

Module 4: Saturation diving and underwater habitats

'Saturation' diving combined with a pressurised 'habitat' on the sea-bed is a technique to allow people to live and work at depths greater than 50 metres for extended periods of time. In 1934, American oceanographer Charles William Beebe and engineer Otis Barton were lowered to about 1,000 metres in a round steel chamber called a 'bathysphere', which was attached to a ship by a long cable. During the dive, Beebe peered out of a porthole and reported his observations by telephone to a colleague.[10]

Experiments were carried out by Jacques Cousteau with his 'Conshelf' underwater habitat[11] and then in collaboration with the Experimental Diving

---

[6] http://www.oceanworks.com/hsCommercial.php accessed 17/05/10.

[7] Bevan, J., 2009, *Another Whitstable Trade: An Illustrated History of Helmet Diving.* SUBMEX Ltd, Gosport.

[8] McCarthy M. 1995, Before Broome. *The Great Circle*, Journal of the Australian Association for Maritime History. 16(2):76-89.

Bailey, J., 2001, *The White Divers of Broome: The True Story of a Fatal Experiment*. Pan McMillan, Sydney.

[9] Austen, T., 1987, *The Entombed Miner*. St George Books, Perth.

[10] Davis, R.H., 1955, *Deep Diving and Submarine Operations: A Manual for Deep Sea Divers and Compressed Air Workers*. Siebe, Gorman Co. Ltd., London.

The Official William Beebe Web Site http://sites.google.com/site/cwilliambeebe/Home/bathysphere accessed 17/05/10.

http://science.jrank.org/pages/7100/Underwater-Exploration.html accessed 17/05/10.

[11] Cousteau, J., 1975,. *The Ocean World of Jacques Cousteau: Man Re-enters the Sea*. Angus & Robertson, London.

http://www.cousteau.org/technology/conshelf accessed 17/05/10.

Unit, lead by George Bond of the US Navy Submarine Medical Centre which resulted in the Sealab I, II and III underwater habitat projects from 1964-69[12]. Today saturation chambers are deployed and tended by a Dive Support Vessels (DSV). The saturation or 'SAT' system is divided into a rest area, the transfer chamber and the dry bell. The divers and all three areas of the SAT system are pressurized down to the depth they will be working from.[13]
The focus for this module is a replica 'habitat' which visitors can climb inside to experience what conditions are like for saturation divers. Indicative objects for this module include a two-man wet bell (WAM accession) and a one-man recompression chamber.

C) Underwater robots

This theme explores the latest Remotely Operated Vehicle (ROV) and Autonomous Underwater Vehicle (AUV) technology used in Australia. The centrepieces will be an observation class ROV in a purpose-built tank (specific funding/sponsorship required) and ROV simulator- interactive which allows visitors to 'fly' a virtual ROV. The objects and interactives will be supplemented with text and audiovisual displays.

Module 1: The development and deployment of the ROV

An ROV is an underwater robot which is linked to a ship by a tether (sometimes referred to as an umbilical cable), a group of cables that carry electrical power, video and data signals back and forth between the operator and the vehicle. Most ROVs are equipped with at least a video camera and lights. Additional equipment is commonly added to expand the vehicle's capabilities. These may include sonar's, magnetometers, a still camera, a manipulator or cutting arm, water samplers, and instruments that measure water clarity, light penetration and temperature. The US Navy funded most of the early ROV technology development in the 1960s. This created the capability to perform deep-sea rescue operations and recover objects from the ocean floor. Building on this technology base, the offshore oil & gas industry created the work class ROVs to assist in the development of offshore oil fields. The precursors of the modern ROV were the programmed Underwater vehicle (PUV) developed by Luppis-Whitehead Automobile in Austria in 1864 and the the first tethered ROV, named POODLE, was developed by Dimitri Rebikoff in 1953.[14] The United States Navy is credited with advancing the technology to an operational state in its quest to develop robots to recover underwater ordnance lost during at-sea tests. ROVs gained in fame when US Navy CURV (Cable Controlled Underwater Recovery Vehicle) systems recovered an atomic bomb lost off Palomares, Spain in an aircraft accident in 1966, and then saved the pilots of a sunken submersible *Pisces* off Cork, Ireland, in 1973. The next step in advancing the technology was performed by commercial firms that saw the future in ROV support of offshore oil

[12] http://www.divingheritage.com/saturationkern.htm accessed 17/05/10.

[13] Barsky, S. & Christensen, R., 2004, *The Simple Guide to Commercial Diving*. Ojai Printing, California.

http://www.divinglore.com/Commercial_Diving_Equipment.htm accessed 17/05/10.

[14] Christ, R. & Wernli, R., 2007, *The ROV Manual: A user guide for observation class remotely operated vehicles*. Elsevier, Burlington.

operations. Two of the first ROVs developed for offshore work were the RCV-225 and the RCV-150 (featured in this exhibition) developed by HydroProducts in the U.S. Many other firms developed a similar line of small inspection vehicles. Today, as oil exploration migrates into deeper and deeper waters, ROVs have become an essential part of the operations and have become not only capable, but highly reliable.[15]

Module 2: Autonomous Underwater Vehicles
The use of Autonomous Underwater Vehicles (AUVs) in various research, commercial and military applications has significantly increased in the recent years. Scientific exploration of the sea has traditionally been performed by submersibles, towed vehicles and ROVs. AUVs have begun to replace these vehicles and complement the capabilities of existing systems, especially deepwater. The AUV can undertake several tasks and carry a variety of equipment, such as sonars, cameras and chemical sensors. The AUV excels at surveys of the shape of the seafloor (bathymetry), sonar mapping, mapping of chemical signatures, and magnetic properties.[16] This module will showcase this new technological field of subsea exploration.

D) PING —Acoustic technology for discovering the seafloor

This theme will examine the use of acoustics to map and measure the sea floor. SONAR or 'sound navigation ranging' is a technique that uses sound propagation through water, to image and measure objects on the sea floor. The term also refers to the instrument which sends out an acoustic pulse in water and measures distances in terms of the time for the echo of the pulse to return. The French physicist Dominique Francois Jean Arago first proposed the concept of using sound to determine the depth of a lake or ocean in 1807.[17] The quest to develop sonar devices was inspired by maritime disasters including the loss of the *Titanic*—the world's first patent for an underwater echo ranging device was filed by English meteorologist Lewis Richardson a month after the sinking.[18] This theme will focus on the use of sonar and related technologies to find and record cultural and natural features on or below the sea-bed. The focus of this theme will be the HMAS *Sydney* display.

Module 1: Acoustic tools (principles and equipment including Side Scan Sonar, Multi-beam, USBL and LBL Positioning systems)
This module will introduce the types of equipment used for mapping and 'prospecting' the sea floor. The textual information will include a basic introduction to marine acoustics and magnetometry.

---

[15] http://www.rov.org/educational/pages/history.html accessed 24/05/10.

[16] Yoerger, D., Jakuba, M. & Bradley, A., 2007, Techniques for Deep Sea Near Bottom Survey Using an Autonomous Underwater Vehicle *Springer Tracts in Advanced Robotics*. Springer Berlin / Heidelberg.

[17] http://www.history.noaa.gov/stories_tales/poletobeam2.html accessed 24/05/10.

[18] Hill, M. N., 1962, *Physical Oceanography*. Allan R. Robinson. Harvard University Press.

Module 2: *Gefechtsbericht*— The finding of HMAS *Sydney* and HSK *Kormoran*

The German account of the engagement between HMAS *Sydney* and HSK *Kormoran* was the starting point for defining a search area for the vessels. The combination of these '*gefechtsberichts*' or 'combat reports', and scientific analyses of the wind, surface currents and other variables, undertaken by a team from CSIRO and the Bureau of Meteorology, allowed the *Finding Sydney Foundation* team leader, David Mearns to nominate a search area.[19] This module will showcase the side-scan and subsea technology used to find both shipwrecks. This will be a world first—this specific side-scan and ROV footage has not been on public display.

Module 2: Underwater archaeology

This module will be installed in conjunction with the HMAS *Sydney* material and is designed to showcase the acoustic survey work to find shipwrecks undertaken by the Department of Maritime Archaeology, WAM in Australia and overseas (e.g. Rottnest deepwater graveyard, the search for HMAS *Vampire*, Sri Lanka).[20] A highlight of this model will be a Stereo 3D shipwreck movie.

Module 3: Acoustics and the blue whale

Most people will not be aware that a subspecies of the largest animal on the planet, the pygmy blue whale, undertakes twice yearly migrations along the Western Australian continental shelf edge. Researchers believe around 1000 pygmy blue whales travel south each year down our coast over October to late December, then north again over February to August. The whales feed on small krill, although how they can locate or manipulate prey at such depths is a mystery. A group of mostly Western Australian scientists have been studying these whales since 2000, including investigating the intense low frequency sounds produced by the whales. These whale songs are detected using sea noise loggers deployed along the coast. The acoustic records give us indications of whale numbers, their local movements and possibly a handle on individual whale identifications. In addition aerial surveys have been conducted, genetic samples taken, and several whales have been tagged with satellite transponders or followed with sonar to study behavioural and diving patterns.[21]

---

[19] Mearns, D. 2009, *The Search for the Sydney: How Australia's Greatest Maritime Mystery was Solved*. Harper Collins, Sydney.

McCarthy, M. (ed.), 2010, *HMAS* Sydney *(II).* Western Australian Museum, Perth.

[20] Green, J. & Souter, C., 2005 *Sri Lanka 2005—the search for HMAS* Vampire *(1942) and the VOC ship* Dolfijn *(1663)* Report–Department of Maritime Archaeology Western Australian Museum, No. 205.

[21] http://cmst.curtin.edu.au/research/marine-ecology.cfm accessed 20/05/10.

http://imos.org.au/anmnacous.html accessed 20/05/10.

McCaulay, R., 20/05/10, email. Centre for Marine Science and Technology (CMST), Curtin University.

Module 4: Underwater technology research and new developments

This module will look at current technology designed in Australia (with a Western Australian innovations focus). These are projects developed by universities and industry for applications outside oil and gas. The projects included will be dependent on the objects offered and researchers interest in exhibiting. The indicative projects and collaborators as of May 2010 are:

a) Curtin University Marine Science and Technology (CMST)
b) L3 Nautronix Subsea acoustic surveillance and other defence technologies

E) Below the sea-bed: The story of oil and gas exploration and utilisation

The Western Australian petroleum industry is the largest contributor to Australia's production of petroleum products with a value of $21.3 billion for the nation's economy. Based largely on development of the reserves of the North West Shelf and other onshore hydrocarbon basins, the industry extracts crude oil, condensate and natural gas from petroleum reservoirs deep beneath the earth's surface. Western Australia will be home to a number of major new LNG projects which are estimated to generate hundreds of billions of dollars in economic growth and government royalties. For example the $43 billion Gorgon project off the Pilbara coast is one of the world's largest natural gas projects and has been named as industry leader in plans for Co2 geosequestration.[22]

The first wells drilled into the sea floor 'offshore' were adjacent to the coast at the Summerland field, Santa Barbara, California, (1890). [23] The offshore platform as we recognise it today was established by Magnolia Petroleum, now ExxonMobil, (1946) at St Mary Parish, Louisana. The first platform established 'out of sight of land' was by Kerr-McGee Oil Industries off Vermilion Parish, Louisiana.

In Australia, the first well was drilled in Albany Harbour, Western Australia in 1907.[24] A joint venture between Caltex and Ampol resulted in the formation of the West Australian Petroleum Pty Ltd (WAPET) in 1952[25]. In the 1970s, massive gas/condensate discoveries off the North-west coast of Western Australia were made. These included Browse, North Rankin and Goodwyn by Woodside Petroleum, Petrel and Tern by Arco and Aquitaine and Gorgon by WAPET. Presently, there are 15 active petroleum projects on the Northern Carnarvon, Browse and Bonaparte Basins: Browse LNG (Woodside), Greater Gorgon including Janszlo (Chevron/Exxon Mobil), Macedon (BHP Billiton), Pluto Project (Woodside), Reindeer/Caribou (Apache Energy), Wheatstone/Iago/Julimar and Brunello (Chevron/Apache), Lady Nora

[22] Moore, N. Minister's Message in: *Petroleum in Western Australia: Western Australia's digest of Petroleum Exploration, Development and Production*, April 2010.

[23] Rintoul, W., 1990, *Wood Derricks and Steel Men: Drilling Through Time*. California Department of Conservation, Division of Oil and Gas. Sacramento, California.

[24] http://www.worldofenergy.com.au/factsheet_petroleum/07_fact_petroleum_development.html accessed 17/05/10.

[25] *. Australia's Oil & Gas History.* Petroleum Exploration Society of Australia. December/January 2003/04. Accessed 17/05/10.

(Woodside), Icthys (Inpex), Spar (Santos), Halyard (Apache Energy), Pilbara LNG-Scarborough (BHP Billiton/Exxon), Pyrenees Terraces- Ravensworth, Crosby, Stickle, Harrison discoveries (BHP Billiton), Prelude (Shell), Van Gogh (Apache Energy), Bonaparte (Santos/Gulf Suez).[26]

Looking for and extracting oil and gas from middle of the ocean and taking it to the shore is a daunting task considering the hazards involved. This needs highly specialized technology for a range of tasks such as collection of data, drilling, constructing mid-sea infrastructure, laying pipelines and maintaining the entire set up.

This theme will follow the story from where it is found, retrieving it from the seabed, how it is processed and conveyed to the shore and onto the domestic use.

Module 1: Underwater geology and development of hydrocarbons

This module will define a number of geological and chemical terms in the description of the resource as well as describe the areas in which it is found.[27] While the majority of the hydrocarbons based in Australia are within the 200 nautical mile territorial limit, some reserves fall outside of territorial boundaries such as the 'Timor gap'.[28] Who owns deep-water oil and gas reserves is a question with global significance—as demonstrated in the recent dispute between Argentina and the United Kingdom over the Falklands potential oil.[29]

Module 2: Geophysics in the search for oil and gas

Seismic surveys conducted with the use of sophisticated geophysical technology including bathymetric and acoustic data, allow us to obtain a precise image of the subsurface rock formations from the earth`s surface or sea-bed down to depths of several thousand metres. Geophysics is able to determine the location of rock formations and traps that may contain oil or natural gas accumulations as well as hydrocarbon migration and seepage. This module will draw on information from industry and academia to put together an overview of how petroleum products are located.

---

26 Tinapple, B., 2010, *Subsea Projects in Western Australia.* Presentation to the Subsea Australia Conference 24-26 March 2010, Petroleum Division, Government of Western Australia, Department of Mines and Petroleum. (http://www.subseaenergyaustralia.com/Documents/Subsea%20Projects%20in%20WA%20-%20Bill%20Tinapple.pdf) accessed 1/05/10.

[27] Bradshaw, J., 1991, *Geological Cross-section Across the West Timor Sea, Bonaparte Basin*, Geoscience Australia, GA Publication-Record.
Longley, I.M., Buessenschuett, C., Clydsdale, L., Cubitt, C.J., Davis, R.C., Johnson, M.K., Marshall, N.M., Murray, A.P., Somerville, R., Spry, T.B. and Thompson, N.B., 2002, The North West Shelf of Australia—A Woodside perspective. In: Keep, M. & Moss, S.J. (eds.), *The sedimentary basins of Western Australia 3, Proceedings, PESA Symposium*. Perth WA, 27–88.
Bradshaw, J., 1991, *Geological Cross-section Across the Offshore Northern Canarvon Basin.* Geoscience Australia, GA Publication-Record.

28 Valencia, M. & Miyoshi, M., 1986 Southeast Asian Seas: Joint development of hydrocarbons in overlapping claim areas? *Ocean Development and International Law*. Volume 16, Issue 3, 211-254.

[29] Mapping the Dispute Over Falklands Oil. http://www.offshore-technology.com/features/feature80989/ accessed 19/05/10.

Module 3: Extraction and production: How an offshore platform and subsea production system works
This module will follow the journey of the resource from its extraction, to its domestic end-user. Companies including Woodside and FMC have already produced high-resolution graphics, animations and film that can be re-purposed for this module. The features and operation of the replica subsea production system and pipeline will be described with the aim to give the visitor an overview of how these systems work, without going into the detailed engineering. This module will also confront contemporary issues facing the industry and how Australia is responding, for example, the recent oil spills in the Timor Sea and the US. In response to these disasters, Australians are leading the way with mitigation strategies. The Pipeline Repair Operator Forum Australasia (PROFA) has been set up with the objective to provide a locally based emergency offshore pipeline and flow line repair capability, covering Australian, New Zealand, and SE Asian offshore developments. This new organisation is currently finalising a Joint Industry Agreement between operators and has three foundation members: Chevron, INPEX and Woodside.[30]

Module 4: Underwater tooling: Clever ways to work in a challenging environment
The majority of subsea inventions offered for this exhibit are related to pipeline repair and maintenance. These tools have been designed for very specific tasks and are best interpreted in conjunction with the replica pipeline. It is envisaged that the tools themselves will be installed, as they would appear to work underwater. This display will be supplemented with text and audiovisual aids

F) Sustainability and the future

This theme will examine the role of the subsea industry and its impacts on different aspects of sustainability, including environment and how Australians have elected to deal with the issue of climate change.

Module 1: Offshore renewable energy
Australia's production of renewable energy is dominated by bagasse, wood, wood waste and hydroelectricity which combined, accounted for 87% of renewable energy production in 2007-8.[31] A range of policy measures have been introduced to support the uptake and development of renewable energy, including offshore wind, wave and tidal power research. These measures include the Australian Government's Mandatory Renewable Energy Target (MRET).

---

[30] http://www.subseaenergyaustralia.com/Documents/PROFA%20-Ian%20Wilson%20.pdf accessed 01/05/10.

[31] Australian Government Department of Resources, Energy and Tourism, 2010, *Energy in Australia 2010*, Australian Bureau of Agricultural and Resource Economics (ABARE), Canberra.

Marine renewable energy devices are designed to extract energy from offshore wind, waves or tidal streams and transfer it (usually in the form of electricity or pressurised water) to land. Carnegie Corporation, based in Perth, is the developer of CETO technology that pumps high pressure seawater ashore for the generation of electricity and /or production of desalinated freshwater from wave energy. CETO has been proven at pilot scale and is now in its commercial demonstration phase.[32] BioPower Systems is a renewable energy technology company based in Sydney Australia who are developing systems for both wave and tidal power conversion. The company is currently working on ocean-based pilot projects and follow-on market opportunities for its products and services.[33] Oceanlinx is a leading international company in the field of wave energy conversion. The company has developed proprietary technology for extracting energy from ocean waves, to remain at the leading edge of marine renewable technology development. Oceanlinx has designed and deployed wave energy systems since 1997, including the Port-Kembla Full-Scale Mk 1 Prototype wave energy converter which was substantially designed and engineered in Perth.[34]

Module 2: Climate change: The responsibilities of industry and government

The people of our world must address the issue of climate change and make our activities more environmentally friendly. When global leaders met in December 2009, they failed to reach a legally binding agreement, to replace the *Kyoto Protocol* decided in 1997, on how this would be best done in every industry across the world. Instead, the *Copenhagen Accord* was produced, which details the importance of reducing emissions in the coming years and will form the backbone of plans by individual countries to form targets to lower their emissions.[35]

To combat the effects of climate change, governments and industry are turning to new technologies, including geosequestration or greenhouse gas (GHG) capture and storage in underground geological formations. Carbon Capture and Storage (CCS) technology could potentially be important in the global effort to reduce carbon dioxide emissions. At the moment there are several geosequestration projects operating worldwide and projects in Australia have also commenced with ten offshore areas released to allow industry to undertake further assessment of potentially viable greenhouse gas storage formations.[36] The Otway Basin Pilot Project in Victoria is the first demonstration of deep geological storage or geosequestration in Australia and is endorsed by the Carbon Sequestration Leadership Forum as a project of international significance. Commercial projects are also being considered including the Gorgon Project on Barrow Island in Western Australia, where it is proposed to re-inject carbon dioxide separated from

[32] http://www.carnegiewave.com/ accessed 01/05/10.

[33] http://www.biopowersystems.com/ accessed 01/05/10.

[34] http://www.oceanlinx.com/ accessed 01/05/10.

[35] UN Climate Change Conference in December 2009: Copenhagen Accord.

[36] Australian Government, Geoscience Australia, *AusGeo News*. June 2009 Issue No. 94 available athttp://www.ga.gov.au/ausgeonews/ausgeonews200906/inbrief.jsp#inbrief1

natural gas.[37]

The module will also demonstrate the relative CO_2 emissions from different energy sources and from different energy consumers. It will highlight the difference between gas and oil or coal, the abundance of gas and its ability to serve as a lower-carbon 'transition fuel' to enable Australia to achieve a more gradual, and therefore much less costly or disruptive, shift to renewably-generated energy sources. This module presents an opportunity to examine the bigger issues and the responsibilities of all Australians when it comes to climate change.

Module 3: How can you have sustainable use of a non-renewable resource?

Sustainable development was defined by the Brundtland Report of the World Commission on Environment and Development as '*meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs'*.[38] Looking at both a global scale and at Australia's use of oil versus gas, this module will consider our dependence on imported crude and the collapse of our domestic oil production due to the depletion of the Gipsland Basin, compared to global forecasts of remaining oil reserves. It will consider the concept of 'peak oil', with the implications for availability and pricing of oil as demand is forecast to continue to rise, while supply is forecast to be static or decline. This can be contrasted against the abundance of gas in different forms, including conventional deposits, seabed methane-hydrates, coal-seam methane, etc.

The direct link between our lifestyles and these concepts is profound – from the dramatic petrol price rises of 2008-9, and the rapid rise in the costs of basic necessities like fruit and vegetables, as well as the pervasive use of petroleum products and plastics in every aspect of our lives. The module will highlight options we have to mitigate this problem, including extending the use of CNG (compressed natural gas) as a transport fuel used in many of Perth's buses to many more cars and trucks; the benefits and issues associated with the production of bio-diesel and futuristic options such as electric and hydrogen-powered vehicles. It will also look at the role of personal opportunities, such as 'reduce, reuse and recycle' as practical actions.

Module 4: Environmental Impact

Industry has a responsibility to the community and accountability to Federal and State Governments to show due diligence in environmental impact and assessment. This module will look at the typical environmental footprint from subsea and offshore projects, including the techniques and

[37] Australian Government Department of Resources, Energy and Tourism, 2010 Carbon Capture and Storage in Australia House Of Representatives Inquiry On Geosequestration Technology available at: http://www.ret.gov.au/resources/carbon_dioxide_capture_and_geological_storage/Pages/carbon_capture_and_storage_in_australia.aspx

[38] Our Common Future, Report of the World Commission on Environment and Development, World Commission on Environment and Development, 1987. Published as Annex to General Assembly document A/42/427, Development and International Co-operation: Environment August 2, 1987. Also available at: http://www.worldinbalance.net/intagreements/1987-brundtland.php

technologies used to evaluate and monitor this by environmental scientists. It will consider both the beneficial and detrimental aspects.

G) Careers in Subsea and The Society for Underwater Technology (SUT)

This theme is for people who wish to find out more about the opportunities for education and careers in subsea technology. A stated aim of this exhibit is to inspire and encourage people into a career on the subsea industry.

<u>Module 1: Who are we? (includes sponsor representation area)</u>
This module is designed to showcase the individuals and organizations responsible for the content of the gallery. This is also an area where sponsors of the exhibit may be recognised and provide company profile information. The SUT is a multi-disciplinary learned society that brings together organisations and individuals with a common interest in underwater technology, ocean science and offshore engineering. SUT was founded in 1966 and has members from more than 40 countries, including engineers, scientists, other professionals and students working in these areas. The Perth Branch of the SUT was formed in 2004. The Perth Branch currently has over 190 individual and 22 corporate members and holds regular underwater technology seminars, courses and technical evenings through the year in and around Perth.[39]

<u>Module 2: Careers in underwater technology (including current education programs TAFE and tertiary sector)</u>
This module provides visitors with an opportunity to find out more about training and employment in the subsea industry. It is anticipated that the major training organisations, many of who have offered objects and information for this exhibit, will be featured.

[39] http://www.sut.org.au/perth/sutau_perth_about.htm accessed 25/05/10.

5. INDICATIVE OBJECT LIST (MAY 2010)

OBJECT	LOAN COMPANY	THEME
Aquatic zoology specimens	WAM	The underwater world
2-man wet bell	WAM	Working and living in an underwater environment
1-man Recompression Chamber	The Underwater Centre Fremantle	Working and living in an underwater environment
WAPET TROV	WAM	Underwater robots
PC-based ROV Simulator	Triton Group / Perry Slingsby	Underwater robots
ROV Manipulator arm	DOF Subsea	Underwater robots
Mini-ROV	DOF Subsea	Underwater robots
ROV tank	SUT Perth Branch	Underwater robots
Marine Technology- models, assorted equipment.	Centre for Marine Science and Technology (CMST) Curtin University	Underwater robots
RCV150 ROV	Challenger TAFE	Underwater robots
RT1 'Rock trencher' model	CTC Marine	Underwater robots
Subsea Acoustic Surveillance equipment	L3 Nautronix	PING —Acoustic Technology
Marine acoustic systems	Centre for Marine Science and Technology (CMST) Curtin University	PING —Acoustic Technology
HMAS *Sydney* Acoustic footage and images	WAM / DOF Subsea	PING —Acoustic Technology
HPASS Marine Acoustic survey system	WAM	PING —Acoustic Technology
ROV pipe repair clamp	Nemo	Limit of humans underwater/ Below the sea-bed
Angel hot-tap coupon	Woodside	Below the sea-bed
Hot-tap cutting tool	TD Williamson	Below the sea-bed
Pipe sections	Woodside	Below the sea-bed
Flexible and umbilical pipe sections	Woodside	Below the sea-bed
Subsea 'Christmas trees'	Woodside	Below the sea-bed (external display only)
Buoys, insulated pipe sections, pipe clamps	MatrixAP	Below the sea-bed
Pipeline Strategic Anchoring system	JP Kenny	Below the sea-bed
FPSO Riser / Mooring Simulator	MCS	Below the sea-bed

Ball-grab tools	First Subsea	Below the sea-bed
ROV Flange Repair Tool	Velocious	Below the sea-bed
Wire cutter tool	SubMec	Below the sea-bed
ROV torque tool	SubMec	Below the sea-bed
XYZ Xmas Tree Tool	SubMec	Below the sea-bed
Echo-Yodel FJ inspection and repair tool	Woodside	Below the sea-bed
Reservoir / Completions Background Context	Schlumberger	Below the sea-bed
Fibre-Optic based Pipe Bending Model	Schlumberger	Below the sea-bed
Java Constructor vessel model	Clough	Below the sea-bed
Clough Challenge vessel model & pipe	Clough	Below the sea-bed
Animations of subsea construction	FMC	Below the sea-bed
CETO Wave Energy Converter	Carnegie Corporation	Sustainability and the Future
Integrated Marine Observation System including Ocean Gliders	IMOS / University of WA	Sustainability and the Future

6. AUDIENCE

As part of meeting the educative objectives of the exhibit, entry into the TEG will be free of charge for the general public

Audience Description

In Western Australia alone, 5552 people are employed in the oil and gas sector and petroleum related industries.[40] For most Australians, however, what happens offshore remains a mystery. This exhibition seeks to show aspects of life for those employed offshore, via the technology they use. The focus will be on equipment used in both industry and science and include a number of interactive components—the purpose of which is to educate as well as entertain visitors. This exhibit will have a strong education focus and a complementary education program which corresponds with the WA state curriculum for secondary schools. The Marine and Maritime Course is offered by all three school systems/sectors in Western Australia, the Department of Education (DOE), Catholic Education (CEO), and Independent Schools Association (AISWA). Western Australian tertiary and TAFE institutions are also at the forefront of training for maritime industry. These institutions will be offered an opportunity to participate in the exhibition via the proposed 'Careers in Underwater Technology' module. The inclusion of the work of the WAM's Department of Maritime Archaeology in conjunction with companies from the oil and gas sector and the Finding HMAS *Sydney* Foundation is expected to be a big draw card for local, national and international visitors. It is proposed that WAM, in conjunction with the SUT also develop a strong multimedia presence to accompany this exhibition.

The proposed run-time for this display coincides with the Commonwealth Heads of Government Meeting (CHOGM) in October 2011 and the ISAF Sailing World Championships in November 2011 which will potentially increase media coverage and general attendance.

This exhibition targets the *Fact finders* and *Experiences Seekers*. The interactivity will be the main attraction for the latter visitors—many who will know very little about subsea technology. As such, it is important to have broad thematic content with modules such as 'The Underwater World' as these will potentially attract a wider portion of the marketplace. The *Fact Finders* will also have plenty of opportunity to learn more about the display through innovative display mediums such as QR codes (see Section 12).

Experience Seekers – generally have a lower household income. They tend to be more representative of retirees and those engaged in home duties.

[40] Government of Western Australia Department of Mines and Petroleum Western Australian Mineral and Petroleum Statistics Digest 2009. Table 6 Average Number of Persons Employed in the WA Minerals and Petroleum Industries p32.

Principal petroleum producers effective September 2009: Apache Energy Ltd, AWE Ltd, Buru Energy Ltd, BHP Billiton Petroleum (North West Shelf) Pty Ltd, Chevron Australia Pty Ltd, ENI Australia Ltd, Origin Energy Resources Ltd, Roc Oil Company Ltd, Santos Ltd, Vermilion Oil and Gas Australia Pty Ltd, Woodside Energy Ltd.

They want have interesting experiences – they want education and excitement. They are likely to visit with children or grandchildren.

Fun First – comprised of working families with young children mainly enrolled in private schools. They have a higher educational status and higher household income, female decision makers. They want to have an exciting time but have little desire to be intellectually challenged. They are likely to visit with children and want the children to be able to play and learn.

Fact Finders – likely to be older, retirees. They want to be intellectually challenged and they seek variation and variety. They have a higher incidence of visiting alone or with friends.

The exhibit also provides opportunities for utilisation by SUT and SUT member companies as part of our education, awareness-raising and for hosting corporate events. Some of these are described below:

Subsea Awareness Course (SSAC) – SUT runs a number of professional training courses each year attended by around 250 delegates per year, with a key part of the course being a site-visit to a subsea-related facility to give first-hand experience of the size and complexity of subsea equipment. The exhibit would form an ideal venue for this, as would the DVD and online content as a resource to delegates.

UWA Masters in Oil and Gas Engineering (MOGE) – UWA runs a masters-degree level programme in oil and gas, with modules on subsea systems and subsea pipelines being delivered by SUT member companies. These courses generally feature prize nights and could make good use of the exhibit.

AGM and SUT Member Corporate Functions – SUT has held its AGM at the VQMM on a number of occasions, and looks forwards to continuing to use this amazing venue for SUT functions. Likewise it is anticipated that SUT member companies, particularly exhibit sponsors, will look to the exhibit and VQMM as a venue for corporate receptions and events.

Australasian Oil and Gas Exhibition and Subsea Conference (AOG) – SUT participates in the AOG exhibition and subsea conference, which is rapidly growing to be a major international event. This year's event attracted over 9000 visits to the exhibition and over 500 delegates to the conference, making it one of the largest events in this region and on par with other major events around the world. The exhibit and VQMM site would form an ideal venue for some of the key conference events, such as the official welcome reception.

Engineers Australia Science and Engineering Challenge – SUT is a supporter of the Science and Engineering Challenge held in WA each year. The event aims to inspire year 10 students to take up mathematics and science subjects as enabling gateways into technical careers. Both the online (web and DVD) content and the exhibit itself form fantastic opportunities for these students to gain an appreciation for the challenges and rewards of a subsea career.

7. COMPARATIVE INTERNATIONAL SUBSEA EXHIBITS

1. National Marine Aquarium, Plymouth UK
www.national-aquarium.co.uk/explorocean
    - 3-4 ROVs in a tank for kids to pilot (most popular exhibit)
    - Ride the Scuba" Fosters internet-piloted ROV contest

2. Offshore Energy Centre, Galveston Texas. USA
www.oceanstaroec.com
    - Located on "retired" Ocean Star Drill Rig

3. Aberdeen Maritime Museum
www.aagm.co.uk/Venues/AberdeenMaritimeMuseum

4. Norwegian Petroleum Museum
www.norskolje.museum.no/index.asp?iLangId=1
    - Web-based museum content
    - Conference / training venue
    - Active schools program
    - Library and education resources

5. Subsea UK 'Energise Your Future Exhibition'
www.subseauk.org/item.asp?item=95 (Aberdeen, June 26 2008)
    - Interactive "WOW" factor, including ROV's and other technology
    - Active engagement with schools and universities
    - Public awareness and vocational inspiration for young people

8. SPONSORSHIP

This exhibit has already been partially sponsored with $140K pledged as of May 2010. The SUT have been instrumental in attracting funds within industry and also via specific granting schemes. A Woodside Community Investment Grant (under the priority area of *Strong and Healthy Communities: Working with community organisations to grow and maintain vibrant communities that we live in to create a self-sustaining future*; and *The Environment: Working with the community to better understand and protect our land and marine environments in the area we live and operate*) was provisionally awarded for the development of this exhibit in October 2010 (NB This grant needs to be invoiced before the close of 2010).

The SUT in conjunction with Western Australian Museum Foundation will be approaching a range of partners to bolster the marketing and communications effort and to secure cash, in-kind and contra contributions.

Sponsorship plan				
SECTOR	COMPANY	SOURCE	PARTNER LEVEL	VALUE
Learned Society (Not for Profit)	SUT	SUT	Principal Partner	$50,000
Energy	Woodside	SUT	Platinum Sponsor	$50,000
Subsea Construction	CTC Marine	SUT	Bronze Sponsor	$10,000
Subsea Construction	DOF Subsea	SUT	Bronze Sponsor	$10,000
Subsea Construction	AGR	SUT	Bronze Sponsor	$10,000
Consulting Engineering	RPS	SUT	Bronze Sponsor	$5,000
Professional Engineering Body	Engineers Australia	SUT	Bronze Sponsor	$5,000
TOTAL				**$140,000**

PROSPECTIVE SPONSORS	
FMC	Rotech Subsea
SS7	Mermaid Offshore Services
Tronic/Expro	Schlumberger
Fugro	Chevron
TD Williamson	Wood Group / J P Kenny
Neptune	Trelleborg
Acergy	L3
McDermott Industries	Saipem/Sonsub
Matrix AP	Granherne
ISS	Peritus
Nemo	Castrol
TS Marine	Clough
Technip	SWG
ASC	Aker
GE Oil & Gas	Cameron
IntecSEA WP	Tamboritha/FoundOcean
INPEX	Amec
TMT	BHP Billiton
Xodus	

9. BUDGET

The target sponsorship for this project is $500,000. This level of sponsorship would fund advanced interactive and multimedia components for this exhibition. The Executive Management Team of WAM has endorsed this project providing a minimum sponsorship target of $200,000 is attained. The final content and degree of interactivity and multimedia will be dependent on final funding, and adjusted as required. WAM will resource the project by providing curatorial, design, education, and commercial unit staff. A project manager needs to be engaged externally and this costing is included in the sponsorship budget.

10. EXHIBITION SPECIFICATIONS

- Entry audio tunnel-acoustic treated interactive space with motion sensor triggers for audio and video content
- Interpretative exhibition hardware eg pipeline reconstraction.
- Saturation diving system re-creations
- State of the art lighting and audio-visual (re-purpose existing hardware from shows such as Pompeii)
- Showcases

10.1. OBJECT DATA AND MOUNTS

- Dedicated props and risers (re-purpose existing hardware from shows such as Pompeii)
- Specific objects could be mounted in such a way to become interactive eg ball-grab tool
- Less conservation requirements
- Open plinth displays
- Labels to include QR codes
- Associated audiovisual accompaniment to explain complex engineering concepts, including podcasts.

10.2. MULTIMEDIA – EQUIPMENT AND CONTENT.

WAM Exhibition and Design Department advise that extended lead times are required for multimedia and interactive development. While much of this will need to outsourced, WAM on-line services have the skill base for web and multi-media editing[41].

One preferred option for multimedia is the use of the HoloPro™ holographic projection system. This may be leased or bought outright for use in future exhibitions. HoloPro™ enables projection onto glass in daylight. This is made possible by the patented HoloPro™ technology: holographic optical elements are beamed onto a highly transparent film by laser. This is then embedded in glass. The result is a sharp, high-contrast picture –even in broad daylight. HoloPro™ screens become a component of the light and room concept. Individual sizes and shapes create lively information areas that structure the room without disturbing its transparency and effect. The transparency of the

[41] Strong, M., Manager, WAM On-line Services. Pers. Comm. 20/05/10.

projection surfaces will lead to creative ways of presenting information. Interactive elements with touch or gesture control extend the possible areas of use.[42]

[42] http://www.holopro.de/en/holoprostart/holopro/ accessed 25/05/10.

11. EDUCATION PROGRAMS

A primary aim of the exhibit is to raise awareness of, and encourage, young people to consider a technical career in subsea technology, including the likely evolution over a 40-year career from skills and knowledge of the ocean environment developed largely by oil-and-gas driven activities to a diverse range of challenges, from marine renewable energy to subsea mining and aquaculture.

11.1. SCHOOL

Links to curriculum

<u>All Years (K- 10)</u>
Scope and Sequence: Society and Environment
The stories and items in the exhibition can highlight the following curriculum outcomes for the Science and Technology and Enterprise Learning Areas of the Western Australian Curriculum Framework:

Science

- Science in Daily Life: Students select and apply scientific knowledge, skills and understandings across a range of contexts in daily life.
- Science in Society: Students understand the nature of science as a human activity.
- Energy and Change: Students understand the scientific concept of energy and explain that energy is vital to our existence and to our quality of life.

Technology and Enterprise

- Technology in Society: Students understand how cultural beliefs, values, abilities and ethical positions are interconnected in the development and use of technology and enterprise.
- Enterprise: Students pursue and realise opportunities through the development of innovative strategies designed to meet human needs.

<u>Early Childhood (K to Year 3)</u>
The Year 3 *Place and Space* program requires students to understand that:

- People work in different jobs
- Skills and resources are needed for different types of work
- Resources are valued and used differently

<u>Middle Childhood Years 4 -7</u>
There are a wide range of Society and Environment learning outcomes applicable to the proposed Exhibition. These learning outcomes include Time Continuity and Change, Place and Space and Resources.
Time Continuity and Change: Exploration for resources, how change has impacted on society and that historical findings are tentative (change due to the progression of manned diving and ROV discoveries ie AE2 and HMAS *Sydney*).

Place and Space: Human activities in an area due to commerce or industry, environmental quality and sustainability, effects of production on air, land or water. This links to working and living in an underwater environment and acoustic technology.
Resources: Middle School students are also required to understand best use of renewable and non-renewable resources, enterprising strategies to manage resources (story of oil and gas extraction and production), impacts of the economic system and the range of careers available.
The sustainability theme runs through the Society and Environment Outcomes.

<u>Marine and Maritime Technology Years 11-12</u>
UNIT 1A (usually Yr 11)
Learning Areas: Maritime Industry and Careers-Identification of roles, skills and opportunities for employment in local marine and maritime operations; martin science-Identification, classification and recording of marine organisms and resources, maritime archaeology and heritage.

UNIT 1C (usually Yr 11)
Learning Areas: Marine science-introductory oceanography, maritime archaeology and heritage.

UNIT 1D (usually Yr 11)
Learning Areas: Marine science-introduction to sustainability, maritime archaeology and heritage.

UNIT 2A (usually Yr 11)
Learning Areas: WA Marine Industries
Maritime Industries careers – underwater construction and mining and scientific research, maritime archaeology and heritage.

UNIT 3A (usually yr 12)
Learning Areas: Maritime design and construction – study of renewable and non-renewable energy systems and their influence on structure design and engineering; cost benefit analysis for design proposals and comparison of construction materials in terms of costs, environmental impact and aesthetics.
Trends and new developments in marine industries and careers.

Selected Modern History Units

Selected Science Units

Partnerships

It is anticipated that partnerships will be formed with the following organizations:
Science Teachers Association of WA
History teachers Association of WA
Curriculum Council of WA

Teacher Professional Development Opportunities

This exhibition is perfectly placed to address many of the curriculum requirements for the Marine and Maritime Technology secondary school course of studies. As such, the WAM Education Department can host several professional development opportunities. This could include industry floor talks.

Education Resources

The WAM Maritime Technology and Change education program was developed by the WAM-Maritime education department over a number years, and addresses the themes of the exhibit. In this education program, subsea technology is highlighted by looking at oceanography, diving and underwater acoustic tools used to find shipwrecks. Sustainability of sea environments, gas and oil exploration and utilisation are also explored and will incorporate the display. The program is suitable for children Year 5 and up.

Interpretive Activities and Resources.

Maritime Education will design and deliver educational programs for school-age children and young adults based on the exhibition's themes and displays. Schools will be encouraged to experience the exhibition first-hand and enjoy entertaining and informative guided or unguided programs supported by web-based resources,

By providing guided tours with a focus on storytelling and with the help of 'hands-on', tactile opportunities throughout the exhibition the stories will be brought to life. The aim is to create an environment that is charged with memorable experiences where meaningful learning takes place. The education programs aim to raise awareness of sub-sea technologies and wider issues, such as the environment, by providing engaging education experiences that create a sense of wonder and excitement at the daily lives of people working in, for what is to most people, an alien world.

Special pre and post-visit activities and resources will be designed for the classroom to reinforce, challenge and expand learning to assist teachers in achieving curriculum focused outcomes for their students in the key learning areas.

The Education programs will create awareness of career possibilities in sub-sea technologies related industries. This will be of particular interest to students undertaking Marine and Maritime Technology course of studies in Yr 11 and 12.

Woodside have expressed the desire to send people to staff the exhibition-this option will be integrated into the education program. Industry experts may also be invited to present career information workshops.

11.2. TAFE AND TERTIARY

This exhibit links to a number of undergraduate, post-graduate, TAFE and vocational courses—some of which are Australian leading institutions in the field, e.g. Challenger TAFE's WA Maritime Training Centre – Fremantle, ROV Pilot Technician course. The University of Western Australia has undergraduate and Masters programs in Oil and Gas Engineering, Oil and Gas Law, Marine Science, Geophysics and Maritime Archaeology. Curtin University of Technology houses the Centre for Marine Science and Technology (CMST) comprises a multi-skilled group of scientists and engineers committed to the development of technical ocean-related skills in Australia. The Centre has earned a reputation as a high quality marine technology research and development facility responsive to industry and government needs. Murdoch University has a nationally recognised program in marine biology.

12. ONLINE PROGRAM

The WAM can host or build a separate web-site in conjunction with SUT. The website can function as a space for sponsors as well as an on-line education portal. It is anticipated that a higher-resolution version of the content may also be available in DVD-ROM format.

Options for Interactive and on-line creative content:

- QR codes (http://en.wikipedia.org/wiki/QR_Code) used to deliver additional information, such as written content and audio interviews to people's phones.

- Education Portal - immerse concepts written against the National Curriculum and rolled out as a perpetual educational resource hosted on our site.

- Exhibition subsite - delivered in a similar style to Pompeii subsite, particularly the "Daily Life" and "Objects" pages to outline the objects and concepts (http://www.museum.wa.gov.au/pompeii/).

- Rich media content - production videos of all the objects in use provided by the partners. Eg, Woodside provide one of their ROVs in use, and this is presented as a mini-documentary hosted on the site, and if desired, streamed into screens within the exhibition.

- Develop web documentary about setting up the exhibition. Let the public know how the logistics for such an exhibition works, and create an interesting "pre-exhibition" documentary about the exhibition and what's involved[43].

[43] Strong, M., Manager, WAM On-line Services, email 17/05/10.

13. BIBLIOGRAPHY

Austen, T., 1987, *The Entombed Miner*. St George Books, Perth.

Australian Petroleum Production & Exploration Association Ltd (APPEA), 2008, *Submission to the Senate Select Committee on Fuel and Energy August 2008.*

Australian Government Department of Resources, Energy and Tourism, 2010, *Energy in Australia 2010*, Australian Bureau of Agricultural and Resource Economics (ABARE), Canberra.

Australian Government Department of Resources, Energy and Tourism, 2010, *Petroleum in Western Australia: Western Australia's digest of Petroleum Exploration, Development and Production*, April 2010

Australian Government, Geoscience Australia, *AusGeo News*. June 2009, Issue No. 94.

Australian Government Department of Resources, Energy and Tourism, 2010, Carbon Capture and Storage in Australia House Of Representatives Inquiry On Geosequestration Technology.

Bailey, J., 2001, *The White Divers of Broome: The True Story of a Fatal Experiment*. Pan McMillan, Sydney.

Barsky, S. & Christensen, R., 2004, *The Simple Guide to Commercial Diving*. Ojai Printing, California.

Bevan, J., 2009, *Another Whitstable Trade: An Illustrated History of Helmet Diving.* SUBMEX Ltd, Gosport.

Bradshaw, J., 1991, *Geological Cross-section Across the West Timor Sea, Bonaparte Basin*, Geoscience Australia, GA Publication-Record.

Bradshaw, J., 1991, *Geological Cross-section Across the Offshore Northern Canarvon Basin.* Geoscience Australia, GA Publication-Record.

Christ, R. & Wernli, R., 2007, *The ROV Manual: A user guide for observation class remotely operated vehicles*. Elsevier, Burlington.

Cousteau, J., 1975,. *The Ocean World of Jacques Cousteau: Man Re-enters the Sea.* Angus & Robertson, London.

Davis, R.H., 1955, *Deep Diving and Submarine Operations: A Manual for Deep Sea Divers and Compressed Air Workers*. Siebe, Gorman Co. Ltd., London.

Green, J & Souter, C., 2005, *Sri Lanka 2005—the search for HMAS* Vampire *(1942) and the VOC ship* Dolfijn *(1663)* Report–Department of Maritime Archaeology Western Australian Museum, No. 205.

Hill, M. N., 1962, *Physical Oceanography*. Allan R. Robinson. Harvard University Press.

Keep, M. & Moss, S.J. (eds.), *The sedimentary basins of Western Australia 3, Proceedings, PESA Symposium*. Perth WA, 27–88.

McCarthy M. 1995, Before Broome. *The Great Circle*, Journal of the Australian Association for Maritime History. 16(2):76-89.

McCarthy, M. (ed.), 2010, *HMAS* Sydney *(II).* Western Australian Museum, Perth.

Macdonald, K., 2010, Exploring The Global Mid-Ocean Ridge: A Quarter-Century of Discovery *Oceanus* Magazine Woods Hole Institution.

Maury, M.F., 1859, *The Physical Geography of the Sea*. Sampson Low, Son, and Co., London.
Maynard, J., 2002, *Divers in Time: Australia's Untold History*. Glenmore Productions, Yarraville, Victoria.
Mearns, D. 2009, *The Search for the Sydney: How Australia's Greatest Maritime Mystery was Solved*. Harper Collins, Sydney.
Norton, T., 1999, *Stars Beneath the Sea*. Century, London.
Pattiaratchi, C., 2009, Integrated Marine Observing System (IMOS) in *Western Australia in Monitoring for Action: Understanding Western Australia's changing marine and coastal environments symposium abstracts.* 24 November 2009. WAMSI.
Rintoul, W., 1990, *Wood Derricks and Steel Men: Drilling Through Time*. California Department of Conservation, Division of Oil and Gas. Sacramento, California.
Tinapple, B., 2010, *Subsea Projects in Western Australia.* Presentation to the Subsea Australia Conference 24-26 March 2010, Petroleum Division, Government of Western Australia, Department of Mines and Petroleum.
UN Climate Change Conference in December 2009: Copenhagen Accord.
Valencia, M. & Miyoshi, M., 1986 Southeast Asian Seas: Joint development of hydrocarbons in overlapping claim areas? *Ocean Development and International Law*. Volume 16, Issue 3, 211-254.

Websites

http://www.sut.org.au/perth/sutau_perth_about.htm
http://www.oceanworks.com/hsCommercial.php
http://sites.google.com/site/cwilliambeebe/Home/bathysphere
http://science.jrank.org/pages/7100/Underwater-Exploration.html
http://www.cousteau.org/technology/conshelf
http://www.divingheritage.com/saturationkern.htm
http://www.divinglore.com/Commercial_Diving_Equipment.htm
http://www.history.noaa.gov/stories_tales/poletobeam2.html
http://cmst.curtin.edu.au/research/marine-ecology.cfm
http://imos.org.au/anmnacous.html
http://www.offshore-technology.com/features/feature80989/
http://www.subseaenergyaustralia.com/Documents/PROFA%20-Ian%20Wilson%20.pdf
http://www.carnegiewave.com/
http://www.biopowersystems.com/
http://www.oceanlinx.com/

APPENDIX 1: ESTABLISHMENT BUDGET

Cost centre	**Indicative Budget**
Project Manager (18 months 0.5 FTE)	$48,575
Build costs @ 700/sqm (based on *Albany Ignite* costs)	$280,000
Catalogue publication	$8,000
Multimedia	$60,000
On-line content development	$15,000
WAM Foundation Administration	$10,000
Marketing	$35,000
SUB TOTAL	$456,575
Contingency (10%)	$45,657
TOTAL	**$502,232**

APPENDIX 2: OPERATIONAL BUDGET

Cost centre	Indicative Budget
Education resources	$5,000
Operational budget ($2000/month for 12 months)	$6000 Part sponsored—equipment donated must have an attendant operational budget from the industry provider.
Marketing	$20,000
TOTAL	$31,000

APPENDIX 3: WA MUSEUM IN KIND STAFFING (INDICATIVE)

Name	Position	Months	% of time	Cost
James Dexter	Director, Exhibition Design and Public Programs	11	5%	$5,121
Corioli Souter	Curator	12 6	90% 30%	$96,570
Mack McCarthy	Curator	12	50%	$48,575
Patrick Baker	Technical Officer (Image curation)	6	25%	$7812
Tim Eastwood	Content Advisor	3	5%	$1543
Paul Morgan	Manager, Exhibitions	11	30%	$23,679
TBA	Designer	8	70%	$38,883
TBA	Designer	8	70%	$38,883
Jessica Needle	Project Officer, E&D	11	30%	$15,912
Danny Murphy	Online Services Designer	3	25%	$5,353
Morgan Strong	Manager, Online Services	3	25%	$5,353
Jason Fair	Director, Business Development	11	5%	$5,121
Perin Mulcahy	Manager, Marketing	8	30%	$5,740
Gemma Travers	Coordinator, Marketing	8	10%	$4,228
Renae Woodhams	Manager, Media	8	5%	$2,870
Flora Perrella	Coordinator, Media	8	5%	$2,114
Lauren Sullivan	Manager, Functions	8	5%	$2,459
Dan Boyes	Manager, Facilities (Fremantle)	4	25%	$6,148
Karen Bassett	Director, Foundation	3	50%	$13,967

Name	Position	Months	% of time	Cost
Trent Norris	Manager, Commercial/Retail	7	5%	$2,836
Andrew Rodgers	Manager, Audience Research	5	5%	$1,536
Jo Martin	Manager, Visitor Services	8	30%	$14,755
Lisa Williams	Fremantle Site Manager	10	10%	$5,402
Mike Brevenholt	Manager, Education (Maritime)	8	10%	$4,228
Felena Alach	Manager, Public Programs	6	5%	$2,430
Ray Coffey	Manager, Publications	3	10%	$2,153
E&D install	Install team	2	100%	$8,522
E&D install	Install team	2	100%	$8,522
E&D install	Install team	2	100%	$8,522
E&D install	Install team	2	100%	$8,522
Manuela Herbert	E&D Administration	5	30%	$6,391
Ian Godfrey	Conservation	0.5	100%	$3,588
				$407,738