SUBMARINE ESCAPE AND RESCUE - THE AUSTRALIAN SOLUTION

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ABSTRACT. *In May 1995, the Australian Submarine Corporation (ASC) in Adelaide South Australia was contracted by the Royal Australian Navy (RAN) to provide a submarine escape and rescue service. This service includes the provision of specialist rescue and survivor treatment equipment.*

As the service provider, ASC is responsible for the deployment of the equipment to the site of the disabled submarine (DISSUB) using identified mother ships and for operation of the equipment. The service is maintained to provide a fast response deployment to any area around the Australian coast.

The paper describes the history of the project, the major equipment elements of the escape and rescue system, the approach taken by ASC and the RAN to ensure the provision of a cost effective service and the potential future development of the service.

INTRODUCTION

Submarine operations are like explosives - they are safe until one forgets how dangerous they can be. In the last 97 years, over 200 submarines have been lost by accident or error [Gray (1)] usually with large loss of life. In early days, material failure was generally the cause but nowadays, as a result of huge improvements in quality control, the risk of submarine accident arises through human error either through failing to detect the ship about to collide or through navigational error. There have been six submarines lost in the last 20 years and a large number of close calls. The emergence of legislation requiring a workplace as safe as reasonable practicable has also placed a greater imperative on the provision of a means of rescuing survivors of a submarine accident.

If an accident should occur and the submarine sink unintentionally, those onboard who survive the initial accident are faced with further threats; pressure, cold and foul air. If the pressure from the water depth exceeds the strength of the submarine's hull, collapse will occur and the end will be mercifully swift. Should the hull remain intact, the survivors are now faced with the prospect of escaping by buoyant ascent or awaiting the assembly and arrival of rescue forces.

ESCAPE

Escape is not simple. The system employed by many of the world's navies, including Australia, was developed by the Royal Navy in the early 1950s and has been successfully tested from depths as great as 180m. That depth generally equates with the edge of the continental shelf beyond which point the ocean floor tends to drop sharply. Successful escape, however, requires that internal pressure of the disabled submarine (or DISSUB) does not rise significantly and that the air quality onboard has not been tainted by noxious fumes or by excessive amounts of carbon dioxide. Too much of any of these factors gives rise to greatly increased risk of decompression sickness; a risk that increases disproportionately with depth. An improperly conducted ascent can also cause a cerebral arterial gas embolism which, without immediate recompression, is generally fatal. Escape training is therefore vital.

RESCUE

The depth of water may preclude escape and the survivors will have to wait for rescue if such a capability is available. Modern submarines are equipped with emergency life support stores to last the crew seven days but stores may be damaged in the accident or prove inadequate in which case replenishment is desirable. Rescue is always preferable to escape but the cost of rescue systems have generally been beyond all but the wealthiest of nations.

Following the tragic loss of USS Thresher in 1963, the US Navy developed two extremely capable but expensive Deep Submergence Rescue Vehicles (DSRVs). Capable of recovering up to 24 survivors at a time from a DISSUB, the DSRV is flown by US Air Force transport aircraft to a convenient embarkation port whereupon it is "piggybacked" on a specially modified nuclear submarine and transported to the site of the accident. While the DSRV can rescue survivors under pressure, it cannot transfer them under pressure without a specially designed mother ship with inbuilt decompression complex. Two such ships were built but they have now been scrapped and the only means of transferring under pressure is to use a British ballistic missile nuclear submarine which has a modified forward compartment capable of use as a decompression chamber.

The USN also possessed a number of McCann submarine rescue chambers. These diving bells were developed in the 1930s and one featured in the only successful submarine rescue ever undertaken; that of USS Squalus in September 1939. The McCann bell suffers severe limitations in strong currents and when dealing with a pressurised submarine or one lying at extreme angles.

AUSTRALIAN SITUATION

The situation faced by the Royal Australian Navy (RAN) in the early 1990s was that its six British-built Oberon class submarines were reaching the end of their useful lives and were close to replacement by a new class of Swedish-designed, Australian-built Collins class submarines. The Navy had repatriated its escape training, and almost all other submarine training, from UK to Australia early the previous decade and had built the world's most modern submarine escape training facility at HMAS STIRLING in Western Australia.

It had designed and built two air-portable recompression chambers nominally capable of treating six patients and maintained stocks of equipment ready to deploy to the site of a submarine accident. The waters off Sydney, in which its submarines generally operated, had a very narrow continental shelf and escape systems were generally regarded as existing for morale purposes only. Suffer an accident more than a few miles off the coast and a quick death was the likely outcome.

The RAN had, however, recognised that it should at least possess compatibility with a rescue system and the casing around its forward escape towers were fitted with a rescue seat in the mid-1980s. It also acquired a small submersible and support ship in 1987 but discovered that the cost of refurbishment of the submersible to convert it to the submarine rescue role was not cost-effective. In 1992, the conversion was abandoned and the navy undertook to "explore alternative means of achieving a submarine rescue capability with urgency[CNS (2)]".

This involved commissioning an extensive study into the resources required to deal with a submarine accident, known around the world as SUBSUNK. The SUBSUNK Resources Study[Mellon (3)] generated over 140 recommendations and, in October 1994, with sea trials for the first Collins class submarine rapidly approaching, the Submarine Escape and Rescue Project (SERP) was formed with a remit to acquire:

- Recompression facilities for 9 stretcher-borne and 8-10 seated patients;
- A means of "posting" emergency life support stores into a DISSUBs escape tower in pressure-tight pods;
- A means of transferring the seated patients under pressure to alternative hyperbaric facilities;
- A submerged rescue capability, probably through a leased service from a foreign navy;
- Significant improvements in the Australian submarine escape and rescue infrastructure.

The required date for the recompression facilities was February 1995 and for a rescue capability by July the same year. Two triple compartment air-portable recompression chambers with capacity for 36 seated or 22 stretcher-borne patients were designed and manufactured by the Australian Submarine Corporation in four months and installed onboard the Royal New Zealand Navy diving support vessel HMNZS Manawanui in time for Collins' initial dive in late February. Along with the supply of the recompression chambers, ASC devised and implemented a method of deploying Emergency Life Support Stores (ELSS) in pressure proof pods. While this was occurring, alternative rescue systems were being analysed.

RESCUE OPTIONS

Only two viable options existed; lease of the Royal Navy's submersible LR5 on a stand-by fly-away basis or acquisition of an Australian-owned system. Use of the DSRV was impractical because of the non-availability of support assets in Australia.

Fig 1. UK Rescue Submersible LR5

All the rescue systems in the world to that point, with the exception of the McCann Bell, used free-swimming submersibles. Skills to operate the systems are either inherited from the offshore industry or developed and maintained in-house by naval personnel. In either case, the maintenance of the skills requires deployment of the rescue vehicles on a frequent basis, generally every four to six weeks, with significant ship and personnel costs. The USN, for example, employs 120 contractors and 210 naval personnel on a full-time basis.

Even when commercial operation was used, such as by the UK Royal Navy with a team of 8, industry could not be relied upon as a source of skilled operators as all mechanical sub-surface operations are nowadays carried out by saturation divers or remotely operated vehicles (ROVs). Submersibles are also complex, heavy and expensive to maintain, requiring specialised support vessels, few of which operated on the Australian coast.

Although the standby costs for LR5 were insignificant, to guarantee a support vessel would involve constant charter for an indeterminate period; a charter that would soak up several million dollars in only a few months leaving no tangible assets when the capability was no longer required. With a build programme extending over several years, these costs would be overwhelming.

ACQUISITION OF AN AUSTRALIAN CAPABILITY

Mellon had suggested that conversion of a diving bell was preferred to a submersible in Australia's situation and ASC subsequently proposed to the RAN, in mid-January 1995, to supply and operate a Submarine Escape and Rescue Service (or SERS). This proposal involved the construction of the world's first remotely operated rescue vehicle, designed to be fully integrated with a new 12 man Transfer Under Pressure chamber and the Recompression chambers to create a decompression complex capable of accommodating up to 72 personnel. Under the proposal, the rescue vehicle would have the capability to mate with a disabled submarine lying at extreme angles utilising an articulated interface, known as the 'skirt'. The entire suite, including the ELSS pods and deployment system would be operated and maintained by a small team consisting of a manager, engineer and two technicians. The service would be on call to the RAN 24 hours a day, 365 days a year and be capable of deploying the suite of rescue equipment at 12 hours' notice.

Fig 2. ASRV Remora mated to a disabled submarine (artist's impression)

The RAN accepted the proposal and a $A20m five year SERS contract was signed in May 1995. ASC was required to provide the rescue capability by early December 1995 for the deep dive trial for Collins. The rest, as they say, is history, and the Australian Submarine Rescue Vehicle (ASRV) Remora was designed, built, tested in 547m of water with a target plate set at 60° and air-freighted to Australia in the astonishing time of 23 weeks.

MOTHER SHIPS

The SERS does not rely on a single support vessel. With a coastline the length of Australia's, such a ship would invariably be in the wrong place at the wrong time and, following its offshore industry pedigree, SERS utilises ships of opportunity from the offshore oil industry. Recently, the RAN has commercialised its operations for Port Services and Support Craft and the contract includes the provision of two 72m Offshore Support Vessels in South Australia and Western Australia for Submarine Trials and Practice Weapons Recovery. Additionally each is capable of embarking the SUBSUNK Rescue Suite and one of these ships would generally be the nominated Mother Ship (or MOSHIP).

Fig 3. Submarine Trials and Safety Ship (MOSHIP)

LAUNCH AND RECOVERY

Launch and Recovery of Remora was not specified in the initial contract as the final shape, weight and requirements of the rescue vehicle were not known. This became the most significant shortfall in the system and a recent decision to acquire an offshore-capable Launch and Recovery System (LARS) for SERS will mean that in less than two months from now, Remora will be deployable anywhere within the region and safely operable in sea state 5.

PERSONNEL

In an actual submarine rescue operation, SERS is deployed from its Adelaide facility and mobilised onto a MOSHIP by the SERS core team. This team is boosted for the operation of SERS by a callout team of specialists normally employed in the offshore oil industry. Medical support is an RAN responsibility and the entire operation is coordinated by a naval officer responsible to the Submarine Search and Rescue Authority.

SYSTEM DESCRIPTION

As this is a defence **technology** conference, you are entitled to expect a description of the system and I don't intend to let you down. At the heart of the suite, ASRV Remora, named for the sucker fish which attach themselves to sharks, is a 16.5 tonne Remotely Operated Rescue Vehicle built about a diving bell, with room for seven people; one operator/attendant and six survivors, capable of operations in excess of 500m in a current of 3 knots and of mating to a DISSUB lying at angles up to 60°. Rescue and transfer under pressures of up to 5 Bar is achieved through mating to a transfer under pressure chamber connected by spool pieces to the two 36-man recompression chambers.

Fig 4. Australian Submarine Rescue Vehicle Remora

The vehicle is powered and controlled by use of a 914m armoured electro-fibre optic umbilical which provides power to the two 75hp hydraulic power units and passes sonar, communications and video data to a containerised Control Van. This is manned by a team of three consisting of a Pilot, Navigator and Dive Supervisor. In a separate compartment at the rear of the van, the naval Coordinator Rescue Forces communicates with the DISSUB via underwater telephone, with the shore-based authorities via INMARSAT and with local assets via VHF radio. Accompanying the suite is a containerised workshop van.

Fig 5. ASRV Control Van Displays

The suite also includes a large backup generator, LP and HP air compressors, bottled gases. Twelve ELSS pods with associated stores are held which would normally be deployed ahead of the main rescue package. By posting these pods using a ROV or Newtsuit, life in the DISSUB can be sustained almost indefinitely.

All items of the suite, with the exception of underwater telephone, are commercially sourced allowing the skills required for operation to be little different to that widely used in industry. Training in the specific skills necessary to operate Remora, which also has the slightly less than serious acronym Really Excellent Means of Rescuing Aussies, is only necessary on two occasions a year and that is conducted off a naval wharf in Western Australia. This exercises the transport aspects of the service as well as being convenient to the home base of most of the ASRV pilots. ASC maintains a register of ASRV pilots, navigators and dive supervisors and always has several available.

The entire suite is either housed in ISO containers or is dimensioned to permit carriage in C-130 Hercules aircraft, road, rail or sea. It is maintained ready to deploy within 12 hours of the alert being raised and can be anywhere in Australia within 36 hours. Subject to a MOSHIP being available, the suite can be mobilised onboard the ship within a further 24 hours and the ship should be ready to sail 72 hours after callout.

The inclusion of an air-portable "A" Frame will complete the suite and an indicative deck layout is shown on this slide.

Fig 6. Indicative Deck Layout

FUTURE CONSIDERATIONS

What, then for the future? The ASRV can be expected to serve the RAN for at least another ten years by which time most nations with a rescue capability will probably have adopted the technology and concepts contained in this paper. If Remora were built from scratch, it would probably have a cylindrical pressure vessel with a capability to mate at the end. The adoption of laser scanning and other non-acoustic sensors would also seem feasible but it would be important not to make the vehicle too military - such an approach would only drive the costs back to previous levels.

SUMMARY

In summary, Australia has taken the concept of a commercial operation pioneered by the UK for a submarine rescue service to new heights (perhaps that should read depths). By using skills resident in and maintained by industry with compatible technology, it has avoided many of the pitfalls suffered by systems no longer supported in industry and a significantly more cost-effective capability is the result. Remora and its associated suite not only represent the leading edge of submarine rescue technology, they also form the only air-portable system capable of rescue and transfer under pressure from a DISSUB at extreme angles and have demolished the myth that submarine rescue has to break the bank.

I thank you for your attention and welcome your questions.

<u>References</u>

1 Gray, Edwyn. *Few Survived* Leo Cooper, London, 2nd ed. 1996
2 RAN Chief of Naval Staff (CNS) advice to Minister for Defence, Sep 1992
3 Mellon, G LEUT. *SUBSUNK Resources Study*, Canberra 1994

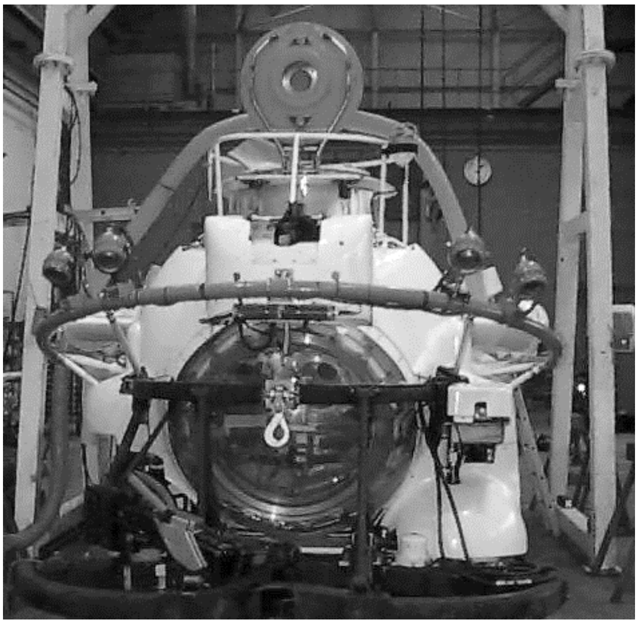

Fig 1. UK Rescue Submersible LR5

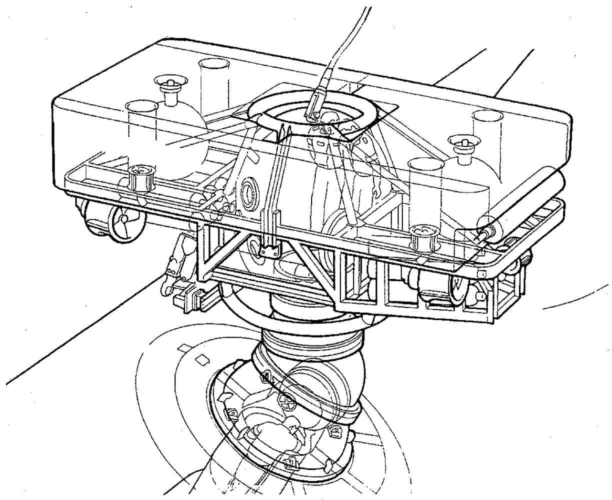

Fig 2. ASRV Remora mated to a disabled submarine (artist's impression)

Fig 3. Submarine Trials and Safety Ship (MOSHIP)

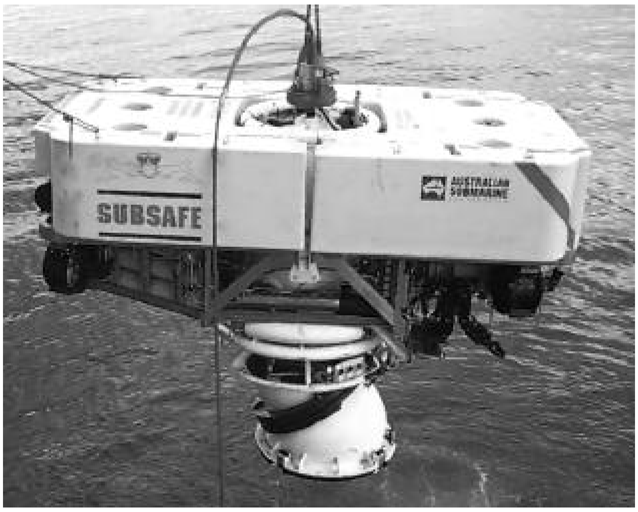

Fig 4. Australian Submarine Rescue Vehicle Remora

Fig 5. ASRV Control Van Displays

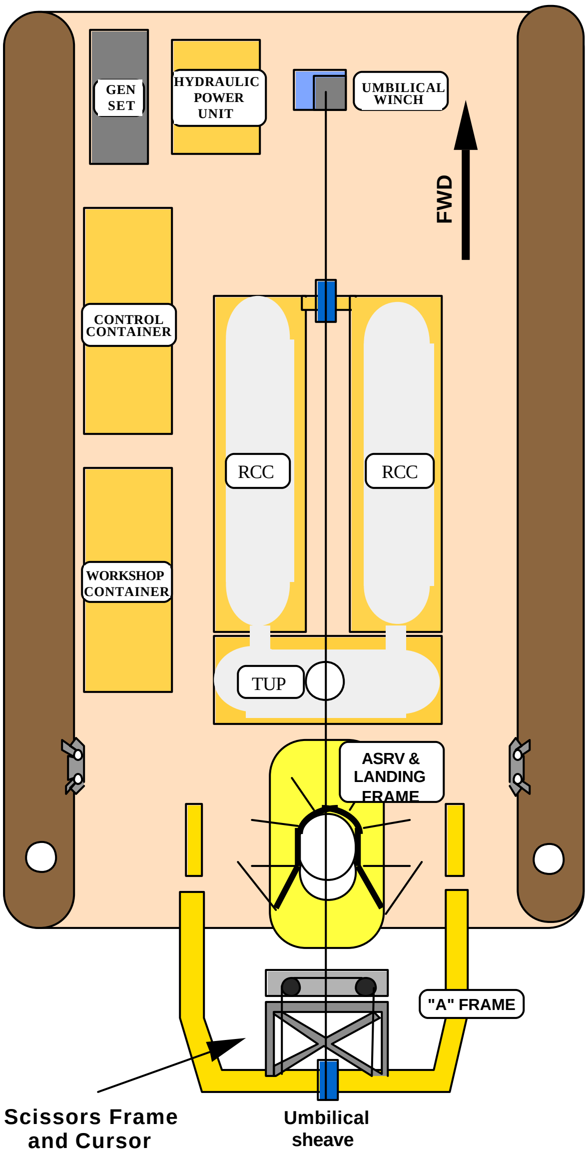

Fig 6. Indicative Deck Layout