Subsunk and Rescue

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Submarine rescue: The Australian experience

In the last 100 years, more than 200 submarines have been lost by accident or error, usually with a large loss of life. Seven submarines were lost in the last 25 years, including the Russian *Kursk*, and there have been many close calls. In the early days, material or design failure was usually to blame, but collision or other human error has been a chief cause over the past 30 years.

In May 1995, the RAN contracted with the Australian Submarine Corporation (ASC) in Adelaide, South Australia, to provide a comprehensive submarine escape and rescue service as a means of rescuing survivors of a tragic disabled submarine (DISSUB) event.

If an accident should occur and a submarine sinks, those on board who survive the initial accident are faced with further complex threats from carbon monoxide, carbon dioxide or other toxic gas poisoning plus oxygen depletion inside the submarine, together with pressure and cold from the surrounding water.

Remora*, the first Australian solution to the submarine rescue problem*

If the pressure from the water depth exceeds the strength of the submarine's hull, the hull collapses and the crew dies quickly. However, if the hull remains intact, it follows that the survivors must either escape by buoyant ascent, await rescue by external aid or experience a slow death through carbon dioxide poisoning or hypothermia.

The Swedish Navy rescue vehicle (USN photo).

Escape by buoyant ascent from a damaged sunken submarine is not simple. The system employed by many of the world's navies, including Australia, evolved from the 1920s Momsen Lung and the USN's 1953 Steinke Hood. The RN developed the Submarine Escape Immersion Ensemble (SEIE) Mk 10 in the early 1950s and it is used by 21 navies, including the RAN and USN. It has been successfully tested to depths as great as 600 feet (182 meters), with a theoretical potential down to 850 feet (259 meters), and provides full-suit thermal protection plus an integral one-man life raft. The SEIE, however, requires the disabled submarine's internal air pressure and air quality to remain relatively normal. Otherwise, both the remaining crew and escapees risk death from decompression sickness or gas toxicity. Other limitations, such as the escape chamber hatch remaining within 45 degrees of the horizontal, surface rescue vessels being nearby and suitable surface weather conditions all contribute to the SEIE's ultimate effectiveness. There are also risks of barotrauma due to Eustachian tube blockage during the pressure equalisation phase inside the tower and pulmonary overinflation syndrome due to survivors failing to breathe normally on the way up. Decompression sickness (bends), hypothermia, thermal stress, traumatic injury and drowning are additional considerations in real-life escape situations.

The British SEIE Mk 10 (left).

Exercise Sorbet Royal

A NATO exercise, Sorbet Royal in May 2002 (Cohen 2003), demonstrated the effectiveness of the system when four crewmembers and five others from Denmark, the UK and USA, both men and women, donned SEIE suits to simulate an escape from the Swedish submarine *Vastergotland*, down 115 feet off the coast of Denmark. The submarine's escape tower had a four to six minutes recycle time, (determined chiefly the time it takes to drain the flooded tower) but they used a 15-minute interval for this demonstration. The exercise worked as briefed, with 18 seconds required for the pressure equalisation phase, the pressure doubling roughly every four seconds or so, and nine seconds required for the ascent. Rescue units, including a decompression chamber, were waiting in smooth seas on the surface.

Russian experience

Improperly conducted escapes can lead to the bends which, without immediate recompression, are generally fatal. Another real life factor is hypothermia. When the Soviet submarine *Komsomlets* sank in the Norwegian Sea in 1989, 34 of 69 crewmen escaped but died of hypothermia, heart failure or drowning (Polmar 2000).

The *Kursk* had escape-survival suits rated to 328 feet (100 metres). Like most other Russian submarines, it also had a built-in escape pod in the sail structure, big enough for the entire crew, but this was probably destroyed by the initial explosions. The *Komsomlets* also had a pod, which broke free as the boat plunged to the bottom at 5,500 feet (1,676 metres). Tragically, toxic gas entered the pod and only one of its five occupants survived.

Water depth may preclude a buoyant SEIE ascent, therefore the survivors must wait for rescue. Rescue is always preferable to escape but rescue systems are expensive.

Following the loss of USS *Thresher* in 1963, the USN developed two extremely capable 24-man Deep Submergence Rescue Vehicles (DSRVs). The 30-ton DSRV can be flown to a convenient embarkation port from where it can be piggy-backed on a specially modified nuclear submarine or rescue vessel to the accident site.

The DSRV rescues survivors under pressure, theoretically down to 5,000 feet (1,500 metres), well beyond the collapse depth of any existing submarine. However it cannot transfer them under pressure without a special vessel fitted with decompression facilities. The USN has eight submarines, the British four and the French two that can operate the DSRV (Walsh 2000) but only the four British ballistic missile nuclear submarines have the additional recompression chamber (RAN 2000).

The USN also possesses two McCann “diving bell” rescue chambers, rated to 1,200 feet (366 metres). Developed in the 1930s, one featured in the successful USS *Squalus* rescue in September 1939. Unfortunately, the McCann Bell suffers from severe operational limitations in that a diver must attach a haul-down cable.

Several nations have rescue submersibles, such as the British LR5. However, they are launched from surface ships, so they too are limited by weather and ice conditions. Some are also limited by depth, such as the British LR5’s 1,312 feet (400 metres).

A British LR5 launching in flat calm seas.

After the *Remora* failure on 4 December 2006, when its main lift cable parted off Rottnest Island in heavy seas, the RAN has relied on the LR5. This "manned submersible" weighs 21.5 tons and operates to a maximum depth of 400 metres with its crew of three in wave heights of five metres. Its maximum speed is 2.5 knots and the LR5 requires a Vmax of one knot of bottom current to mate successfully with the submerged submarine.The LR5 requires a heel of less than 10 degrees and a 60 degrees bow up attitude on the distressed submarine, but this may be modified with 15 degree wedges. Its chamber will accommodate 15 survivors at a time. Australian support vessels have been modified to accept the vehicle and it employs the standard NATO rescue seat, with which our submarines are fitted.

The LR5 is air-transportable. For the annual Black Carillon submarine escape exercise programmed for late 2009, two standard containers of auxilliary equipment were transported by commercial airline and the submersible itself was carried by an RAAF C-17. (Navy News photo: LAC Benjamin Evans, 11 June 2009.)

RAN experience

In the early 1990s the RAN's six Oberon class submarines were being replaced by the Collins class. The RAN, following UK procedures, built a modern submarine escape training facility at HMAS *Stirling* in Western Australia. This included two air-portable recompression chambers nominally capable of treating six patients, and stocks of equipment to deploy to the site of a submarine accident.

However, the waters off Sydney, in which the Oberons generally operated, have a very narrow continental shelf. Therefore escape systems were generally regarded as existing chiefly for morale purposes. If a submarine sank more than a few miles off the coast it would fall quickly beyond its safe hull depth or to depths beyond which escape was impossible. In either event a quick death for the crew would be the likely outcome.

RAN submersible, 1987

The RAN required some sort of rescue system compatibility and as far back as the mid-1980s fitted a rescue flange on the casings around the Oberons' forward escape towers. In 1987 the RAN acquired a small submersible and support ship but found the cost of refurbishing was prohibitive, so this was abandoned in 1992.

Next, the RAN commissioned a study that resulted in the 1994 formation of project group tasked to acquire:

- *recompression facilities for nine stretcher-borne and eight to ten seated patients;*
- *a means of transferring emergency stores into a sunken submarine;*
- *a means of transferring the seated patients under pressure to alternative re-compression facilities;*
- *a submerged rescue capability, probably through a leased service from a foreign navy; and*
- *significant improvements in the Australian submarine escape and rescue infrastructure.*

Skills training

Analysis indicated only two viable rescue system options existed. Either the RAN could lease the Royal Navy's submersible LR5 on a "stand-by fly-away" basis or it could build its own. The American DSRV, although highly capable, was impractical because it lacked support assets in Australia.

With the exception of the McCann Bell, all rescue systems used free-swimming submersibles. The skills to operate the systems are found in the offshore diving/oil industry or developed and maintained in-house by naval personnel. The USN employed 120 contractors and 210 naval personnel on a full-time basis.

In either case, skills maintenance required deployment of the rescue vehicles, every four to six weeks, at significant ship and personnel costs. Even when commercial resources were used, such as by the RN with a team of eight, industry could not be relied upon as a source of skilled operators.

All mechanical sub-surface operations were carried out by saturation divers or remotely operated vehicles (ROVs).

The submersibles are also complex, heavy and expensive to maintain. Additionally, they require specialised support vessels, few of which operate near Australia.

Chartering the LR5 initially looked viable, but further analysis revealed problems. Although the standby costs for LR5 were insignificant, the only way to guarantee a support vessel (without purchasing one) would involve constant charter for an indeterminate period. Such a charter would use up several million dollars in only a few months. These costs would be overwhelming and would not guarantee vessel availability if it was needed for an Australian emergency response.

ASC proposal

With such prohibitive costs and the complexity of operating a submersible, the ASC concluded that some form of diving bell would provide a much more viable option. Accordingly, in January 1995 they proposed to the RAN that they supply and operate a Submarine Escape and Rescue Service (SERS).

The ASC proposed constructing the world's first remotely operated rescue vehicle. This would be fully integrated with a new 12-man Transfer Under Pressure Chamber and recompression chambers that would create a decompression complex capable of accommodating up to 72 personnel. Two triple compartment, air-portable recompression chambers with a capacity for 36 seated or 22 stretcher-borne patients were designed and manufactured by the Australian Submarine Corporation. They were installed onboard the Royal New Zealand Navy diving support vessel HMNZS *Manawanui* in time for HMAS *Collins*' initial dive in late February that year.

Along with the supply of the recompression chambers, ASC devised and implemented a method of deploying Emergency Life Support Stores (ELSS) into a submarine using pressure-proof pods. Under the proposal, the rescue vehicle could mate with a disabled submarine lying at extreme angles by utilising an articulated interface, known as a "skirt". The entire suite, including the ELSS pods and deployment system would be operated and maintained by a small team. The service would be on call to the RAN 24 hours a day, 365 days a year and would be capable of deploying at 12 hours' notice.

The RAN accepted the proposal and in May 1995 signed a $20 million five-year contract. Under the terms of the contract, ASC provided the rescue capability in early December 1995, before HMAS *Collins*' first deep dive trial.

The Australian Submarine Rescue Vehicle (ASRV) *Remora* was designed, built in Canada, tested in 1,800 feet (547 metres) of water with a target plate set at 60 degrees and air-freighted to Australia in 23 weeks.

It was a 16.5 tonne remotely operated vehicle built about a diving bell. It had room for seven people, the operator/attendant and six survivors. It could operate at more than 1,600 feet (488 metres) in a current of three knots and mate to sunken submarines lying at angles of up to 60 degrees from the vertical in moderate (one and a half meters) seas. Rescue and transfer under pressures of up to five Bar (approximately 150 feet, 45 metres) is achieved through mating to a special chamber connected to either of two portable 36-man recompression chambers carried in the recovery vessel.

Armoured cable

The vehicle was controlled by a 3,000 feet (914 metres) armoured cable that powered two 75 hp hydraulic power units. A team of three comprising a pilot, navigator and dive supervisor manned the surface van. In a separate compartment the Naval Coordinator, Rescue Forces, communicated with the sunken submarine via underwater telephone, with the shore-based authorities via INMARSAT, and with local rescue assets via VHF radio.

Accompanying the suite was a containerised workshop van. The entire suite was either housed in cargo containers or packed for carriage by aircraft such as the C-130 Hercules, or by road, rail or sea resources. It was ready to deploy within 12 hours of the alert being raised and could be anywhere in Australia within 36 hours. The suite could be deployed onboard a ship within a further 24 hours and the ship should be ready to sail 72 hours after callout.

The RAN's contract with ASC includes the provision of two 72 metre Offshore Support Vessels in South Australia and Western Australia, respectively, for submarine trials and practice weapons recovery. Additionally, as well as operating *Remora*, each was capable of embarking and operating the entire SUBSUNK Rescue Suite.

New Technology

Around midnight 4 December 2006, a *Remora* main lift cable parted in moderate seas off Rottnest, WA, due probably to a manufacturing defect. The craft was conducting certification trials before an Exercise Black Carillon, a mating drill with the Collins class submarine HMAS *Shean* . After the malfunction, the operators lowered the *Remora* to the ocean floor, 130 metres below, with two civilian contract crewmen trapped aboard for about 13 hours. The umbilical cord to the mother ship, providing power and communications, remained intact. After two aborts, a gentle lift around midday the next day brought them to a depth of 15 metres, when two divers from the surface ship descended and opened the craft's hatches. The two contractors inside swam out, buddy-breathing with the divers until they reached the surface. The *Remora* craft was then lowered to the bottom and secured, awaiting insurance and other decisions before determining recovery procedures. The vessel was eventually recovered by the United States Navy Supervisor of Salvage and Diving on 26 April 2007 and shipped back to Canada for repair and refurbishment.

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