REMOTELY OPERATED RESCUE VEHICLES – ARE THEY REALLY THE SOLUTION?

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SUMMARY

In May 1995, the Australian Government signed a contract with the Australian Submarine Corporation for a Submarine Escape and Rescue Service centred around a Remotely Operated Rescue Vehicle (RORV) to be built by Hard Suits Inc of Vancouver, British Columbia. *Remora*, as it became known, was the first of its kind, all previous submarine rescue vehicles having followed the US Navy concept of free-swimming submersibles. 23 weeks later, *Remora* was air-freighted to Australia having been designed, built, certified and trialled incorporating a mate with a target plate set at 60° in 547m of water.

With the RORV concept proven in early Australian exercises, the US Navy embarked on its own revolution in submarine escape and rescue, embracing the rescue philosophy pioneered by the Royal Australian Navy (RAN). The Pressurized Rescue Module System (PRMS) forms part of a larger Submarine Rescue and Diving Recompression System (SRDRS) and is presently being built by Hard Suits, now known as OceanWorks International. Within three years, the two PRMs will replace the USNs Deep Submergence Rescue Vehicles (DSRV).

This paper examines the reasons behind selection of ROV technology for submarine rescue, discusses the strengths and weaknesses of free-swimming and tethered submarine rescue vehicles, reviews the progress in RORVs since 1995 and discusses whether the concept is likely to be embraced by other navies. All of this in a climate where the *Kursk* tragedy has highlighted the need for a submarine rescue capability. Navies embarking on new submarine rescue projects include those of NATO, Singapore, India and the People's Republic of China.

AUTHORS' BIOGRAPHIES

Frank Owen served the Royal Australian Navy (RAN) for 28 years, retiring in 1999 as a Commander following the successful introduction into service of the world's first air-portable submarine rescue capability to incorporate a complete Transfer Under Pressure capability. He founded InDepth Project Management Pty Ltd in August 2000 as a submarine rescue and safety management consultancy and is part of Team OceanWorks' bid to provide and operate a free-swimming submarine rescue vehicle for the Republic of Singapore Navy. Frank is currently providing project management services to the Submarines Branch of the Defence Materiel Organisation in Canberra assisting the task of coordinating the enhancement program for Australia's Collins class submarines.

Lieutenant Commander **David Jones** is the RAN's Submarine Escape and Rescue Manager at HMAS STIRLING, Western Australia having served in the position since May 2000. David qualified in submarines in 1989 and conducted Exercise Black Carillon in April 2001 off Western Australia.

1. INTRODUCTION

Submarine Rescue is a capability many navies have desired but few have felt they could afford since the widely publicised cost blow-outs of the US Navy's Deep Submergence Rescue Vehicle (DSRV) program in the early 1970s. Readers of *Blind Man's Bluff* will, however, be aware of the other factors which contributed to those highly sophisticated vehicles. With industry discarding diver lock-out submersibles as a means of transporting saturation divers to great depths, vehicles such as LR5 became surplus to their requirements and some were adapted for submarine rescue using the DSRV philosophy. While LR5 overcame many of the shortcomings of DSRV in terms of mobility and deployment from a wide variety of platforms, it likewise lacked a means of maintaining the survivors at the pressure under which they were rescued for transfer into decompression systems.

Against this background, the Royal Australian Navy (RAN) identified an urgent requirement to provide a rescue capability prompted by the imminent sea trials of its new *Collins* class submarines. A previous attempt to acquire such a capability, using the Perry submersible PC-1804, had foundered when the real costs of operating such a vehicle became clear.

2. THE AUSTRALIAN CHOICE

Confronted with a challenging timeframe of less than a year to acquire recompression chambers, pressure-proof pods for posting Emergency Life Support Stores (ELSS) and a submerged rescue capability, the obvious solution was to draw on an existing capability on a "flyaway" basis. Two systems immediately came to mind:

- The USN DSRV (unsuitable because of lack of deployment platforms); or
- as Alan Hoskins has just illustrated, the UKs LR5.

The easy option would have been to rely on LR5 and such a solution would have met the expectations placed on the Submarine Escape and Rescue Project (SERP). It would not, however, have allowed survivors who might have rescued under pressure to be transferred into decompression chambers at the same pressure. It would also have required a specific type of Offshore Support Vessel (OSV) to be permanently chartered at a cost likely to exhaust the available funds with little tangible return.

Following consideration of a paper discussing the options available to it, the RAN decided to embark on a program to acquire its own capability using a diving bell as its basis. The reasons behind this were a perception that submersibles were complicated systems requiring high skill levels to conduct successful submarine rescue operations. They were also relatively heavy since the control compartment needed to be separate from the rescue chamber in order not to saturate the pilots.

The acquisition of the Australian Submarine Rescue Vehicle (ASRV) *Remora* as a leased capability owned by the Australian Submarine Corporation (ASC) was a triumph of fast-tracking for Hard Suits Inc. of Vancouver, Canada. Even with a Government-caused delay of 10 weeks, the system was conceived, designed, built, trialled, certified and delivered inside 11 months. *Remora* (**Fig 1**) was different to any other rescue vehicle.

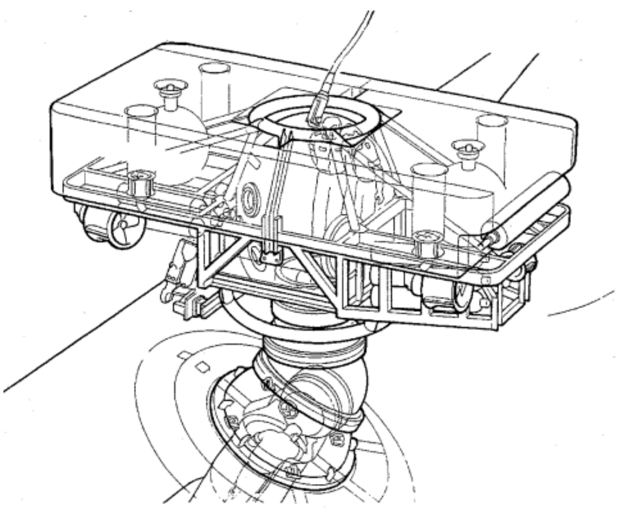


Figure 1: ASRV Remora mated to a disabled submarine at angle.

Firstly, it was a Remotely Operated Vehicle (ROV) built around a converted diving bell as its rescue chamber. Secondly, and this is its most unique feature, its skirt was articulated with two rotary joints allowing the sealing face to align with a rescue seat lying at up to 60° from the horizontal while still allowing the vehicle itself to remain upright.

Remora was delivered on time and within budget and formed the centrepiece of the first air-portable system to incorporate a Transfer Under Pressure (TUP) capability. Its utility was significantly enhanced when an air-portable Launch and Recovery System (LARS) was acquired from Caley Ocean Systems in 1998. (see **Fig 2**)

Figure 2: *Remora* and its LARS

3. SRV VERSUS RORV

3.1. KEY DIFFERENCES

The difference between free-swimming submersibles, known as Submarine Rescue Vehicles (SRVs) and Remotely Operated Rescue Vehicles (RORV) is not as stark as simply that one is untethered. While the umbilical clearly has a significant impact on RORV operations, the first consideration in choosing a submarine rescue capability is whether or not it can be afforded. In the light of the *Kursk*, some would also include political cost in that equation.

3.1(a) Affordability

While acquisition costs always loom large in any system, the reality is that, where such a system does not form part of the “core business” of the acquiring party, operating costs will generally form a much higher proportion of the through life costs than would otherwise be the case. Thus, the USN found itself spending tens of millions of dollars each year maintaining a capability mainly because each pilot came to the Deep Submergence Unit with no basic submersible piloting skills. It takes about 18 months to produce a competent submersible pilot and, with a posting cycle of 2-3 years, the training overhead is clearly very significant with DSRV deployed almost every week of the year.

The UK took a very different approach and engaged industry to meet its needs. As mentioned, LR5 became surplus to the offshore oil and gas industry and is privately owned and operated. While pilots still need offshore time to maintain their skills, the pilots tend to make this job their career since the market for submersible pilots is now very small. This keeps costs to a manageable level.

The RORV, on the other hand, can draw on ROV pilots who can, and generally are, employed around the world and whose services can be called on when required. Training is still required to deal with the various unique aspects of submarine rescue such as skirt alignment, but experience has shown that a competent ROV pilot can achieve a “mate” within 30 minutes of first taking the controls. Provided the “pool” of pilots is carefully maintained, the RORV can thus be maintained with a small core team of four to five with offshore deployments conducted at intervals of months compared to weeks.

3.1(b) Power

The indisputable aspect of the SRV/RORV argument is that the umbilical gives virtually unlimited power to the vehicle. Conversely, the drag imposed by the umbilical in a current demands a powerful vehicle to pull it through the water. Once at the DISSUB, however, and mated, the RORV is not constrained by battery endurance in using that power to dewater the skirt or pump water ballast overboard. This removes the requirement for an extra “hard” tank into which water must be transferred with attendant weight savings.

Some vehicles have no means of dewatering the skirt except for draining the contents into the submarine’s bilges. This requires a co-operative submarine crew and a double hatched tower underneath the rescue seat. Some smaller submarines do not have the space for a dedicated escape tower, relying instead on the conning tower for escape.

3.1(c) Communications

Here the RORV has a clear advantage over the SRV. Not only is it equipped with underwater telephone and a tracking transponder, it also has fibre-optic cables in the umbilical for transferring voice, sonar and video data to the surface.

Remora is limited in its UWT capability since the only transducer is pointed up as a back-up to the umbilical for the safety of the bell occupants. It is therefore unable to exploit the acoustic benefit of being in the same water stratum as the DISSUB and UWT comms between surface (the Navy Coordinator Rescue Forces) and DISSUB are conducted over a separate UWT transducer lowered over the side. This introduces interference problems from the support ship machinery as well as the real issue of communicating across thermal layers. Plans are in hand to fit a second transducer to the lower half of *Remora*.

3.1(d) Umbilical Management

Clearly, this issue relates only to RORVs. Much is made by its detractors, that the RORV is severely constrained by the presence of an umbilical with entanglement and breakage the most commonly highlighted issues. It is true that an umbilical requires extra care but fouling around hydroplanes and rudders has never been encountered using umbilicals of the dimensions of that fitted to *Remora*. The 50mm diameter double armoured umbilical which has a bend radius of approximately 1.5m cannot be compared with the 20mm flexible garden hose used by smaller ROVs such as *Scorpio*. The floats fitted to the first 30-40m of the umbilical for snatch management also keep the umbilical well clear of any protuberances.

The failure of the umbilical in the last Exercise *Black Carillon* (April 2001) was not a result of snatch, bending or fouling as some of the bar talk would have it. It was caused by a manufacturing defect unable to be analysed or corrected at sea because of a decision not to acquire the appropriate test equipment. That shortcoming has been addressed and the new umbilical performs significantly better than its predecessors.

If multiple umbilicals or cables are in the water, then careful management is necessary to avoid conflict. This is possible if all systems are umbilically connected; less so if one of the vehicles is free-swimming.

Finally, if umbilicals were as vulnerable as some would suggest, it would be most unlike an industry as competitive as offshore oil and gas to risk unproductive time loss caused by umbilical failure. Vehicles of the same characteristics as *Remora* have been commonplace in the North Sea and Gulf of Mexico for many years now and ROVs frequently weave their way in (and out) of platform legs without problems.

3.1(e) Visibility

Any vehicle working underwater needs to provide the pilot with the best possible view of the environment and, of course, the target. With a large domed viewport, submersibles such as LR5, have an advantage over other systems which have to rely on cameras or small viewports. These other vehicles include DSRV (USN, Japan) and *Remora*. If, however, this was the sole determinant for successful outcomes underwater, industry would have retained manned vehicles for underwater intervention.

3.1(f) Launch and Recovery

The umbilical provides both benefits and problems for launch and recovery. The major benefit is significantly simplified recovery since latching can occur sub-surface away from the splash zone. Even though diverless recovery systems are now being developed for SRVs, there still will remain high levels of human involvement in snagging the tow/recovery line.

Conversely, once the SRV has been "captured" and can be towed, the support vessel can make some headway and so reduce the difference in motion. The RORV support ship needs to remain stationary, reducing its ability to manage its own motion.

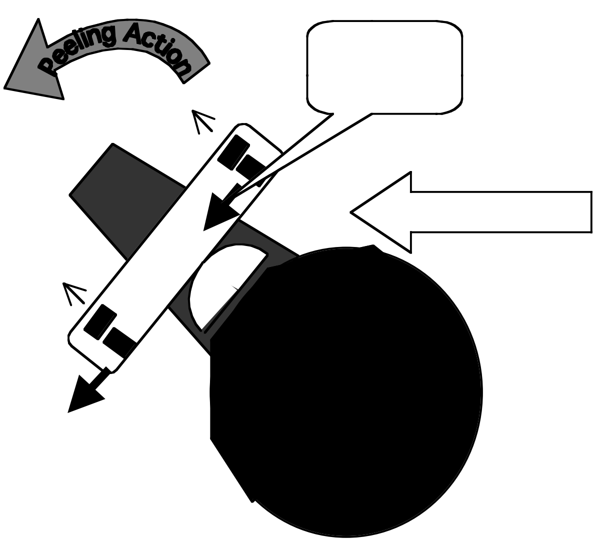
3.1(g) Articulated Skirt

While the articulated skirt is not necessarily a feature unique to the RORV, it is unique to vehicles produced by OceanWorks International (previously Hard Suits Inc.) since it owns the patent to that concept. The great strength of the articulated skirt is that the rescue vehicle can remain in its normal attitude throughout the rescue cycle. Not only does this do away with complex trimming systems (including some which use mercury as the trimming medium), it allows the crew to operate in the most effective attitude.

Most importantly, it permits the rescue vehicle to maximise its thrusting capability. Consider a situation where a submarine is lying at an extreme angle in a strong current. Both types of vehicles will typically stem the current.

The SRV has to approach the DISSUB, align itself with the DISSUB angle and then attempt the mate. Underwater vehicle thrusters are typically strongest in the longitudinal direction since progress against a strong current is the most demanding criterion. This is also the direction against which wetted cross-section is optimised. Vertical and athwartships thrusters, however, are generally rated to approximately 25% of the longitudinal power. Added to this is the overall limitation imposed by battery endurance. **Fig 3** illustrates the problems faced by a SRV attempting a mate in this situation.

The vehicle with an articulated skirt is able, as illustrated in **Fig 4,** to stem the current while keeping its main thruster power, generally stronger than available to the SRV, working to best effect. It does not, in effect, "expose its belly" and also offers the occupants the best possible environment in which to conduct the challenging task of bringing stressed survivors into the vehicle.



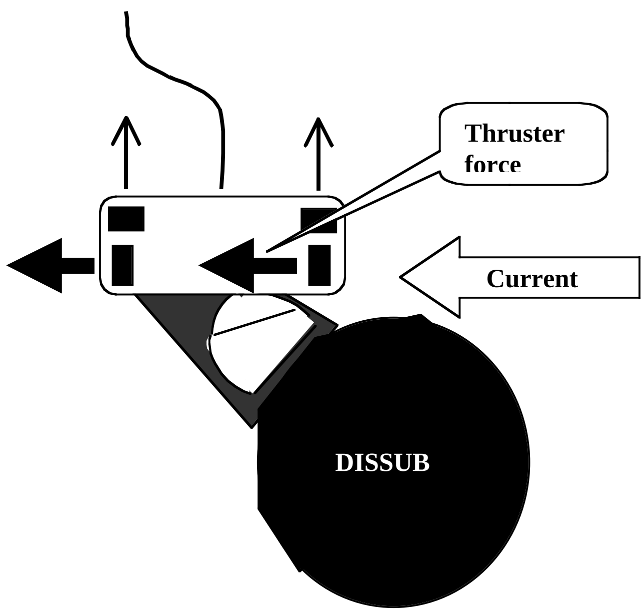


Figure 4: RORV mating against a strong current

3.2. TECHNICAL IMPROVEMENT

Since the SRV is now only operated by tourist companies, scientists and some submarine rescue providers, the opportunities for technological enhancements through research and development are somewhat limited. The offshore oil and gas industry, on the other hand, is always looking for ways to reduce its costs and innovative systems such as laser line scanning systems, interaction with CAD packages and improvements to umbilical technology can have immediate translation into submarine rescue with little modification.

4. PROGRESS IN RORV DESIGN

4.1. PRESSURIZED RESCUE MODULE SYSTEM

With the US Navy's decision to adopt the concepts pioneered by *Remora* has come significant development. The key improvements are explained below.

4.1(a) Rescue Chamber

Where *Remora* adopted, by choice and time constraints, an existing bell, the Pressurized Rescue Module (PRM) will incorporate a cylindrical pressure vessel (**Fig 5**). Not only does this provide "comfortable" accommodation for 18 personnel compared with *Remora*'s cramped seven, it also provides displacement and the ability to dispense with several hundred kilograms of syntactic foam buoyancy blocks.

Also, while adoption of a diving bell with its very "stiff" metacentric height forced development of the articulated skirt for *Remora*, the PRM has the flexibility of being able to change its pitch should that prove necessary. To do so, however, especially in a strong current, would expose the PRM to the same problem faced by systems without an articulated skirt – exposure of the "belly" to the current.

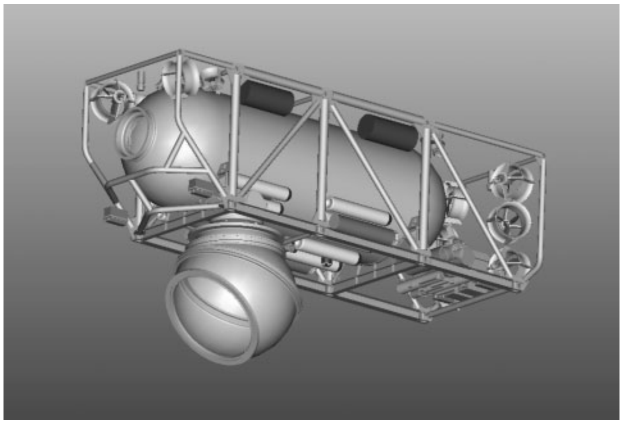


Figure 5: Pressurized Rescue Module (PRM)

4.1(b) Personnel Transfer

Remora was formerly a saturation diving bell and the act of TUP was simply an extension of the normal means of transferring divers into their saturation "habitat" by mating the vehicle to the top of the TUP chamber. Although this is not an issue with healthy divers, this presents some difficulties in the submarine rescue situation. Firstly, the skirt had to be removed if the height of the overall structure was to be maintained within reasonable limits. While this is not overly time-consuming, taking around 20 minutes to accomplish, it adds complexity to the system.

Secondly, while vertical transfer of survivors into the rescue vehicle from the DISSUB cannot be avoided, the patients may well have been stabilised while inside the rescue vehicle. Removing them from a stretcher in a horizontal position back to the vertical for lowering into the TUP chamber could well be dangerous.

The PRM, along with LR5 in its modernised configuration, has adopted a means of mating horizontally to a Deck Transfer Lock (DTL) where stretcher patients can then be maintained in a horizontal position while being transferred into the Decompression Chambers. Use of a vertically-oriented chamber as DTL allows this to occur since the stretcher can be brought horizontally onto an intermediate "ledge", attached to a hoist and lowered to the floor. The stretcher can then be passed through manways into the Decompression Chambers. The arrangement is illustrated in **Fig 6.**

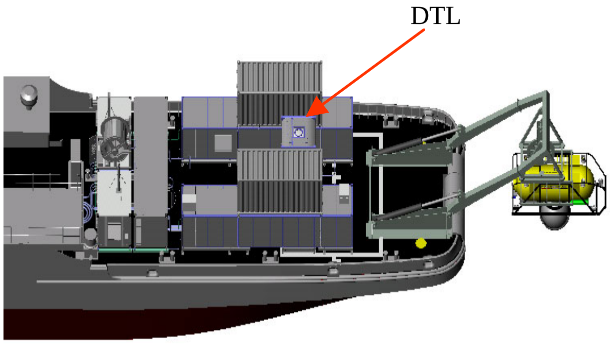


Figure 6: SRDRS on US Navy T-ATF Vessel

4.1(c) Rescue Chamber

As mentioned, the PRM rescue chamber (**Fig 7**) is considerably more comfortable than *Remora*. Each person has a seat, the chamber is fitted with an Emergency Breathing System (EBS) for all occupants, rather than merely the attendant, and there is room for stretcher-borne patients.

Figure 7: Internal View of PRM Rescue Chamber (looking aft)

5. RORV PROSPECTS

Since the tragic loss of the *Kursk*, navies have had to confront their responsibilities with respect to submarine rescue and it is no coincidence that Singapore, India and the Peoples Republic of China are all planning acquisition of such a capability. The RORV is not necessarily the answer for all. Singapore has already decided to adopt the SRV while NATO, which already had formed a cooperative project for a NATO Submarine Rescue System (NSRS), is relying on industry to identify the most cost-effective options.

Release of a Request For Tender (RFT) by India is understood to be imminent and her requirements are understood to be for two systems. Although it is unlikely to be specified, India's preference is understood to be for a RORV. The People's Republic of China presently operates a DSRV which is understood to be obsolete. Replacement plans are unclear at present but it is understood the acquisition program is well underway. Informal feedback from the Japanese Maritime Self Defence Force during the recent submarine rescue exercise *Pacific Reach 2002* was that Japan was likely to adopt the RORV once it needed to replace its DSRVs. The first of these DSRVs is now 10 years old and replacement may well occur in the next ten years.

If such a rescue capability is to follow the same principles as the RAN and USN where a relatively small core team is supplemented when necessary from a pool of practitioners in industry, the RORV technology is probably the most suitable. Where a permanent team is to be maintained, whether that be naval or civilian, either system could be used.

6. CONCLUSIONS

Although it was not perfect, ASRV *Remora* brought a new perspective to submarine rescue in 1995. Not only was submarine rescue demonstrably affordable by a single navy, it opened the field to range of technologies not previously considered. Too often, however, the arguments rage between proponents of one system or the other about the merits of each and all too rarely is there recognition that each type of vehicle can perform the act of submarine rescue extremely well, each with their own particular strengths and weaknesses.

The fundamental issue is one of through-life costs. It is not worth spending several million units of your national currency to acquire a rescue capability if the ongoing costs cripple the navy. It is also not necessarily worth equipping naval personnel with submersible piloting skills if those skills cannot be put to good use in their subsequent career postings.

The RORV is not therefore suitable for all. Adoption of the technology by the US Navy will tend to lead others in the same direction but it will be ongoing development of ROV technology by the offshore oil and gas industry which will sustain the RORV. A bold prediction of this paper is that by 2030, there will be no free-swimming SRVs remaining in service.

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