MUDDYING the WATERS (littorally speaking):

Rethinking Coastal ASW

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INTRODUCTION: DOCTRINAL ASPECTS

> 'At sea, the emphasis is continuing to move away from large scale maritime warfare and open-ocean operations in the North Atlantic. In future littoral operations and force projection, for which maritime forces are well suited, will be our primary focus.'[1]

The arguments projected in this article are founded on the belief that much current Anti-submarine Warfare (ASW) doctrine remains imbedded in its Cold War roots. If true, this doctrinal obsolescence lays two traps. One, the perceived total submarine threat is linked to the past, rather than the present and future. In other words, the reduction of the old Soviet submarine threat still threatens to overshadow the horizontal proliferation of conventional submarines and – more importantly – associated technologies. Two, tactically we are in danger of confronting the wrong threat. This paper examines the latter. It does so from the perspective of current ASW doctrine as defined in *AP 3000* and

Reduction of the older Soviet submarine threat overshadows the proliferation of conventional submarines such as the export Russian Kilo class seen here

BR1806. Political options, such as responding to a rogue state's illegal use of submarines (or any other military asset) by way of military coercion or economic sanctions, are not considered here. That is not to argue that they are not valid counterforce solutions, but merely to reflect that they are the domain of the political or foreign policy analyst – not the military commentator. For those who perceive this delineation an academic 'sharp practice', consider the following.

Sea Control is defined thus:

> 'The condition which exists when one has freedom of action to use an area of sea for one's own purposes for a period of time and, if necessary, deny its use to an opponent. Sea control includes the airspace above the surface and the *water volume and seabed below*.'[2]

Therefore, we must maintain the means to fulfil this condition for current maritime doctrine to remain tenable. If we cannot, then the expeditionary mission in the opening quote is not underwritten and consequently our foreign policy – and its associated procurement programme – is in default. One further point, aimed at those who would argue that we can merely coat-tail the US: the shortfalls in littoral ASW capability highlighted in this article are not merely British, they are evident throughout NATO and beyond.

DEFINING THE LITTORAL

There is broad consensus on the definition of the littoral region in the military context:

> 'The area from the open ocean to the shore *which must be controlled* to support operations ashore, and the area inland from the shore which must be defended and supported from the sea.[3]

Opinions differ on the distances involved: in some circumstances, the US envisage the littoral extending to 650 nm offshore, whilst the UK generally limit the range to 200 nm.[4] Most analysts agree that, within these broad parameters, the littoral region is determined more by military capabilities that geographical characteristics.[5] For example, the US Office of Naval Intelligence (ONI) has evaluated Iran's littoral defences and concluded that they extend to 100 nm: enough to cover the Straights of Hormuz from shore to shore.[6] The key word in the definition above is 'control'. As defined earlier, in the context of littoral operations, air supremacy is a pre-requisite. In simple terms, ASW forces cannot fulfil their role effectively unless they are operating in a benign environment.

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THE OMNIPOTENT TARGET

Assuming air cover has done its job and ASW forces have freedom of action, how difficult is ASW in the littoral environment? Who better to ask, than a littoral submariner:

> 'In the Royal Swedish Navy's experience, the conditions make it very difficult to detect and prosecute a submarine. Put simply, the Baltic is an ASW officer's nightmare and a submariner's heaven...For an aggressor, submarines operating in the littoral environment are very bad news, and the resources and time required to find and prosecute a submarine threat are likely to be disproportionately high.'[7]

Although littoral environmental conditions are complex and infinitely variable, poor sonar conditions resulting from unfavourable topography and downward refracting sound velocity profiles (SVP) are the norm, rather than the exception. The ambient noise in coastal waters is generally higher than in the open ocean due, in part, to the many varied commercial shipping movements that are focused in offshore areas. Seismic and oceanographic surveying associated with the oil and gas industries are also on the increase. These activities, coupled with the sound generated by fixed and mobile petrochemical installations and their support infrastructure, increases the noise entering the water. Equally, propagation loss of sound (proploss) is exacerbated in shallow water. The effects of wind and (to a lesser extent) tides increase surface losses, while the thin sedimentary layer, typical to coastal regions, produces high bottom loss. The combined proploss is often greater in shallow water than over a comparable distance in deep water. Large variations in salinity, seldom seen in deep water, are common in some shallow water areas. River discharges, land run-off and ice-melt-water in coastal regions all effect significant changes in the salinity of the water mass and hence the SVP. Similarly, in areas of high ambient temperature, solar heating can cause evaporation and thus generate near-surface salinity gradients. In extreme cases, the combined effects of salinity and temperature can greatly restrict sonar performance. For example, during the spring in the Norwegian littoral a positive sound speed gradient produces a surface duct that has an almost impenetrable shadow zone beneath it. Equally, during the summer months, downward refraction and reverberant topography combine to make the warm waters of the Red Sea and Gulf of Oman extremely difficult to search. In both cases covering the full water column, even with variable depth sonar or adjustable sonobuoy cable lengths, becomes problematic.

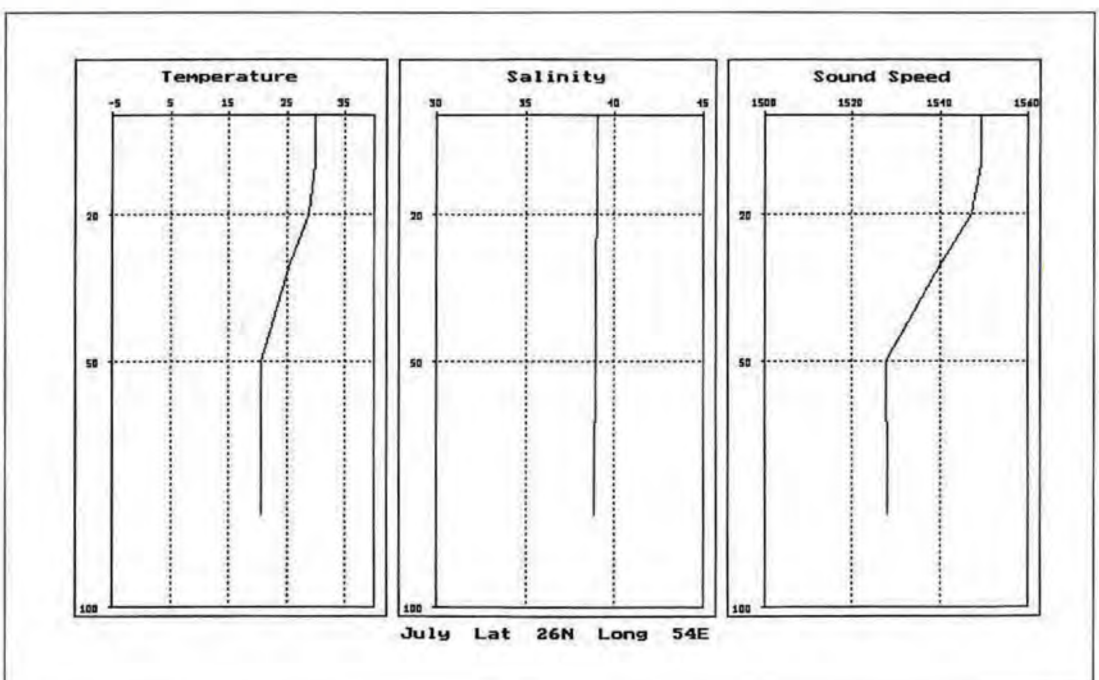

Figure 1

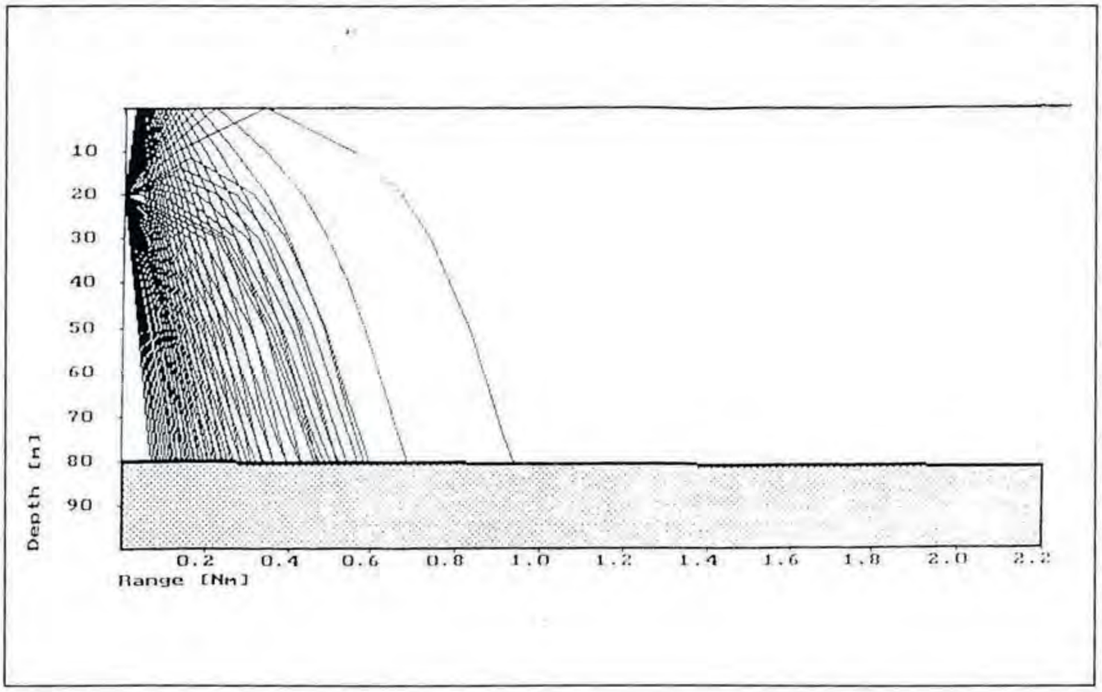

Figure 2

The combination of higher ambient noise, increased proploss and variations in salinity, all degrade the performance of both active and passive sonar systems. Of course, the poor conditions affect both submarines and ASW forces; but the equation is not an equal one. Capt Lundgren again:

> 'The submarine can exploit these poor sonar conditions, operating close to, or sitting, on the bottom. Although the environment also affects the submarine's ability to detect targets, there are sound channels that make it possible to establish tactically significant passive sonar ranges even during worst summer period conditions. These channels also provide a sonar window in which the submariner itself can be detected. However, the latter has the advantage of being able to choose the time spent in the sound channel, and can easily hide again in the thermocline or close to the bottom.'[8]

Above the surface, radar searches are complicated by the high contact density, and especially by the myriad of small intermittent contacts resulting from small surface traffic, fixed and mobile buoys of all varieties, shoaling waters and surface debris. To complete the scenario, geological magnetic interference – when present – is usually at its most intense in shallow water. Into this unfriendly environment, the submariner is bringing a host of technologies that threaten to make him virtually omnipotent.

Launch of the *Västergötland* by Kockums, Malmö, September 1986

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SUBMERGED ENDURANCE & AIR INDEPENDENT PROPULSION (AIP)

Tactically, the littoral offers an advantage to even the oldest conventional boats, simply because they do not incur the battery life penalties associated with lengthy outbound transits. Creeping around a patrol area relatively close to its operating base, a typical modern European SSK will comfortably maintain battery mode for 72 hours at a patrol speed of 3 knots, with or without air independent propulsion (AIP).[9] Russian built boats perform even better.[10]

Although AIP has taken an age of gestation, it is not a new idea: the German Navy conducted sea trials on an AIP system between 1936 and 1945 (the Walter V-80).[11] Although AIP is a broad term, in the context of conventional submarine propulsion it is taken to be a means of propelling a vessel without diminishing the battery charge, or utilising the surface. Historically, analysts from the major Western navies have been somewhat dismissive of AIP in particular and the conventional submarine in general. There has been an ongoing debate over the relative merits of both, in the pages of the USN's magazine: *Proceedings*.[12] Closer to home, one eminent commentator has stated:

> AIP in some forms is inherently dangerous to live with in a confined space and its advantages are not that compelling unless a diesel submarine is forced to operate in a very hostile radar or surveillance environment...but the idea that this could develop into an alternative for nuclear power is nonsense.[13]

There is a marked oxymoronic element to the abstract above: surely it is the function of ASW forces to ensure that an opposing diesel submarine *always* has to operate in a hostile environment; moreover, AIP has been developed to counter-balance this very situation. Notwithstanding the inherent problems and technical difficulties, AIP is coming of age, as the following summary shows. In the context of military submarine operation, there are four main variants of AIP: all are operational, or at an advanced stage of integration with an existing platform.[14]

- **The Closed Cycle Diesel.** The closed-cycle diesel (CCD) is basically an engine which 'breathes' its own waste. In order to function, water and carbon dioxide must be removed from the exhaust gases before they can be fed back the combustion chamber. Various methods of exhaust gas regeneration exist: water absorption is the preferred option in the current designs intended for military use. A 400kw CCD is under development for the Dutch *Moray* Class SSK.

Moray Class SSK

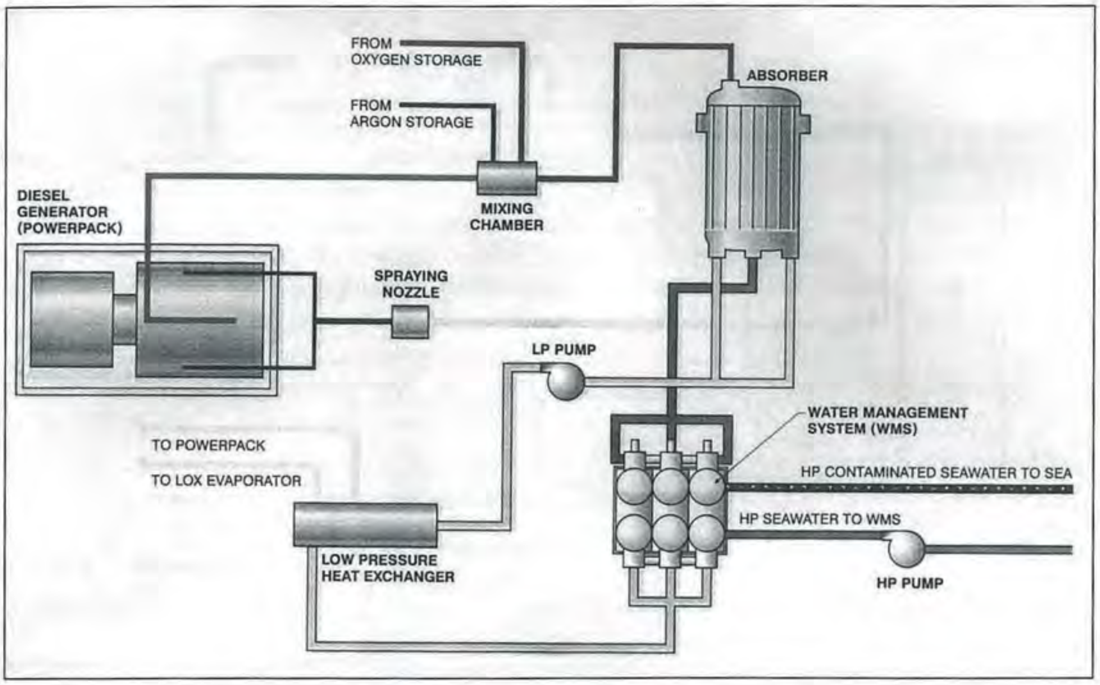

Figure 3

- **The Stirling Engine.** Robert Stirling developed the Stirling Engine in 1816. It is an external combustion engine that burns diesel oil in pure oxygen in a pressure vessel, creating a thermodynamic cycle. Stirling engines are small and are therefore either used in groups, or act as a supplementary propulsion source. Sweden has operated the Stirling engine successfully for over twenty years and both the Japanese MSDF and Australian Navy are investigating possible Stirling engine retrofits. There is one other significant benefit of the Stirling engine: it is typically 25dBA quieter than a normal diesel.

- **The Rankine Cycle.** The Rankine Cycle utilises a design derived from the secondary circuit of a nuclear propulsion system that is functioning in turbo-electric mode. In the design, the nuclear reactor is replaced by a conventional thermal source, such as the oxygen-ethanol combustor fitted to the 200kw MESMA system supplied for the Agosta 90B operated by the Pakistan Navy. Thermal energy produces steam which generates electricity via a turbo-alternator.

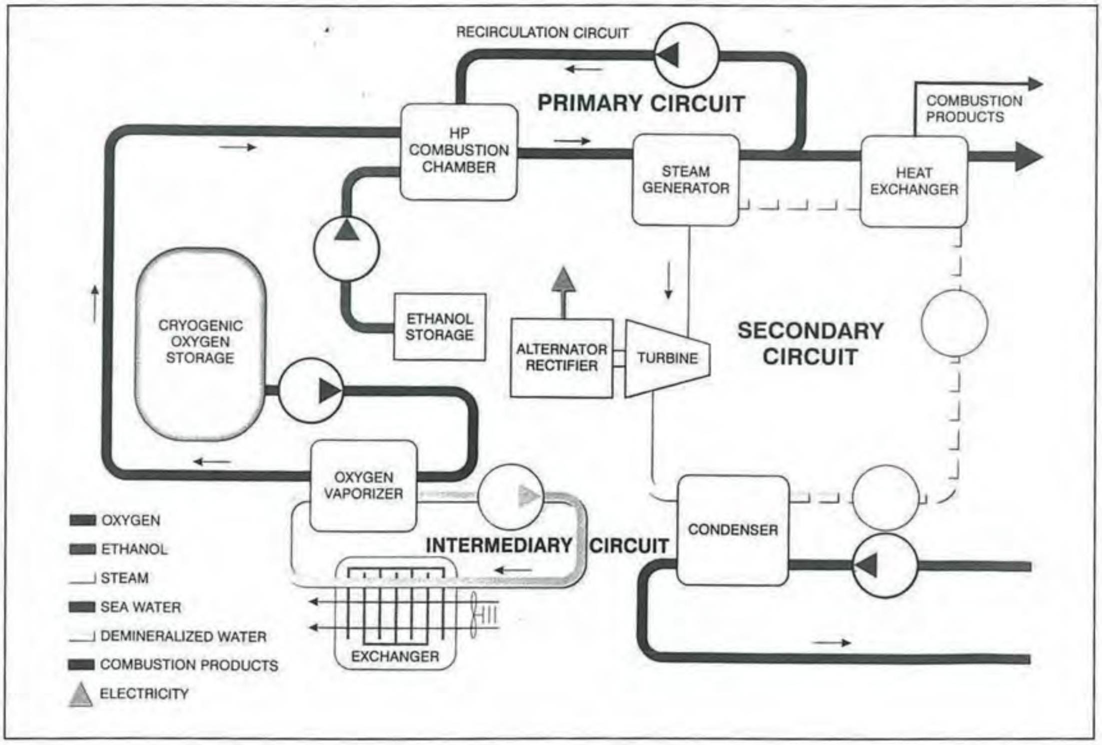

Figure 4

● **Fuel Cell.** Fuel cell technology also dates back to the early nineteenth century. Discovered by Professor William Grove, it is the process by which electricity is produced by electrochemical reaction, without combustion. Currently Siemens' Polymer Electrolyte Membrane (PEM) fuel cell can be retrofitted as a 'hybrid' component in various German designs. However, the Canadian company Ballard is extending the concept to form the basis of the first all fuel-cell propulsion system: the so-called 'monoboat' principle. The Ballard system, offered as an Upholder Class retrofit, will produce submerged endurance of over 30 days.[15]

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COMMUNICATIONS, SENSORS AND TACTICAL SYSTEMS

Increased submerged endurance is not the only submarine characteristic that is limiting detection opportunities. Improved exploitation of passive acoustics through data fusion and tactical systems, submerged communication facilities, modern environmental systems and smart weapons, all combine to produce a formidable subsurface weapons system; crucially, one which is becoming easier to operate effectively. All of these technologically advanced capabilities are available commercially off the shelf (COTS). One marker by which this process of automation may be measured is the dramatic decrease in crew size over the past thirty years. In the early sixties a 2000 tonne SSK would have been crewed by approximately 70 officers and ratings. By the eighties that figure had dropped by 40 percent. Progress continues unabated. The contemporary SSK reflects the fusion of technological progress in all the areas detailed above:

> 'A good submarine is one which is a homogeneous whole. The platform, propulsion plant, signatures, weapons and sensors as well as the navigation, communications and command and control systems must be designed, developed and manufactured as one overall system.'[16]

As state-of-the-art examples, the German T212 and Swedish Gotland Classes have complements of approximately 27;[17] whilst the 3000 ton Australian Collins Class – one of the largest SSKs ever built – has a crew of only 43. For those who doubt the importance, relevance and salience of the submarine as a future asset of maritime security and, conversely, as a potential threat, the Collins class provides a definitive lesson. A high-risk programme and one that is not without teething problems, at US$3.4 billion the Collins SSK is Australia's single most expensive defence equipment

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acquisition project.[18] Australia has a history of parsimony when it comes to defence expenditure, but in this case, she has seen the writing on the wall. Faced with rapid Asian Naval expansion, Australia has selected and procured arguably the best guarantor of maritime security. Other naval forces will undoubtedly follow suit.

The ASW community has been slow to respond to the barrage of advancing sub-surface technology, thus the remainder of this article focuses on the measures needed to restore some measure of equilibrium to an equation that is dangerously one-sided.

RE-THINKING CONVENTIONAL ASW

The progressive improvement of tactics and training are inevitable requirements in the solution of any given military dilemma but, in the context of littoral ASW, a technological breakthrough is needed before these vital issues can be addressed. Fortunately one is at hand. Given the SSK's inherent low passive signatures and the rapidly reducing opportunities for radar detection, active sonar offers the best prospects for disturbing the littoral submariner's asymmetric advantages. Many ASW analysts are advocating Low-Frequency Multistatic Active (LFMSA) as a vital ingredient in countering the SSK/littoral threat.[19] LFMSA requires the deployment of both passive sonobuoys and multiple acoustic 'sound sources' (such as the US air-deployable SSQ 110 Extended Echo Ranging sonobuoy).[20] The sound sources are activated sequentially and the resultant echoes are monitored on a passive sonobuoy field.[21] In addition to the actual detection prospects, two inherent advantages are immediately apparent. First, LFMSA will augment the passive acoustic search, because it will utilise the same sonobuoy field. Second, it is extremely overt, thereby forcing the submariner to proceed cautiously. The unforgiving acoustic and geological conditions in the littoral will ask much of the data-fusion, false alarm and automatic classification devices, but acoustic systems such as the Autonomous Multistatic Active-Passive Processing System (AMAPPS) are technical realities which will soon be commercially available.[22] LFMSA may be in its infancy but, added to existing sensors as part of a multi-platform package, it has the potential to significantly alter the littoral balance in favour of ASW units.

Building on the anticipated arrival of LFMSA, a coherent approach to littoral ASW becomes viable. Traditionally, ASW against the diesel boat is founded on the twin pillars of deterrence (operations to inhibit a submarine and deny it freedom of action) and detection (operations designed to locate and destroy a submarine during hostilities).[23] However, the detect/deter tactical variations are often small and inconsequential; moreover, in a multi-national, multi-platform force, unit deviations often render the differences between submarine deterrence and detection largely immaterial (not least, because on-scene tactical commanders will apply their own initiative and idealogy). LFMSA, coupled with data fusion and sensor interoperability, offers to render the detect/deter tactical dichotomy an irrelevance. Designed to detect, LFMSA is by its very nature, overt and aggressive. In order to maximise the benefits of LFMSA, ASW platform designs should harmonise sensor operation, such that all the main search sensors can be focused simultaneously. At the unit level and in the case of the LRMPA, the littoral ASW search would include LFMSA, passive acoustics and radar, all operating synergistically. When this homogeneous package is deployed as part of closely integrated combined ASW force, including ships, helicopters and friendly submarines, the task of the hostile SSK is no longer elementary.

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Training forms the third element of this doctrinal triad. ASW has long been recognised as a perishable art and the UK maintains, arguably, the best ASW training organisations anywhere in the world. Outfits such as the Joint Maritime Operational Training Staffs (JMOTS) have a long and prestigious history in the field of ASW excellence. Yet, if any criticism can be mounted against JMOTS, and other ASW establishments, it is that all too often training programmes and exercise scenarios are skewed towards unrealistic detection opportunities, either through scripted interaction, target augmentation or pre-programmed run-plans. That is not to argue that operator training is not vital – or course it is! No amount of simulation can realise all the benefits of real submarine contact and, within the context of a layered basic training programme, some interaction must be guaranteed. But unless the overall training plan includes the provision of challenging littoral ASW exercises against un-scripted modern SSKs *over a realistic timeframe*, tactical expertise will diminish relative to technological progression. Worse still, continuous unrealistic detection opportunities can breed complacency and inhibit tactical innovation.

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German Type 209 under construction

CONCLUSION

Is the threat of conventional submarine proliferation being overstated? Market analysts project that a conservative estimate of the total conventional submarine market is comparable with the current global expenditure on military fighter, attack and trainer aircraft.[24] Although not all of the most sophisticated models will be immediately released, two widely exported designs, the Russian Kilo and the German T209, are being updated and aggressively marketed.[25] Many of the submarine innovations described in this article are being retrofitted to these commercially attractive packages. The traditional submarine versus anti-submarine technological pendulum has swung progressively towards the modern SSK over the last two decades. A comprehensive ASW capability is an integral component of any expeditionary force that may need to operate in the littoral environment; the future of this capability hangs in the balance. The UK is moving in the right direction with several major ASW projects in an advanced stage of development: notably the MERLIN and the NIMROD MRA4. However, to count in the littoral they will need LFMSA and their operators will need a fresh approach. In an award-winning essay in which he highlights the perils of embedded dogma, Captain Bruce Linder USN encapsulates the littoral threat. In deference to his literary eloquence, he shall have the last word:

> 'It is becoming increasingly clear that the next substantial US naval expedition abroad – the next Desert Storm – may well face an enemy with submarines in its order of battle. The transfer of sophisticated diesel submarines to regional powers and third world wannabes is on the upswing...these will be the weapons of war that an enemy will order forward to lurk unseen in harbour approaches, in roadsteads and anchorages, or off homeland reaches susceptible to amphibious attack. Their mission will be to disrupt and sting, to slash and feint, to use stealth as a mugger might use the shadows. Their jab will be that of a stiletto, sharp and clean'.[26]

NOTES

1 *The Strategic Defence Review* (1998) The Stationery Office, p.22.

2 *BR 1806 Fundamentals of British Maritime Doctrine* (1995) HMSO, p.221.

3 Ibid, p.235.

4 See Fraser, *S Littoral Warfare and Joint Maritime Operations* (1997) CDISS, Lancaster University, p.10 & US Navy, Forward...From the Sea: The Navy Operational Concept (1997) passim.

5 Op Cit Fraser, S (1997), p.10.

6 See *Janes Navy International* April 1997, p.4.

7 Lundgren, C Royal Swedish Navy 1st Submarine Group *Stealth in the Shallows: Sweden's Littoral Submariners* in *Janes Navy International* (1997) 102:9, pp.16 & 23.

8 Ibid, p.16.

9 Andres de Lionis *The Allure of AIP beckons the Navies of Developing States* in *Janes Intelligence Review* February 1998, pp.39-41.

10 Windolph, W *The Better AIP* in Naval Forces 4/98, p.119.

11 Gabler, U *Submarine Design* (1986) Bernard & Graefe Verlag, Koblenz, Germany, p.78.

12 Following article from *Proceedings* Capt C Wilbur USN (rtd) *Remember the San Luis!* March 1996, pp. 86-88; Rear Admiral W Holland USN (rtd) *Diesel Boats Again?* June 1996, p.13; Cdr J Lodmell USN *It Only Takes One* December 1996, pp.30-33; Rear Admiral W Holland USN (rtd) *Battling Battery Boats* June 1997, pp.30-33; Cdr P Murdock *SSNs Aren't Enough* February 1996, pp.48-51.

13 Capt Richard Sharpe, editor *Janes Fighting Ships 1997-1998*, p.23.

14 Robertson, T *Air Independent Propulsion: A Look at What is Currently on Offer* in *Naval Forces*, 6/96 pp.36-39.

15 Grant, D *Canada gets a Deal on Upholder Buy* in *Naval Forces* 3/98, pp.10-14.

16 Rear Admiral Waldemar Feldes (Chief Navy Systems, German Navy) *The Realisation of Operational Requirements in International Defence Technology* Sep 1997, p.14.

17 Rauch, H & Dinse, R *Submarine Class 212* in Ibid, pp.41-44 & Lindholm, S *Gotland Class Submarines – A New Breed* in *Sea Technology* November 1998, pp.25-31.

18 Grazebrook, A *Collins Class comes up Down Under* in *Janes Navy International* Jan/Feb 1998, pp.21-35.

19 Skarda, G *21st Century Sonar Processing* in *Sea Technology* November 1997, pp.10-13 & Skarda, G Metzger, J & Wright, W *Automation and Data Fusion for Acoustic ASW in the Littoral* in *Maritime Patrol Aviation* 4:3, pp.51-57.

20 Wolf, G US *Navy Sonobuoys – Key to ASW* in *Sea Technology* November 1998, pp.41-44.

21 Op Cit. Skarda, G (1997), pp.10-13 & Skarda, G Metzger, J & Wright, W 4:3, pp.51-57.

22 Ibid.

23 *AP 3000 Air Power Doctrine*, p.66.

24 *Run Silent – Run Deep: Submarine Technical and Market Trends for the 21st Century* in *Naval Forces* 1/97, pp.69-89.

25 Ude, U & Ritterhof, J in Op Cit *International Defence Technology* Sep 1997, pp.33-35 & 54-57; Kormilitsin, Y *Working at Exports* in *Naval Forces* 3/97, pp.54-55.

26 Capt B Linder, USN *ASW as practised in Birnam Wood* in *Proceedings* May 1996, p.63.

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