

CANADA'S FUTURE SUBMARINE CAPABILITY

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ABSTRACT

Against a backdrop of constantly-changing and complex world in which Canada and the other major industrialized nations have an obligation to help prevent and contain instability as well as be responsible stewards of their own maritime domains, this paper argues that naval forces, especially submarines, have a unique role as the centre pieces of the initial response to crisis and also in providing early warning and pre-deployment intelligence. In this respect, Canada's four *Victoria*-class submarines have the potential to become invaluable players in the new crisis management strategies at home and as part of multinational operations, especially in: conducting intelligence, surveillance and reconnaissance (ISR) tasks in support of both domestic and international operations under a wide range of situations; conducting anti-shiping and antisubmarine defensive operations in distant support (as opposed to close support) of national and international formations; supporting special forces operations in counter-terrorist and counter-insertion operations in Canadian waters as well the provision of support to special forces in joint international operations; conducting "presence" operations in northern and other remote Canadian waters; and providing ASW training for national and international formations.

However, to be fully effective in these roles, a modernization program is necessary to accomplish the following:

- increase the submarines' endurance, with priority going to the introduction of an air-independent (AIP) system that would allow the submarine to conduct the greater part of a 30-day intelligence-gathering patrol;
- incorporate a sophisticated command, control, and information-management system that is capable of integrating all sensor inputs, providing the capability for data processing, and providing real-time information to supported formations and headquarters—reliable satellite communications in particular; and
- acquire state-of-the-art sensors to support the information-management role; in this, consideration should be given to the acquisition of unmanned, automated systems.

Such a modernization program, as a component of the "revolution in military affairs (RMA)" is also an opportunity to further a wide-spectrum of oceans and military R&D and create new personnel categorizations and skill levels, thereby exploiting the potentially powerful synergy

that exists between the submarine and the scientific communities, especially in areas of underwater survey and exploration and in the related process of experimentation.

INTRODUCTION

In April 1998, the Canadian Government closed the deal with Great Britain for the lease of four *Upholder*-class submarines for a period of eight years. It was not a simple arrangement and had taken several years to finalize.¹ Now, four years later and with the submarines entering Canadian service, a need exists to look beyond the immediate future at Canada's longer-term requirements for submarines, in particular at what should happen to the four *Victoria*-class submarines in the post-2010 period.² Central to this examination is the need to re-assess the functions of the submarines and to look at the new and emerging technologies that are changing the nature of submarine operations. Although these developments are closely linked to the naval dimensions of the so-called Revolution in Military Affairs (RMA), they have far deeper implications than technology alone, drawing in personnel management concepts as well as support infrastructure. In short, the opportunity to modernize the four *Victoria*-class submarines is also a significant opportunity to embrace many new technologies and military management concepts.

However, before starting to look at future submarine requirements and the longer-term implications of related change, in the broadest sense, we need to answer the overarching and essentially political question "Why maintain a submarine capability at all?" That submarines have always been a very contentious policy issue in Canada makes that question an important prerequisite to any discussion on future capabilities. The experience of Canadian submarine acquisition programs from the attempt in the early 1950s to borrow some British U-class submarines to the mid-1990s when the four *Upholders* were leased, should tell us that time spent preparing the way for the eventual political discussion is time well spent.

AIM

This paper has two objectives; the first is to look at the evolving role of the submarine in naval and joint operations and at the many new and emerging technologies that hold the potential to

¹The official announcement of 6 April, 1998 stated: "The project includes \$610 million for the acquisition and \$140 million for project-related costs. It includes the cost of crew training, simulators, spare parts, Canadian modifications, and project support. To maximize savings and value for Canadian taxpayers, the project involves an innovative eight-year, interest-free, lease-to-buy agreement in which Canada's lease payments will be 'bartered' for the ongoing use of Canadian training facilities by the British forces at Canadian Forces Bases Wainwright, Suffield, and Goose Bay." (Department of National Defence *News Release NR-98.018* of 6 April, 1998)

²The lease-to-buy agreement technically expires on 1 April 2005 but the conditions actually state that the lease starts on the acceptance date. Because the option to purchase contained in the agreement has already been exercised in the case of *Victoria*, the issue of a political decision to keep the other submarines is probably moot.

make it an even more effective platform and, second, offer some options for the future development of the Canadian submarine capability.

The approach taken is “from the general to the specific” in outlining initially the changing nature of the international system and the roles of naval forces and submarines in crisis management and in homeland security in the wake of the events of 11 September, 2001, and from there, summarizing the major technological advances that have already changed submarine operations and which have the potential to change them even further in the years ahead. From that foundation the paper looks at the options for using Canadian submarines as both contributions to international crisis management operations and as integral components in new concepts of homeland security. The final part of the paper will look at what can be thought of the “art of the possible” in making changes in the Canadian concept of submarine operations.

THE CHANGING WORLD IN WHICH WE LIVE

Even though widespread change is taking place in the international system today, several important aspects of that system have not changed. Foremost of these is the fact that the world remains a violent place. Because of this, the majority of states naturally retain the ability to defend themselves, their citizens, and their vital interests. Many states also find it necessary to act collectively to ensure the overall stability of the socio-economic system in which the global economy functions and upon which their own economies depend. In addition, a compelling moral requirement exists that demands intervention in situations we find inhuman. For these reasons, states maintain armed forces for three purposes:

1. defence of the homeland (and thus the preservation of territorial sovereignty);
2. internal security; and
3. expeditionary operations.

While a measure of choice exists in the last area—reflecting the state’s level of involvement in world affairs—the first and second areas reflect obligations on the part of a government to provide for the security of its citizens. This requirement can be seen as the price of being a sovereign state. Within this national security framework, navies have two purposes: maintain the security of the state’s ocean domain, and support the state’s foreign policy, including any contribution to collective security. Simply, navies are the instruments of state policy at home and abroad over, under, and on the oceans; as such, they must remain operationally relevant within the changing international system.

The evolution of the global economic system—globalization—has led to a rather fragile socio-economic structure susceptible to disruption at many places and in many ways. As a result, the industrialized world, of which Canada is a major part, faces threats of instability on three fronts:

- economically, because of the interdependence and lack of resilience in the global economy—largely as a result of manufacturing diversification, coupled with a trend to “just-in-time” delivery, and heavy reliance on containerization to move commodities (component parts and

finished goods) and the related dependence on high-speed data links to control production and transfer money;

- geo-politically, because of the risk that regional instability—especially where sectarian and cultural minority unrest and violence prevails—could lead to more widespread unrest and instability which, in turn, has the potential to disrupt the global economy; and
- domestically, under various scenarios, including terrorist and criminal activities, which present challenges to the established government through direct threats to national infrastructures and citizens.

In terms of the delicate balance that now exists within the global economy, any disruption to the system or any situation with the potential to deteriorate will represent an impending crisis to one or more states. Even though some infrastructure and system redundancy exists through duplication of essential services and facilities, the global economy can be brought to its knees quite easily. And when the global economy slows down or is disrupted, the impact on national economies and thus societies is almost immediate. The events of 11 September, 2001, stand as an example of the system's fragility and of our resolve to act decisively when the system comes under real threat. No country today is self-sufficient, the states of the industrialized world have become economically interdependent. Hence, the foremost national security concern is the prevention of instability in the international system.

Today, modern democracies also express international security concerns in terms of their national values. Whereas national interests are relatively easy to express in economic or territorial terms, national values are much harder to define and are invariably functions of the state's social structure and political culture. It is indeed a brave state that can include the statement that, "We do not want to stand idly by and watch humanitarian disasters or the aggression of dictators go unchecked."³ in its national strategy, as the British did in 1998. In most cases, the decision to respond to some international outrage or disaster is made in reaction to events rather than as part of some pre-determined policy. The military implications of this reality are that time for detailed planning is invariably short and a high degree of improvisation is often necessary.

The decision to respond to an actual or impending crisis is political, whether at home or overseas and irrespective of whether it is done in support of national interests or national values. But such decisions should not be made in isolation. It is as important to consult with allies as it with domestic authorities including the military leadership to ensure that political expectations and military capabilities are harmonized to the highest possible extent. In this consultation process, the key question is, or should be, "What is the best way of responding?"

RESPONSE TO CRISIS

³The Rt. Hon. George Robertson, MP, "Introduction", *UK Strategic Defence Review* (<http://www.mod.uk/policy/sdr/wpintro.htm>).

In simple terms, two forms of crisis response exist:

- through the use of military force both directly and indirectly as an adjunct to diplomacy, and
- by non-forcible intervention through the use of economic, technical, and humanitarian measures.

This paper is concerned only with the former option—the use of military force, and the use of naval forces in particular.

The application of military force today raises complex problems which are largely beyond the scope of this paper. Nevertheless, some key points should be established to provide an accurate framework for this discussion. First, irrespective of the fact that the UN Charter forbids war, we have in fact waged several wars in the past 55 years—Korea, Vietnam, the Israeli-Arab Wars, the Iran-Iraq War, the Falklands, the Persian Gulf, Bosnia, Kosovo, and now the “war” on terrorism to name but a few. Second, despite the recent trend to war within states rather than war between states, it does not prove that states will never wage war against each other again. There is absolutely no evidence to suggest that in the future states will not resort to violence to solve their problems or use violence in self-defence. Wars may not be declared formally, but they will nevertheless be waged. Third, we now wage war without declaring it and try to hide military operations under a cloak of ambiguous terms such as *operations other than war* and *peacekeeping*; yet, as many authors have made clear, the operations in Bosnia and Kosovo, and now in Afghanistan, were wars—extreme violence was unleashed and both military people and civilians died. Fourth, and last, war has become a far more broadly-based activity than at any time in recent history and necessarily tied to diplomacy with the use of force being the last resort when diplomacy fails. In this respect, *crisis management*, in the interests of restoring stability, will be a frequently-used political response to regional crises.⁴

⁴One of the underlying reasons for this is the belief that Western involvement in small wars in the name of *crisis management* draws less political attention from electorates at home than do larger, more complex affairs. Christopher Bellamy, for instance, predicts the end of total war, other than in non-military terms under a rather complex construct of economic warfare, in favour of a near-continual series of intervention operations on the part of the industrialized states in order to maintain stability in their economic hinterlands. He has some thoughts that will chill many army hearts in stating that “the most visible trends in the evolution of conventional armed forces are the end of the mass army, and probably a reduction in the importance of armies vis-a-vis navies and other types of force.”(Christopher Bellamy, *Knights in White Armour: The New Art of War and Peace* (London: Hutchinson, 1996), 234.) In the context of his projected requirement for rapid response capabilities as the primary focus of future armed forces, this statement makes sense. Highly mobile forces with the capacity to deploy and apply military force quickly are essential in making effective and timely responses to crises.

War is a relatively well-controlled event in international law provided the belligerents are states. When the belligerents are non-states, the rules become difficult, if not impossible, to enforce on all parties. By whatever name and under whatever qualifiers may be attached, war—being an act of force to compel our enemy to do our will, to use Clausewitz’s definition—will continue to be a dominant feature of the emerging international system. The key issue for the future will be the manner in which states respond to violence perpetrated against them and against their interests and values. This will raise difficult questions on the proportionality of the response and on the legality and morality of third party intervention, especially in situations where one party claims to be acting in self defence. The point we must accept is that warfare today, by whatever name, is tightly controlled politically. Rules of engagement are far more stringent than at any time in the past. Operational units simply do not have the freedom of action previously enjoyed.

Military Response to Crisis

One clear trend in international relations and in the complex and controversial process of trying to keep order in a volatile world is the preference for comprehensive crisis management strategies. By many names, such as *peacemaking*, *peacekeeping*, or *peace-building*, we have adopted crisis management strategies on many occasions. In theory, a crisis passes through a series of stages some of which can be controlled relatively easily if the right action is taken early enough. The key is to take action in sufficient time to prevent the situation deteriorating. It is the decision to use force that is politically difficult in the West today because the need to use force when one’s own country is not at risk sits uncomfortably with most politicians.

Military response to crisis passes through four distinct phases:

- early warning through surveillance, intelligence gathering and analysis;
- initial and rapid response as either a deterrent deployment of forces or in the direct application of coercive or punitive force;
- deployment of follow-up forces to establish and maintain order; and
- peacekeeping and restoration.

Over the years, there has been a political preference for using naval forces, especially submarines, in making the initial response to crises. Submarines also play an important role in the early warning and intelligence gathering phase. The reasons for reliance on naval forces are self-evident: they can deploy in days rather than in weeks and do not require re-configuration. Rather, the tasking exploits the inherent flexibility and capabilities of warships (including submarines) and naval aircraft. In the uncertain and unpredictable future, governments will find, as they have in the past, that naval forces offer them greater flexibility in providing force and influence in international relations than either armies or air forces.

Used well, with the precision of a scalpel rather than with the crudeness of a chain saw, naval forces incur the lowest degree of risk of any branch of the military. The political attractiveness of navies was well summarized by D.P. O’Connell:

[by] their ambiguity, navies alone afford governments the means of exerting pressure more vigorously than diplomacy and less dangerous and unpredictable in its results than

other forms of force, because the freedom of the sea makes them locally available while leaving them uncommitted. They have the right to sail the seas and the endurance to do so for the requisite periods, while land forces cannot present a credible level of coercion without overstepping the boundaries of national sovereignty.⁵

⁵D.P. O'Connell, *The Influence of Law of Sea Power*, 3-4

The point to take forward is that navies are highly versatile instruments of state policy on, under, over, or from the sea. An overarching fact is that the deployment of sea-based forces carries a very low political risk, especially the use of submarines to gather intelligence ahead of the initial response and as part of the early warning process. Committing naval forces to combat subsequently carries a much lower political risk than the deployment of land forces. But, eventual stability will only be achieved by army units on the ground. Although sea power remains the “great enabler”, as Colin Gray reminds us,⁶ it is not the sole means by which a crisis or war will be ended.

International Crisis Management

It is now perfectly clear that the United States is not going to bear the lion’s share of the burden of international crisis management, in terms of either body bags or national treasure. The partners in the global economy must now share that burden. To this end, new concepts of applying coercive force have been adopted and shape much of the initial response to crisis. With the advances in stealth technology, precision guidance systems, and space-based information systems, a strong belief has emerged that war can be waged without the traditional huge loss of life.⁷ This has radically changed the nature of warfare. Keeping the peace in the global system is now a coalition undertaking with all partners sharing in the cost. Today, the dominant naval power is the United States Navy (USN) which is able to sail the world’s oceans with almost unrestricted freedom. Similarly, the US economy is a dominant feature of the present international system, although challenges could take place at some time in the future. Thus, we exist in what can be seen as *Pax Americana*.

To support their global position the Americans have embraced a national strategy that is intended to resolve problems “...*From the Sea*” and are making considerable investments in the naval and related joint capabilities to make that strategy work. In view of the investment made in hardware and structures, it is unlikely that the strategy will change in the next 20-25 years. It would thus seem that international expeditionary operations will be conducted within the framework of a “...*From the Sea*” scenario for the foreseeable future. This means two things: first, states wishing to play a meaningful role in the front end of crisis management operations will have to be prepared to do so within a combined and joint force structure with the US in the lead; and second, states wishing to do this will have to make their military forces interoperable with those of the United States, and this is not just technological interoperability, it also will require

⁶See, Colin S. Gray, *The Leverage of Sea Power: The Strategic Advantages of Navies in War* (New York: The Free Press, 1992). and his “Sea Power: The Great Enabler”, *Naval War College Review*, Winter 1994, 18.

⁷*The Economist*’s 1 December 2001 editorial said it well, “To be body-bag averse is far from shameful: no one should relish unnecessary casualties, and technology now enables Americans to do much of their fighting from a height or a distance in comparative safety. But air strikes alone do not win wars; they need to be complemented with fighting on the ground...”

intellectual interoperability. The issues in play here are extensive and roll in such politically-charged topics as sovereignty, which lie outside the scope of this paper.

Those states which adopt an essentially self-centred approach to security will maintain only those naval forces necessary to uphold the security of the waters under their national jurisdiction. Internationalist states will maintain somewhat different naval capabilities—including capabilities that give them the ability to use those forces to support diplomacy, take action in regional and/or international crises, and to ensure the security of their own waters.⁸ Although a determining factor is the extent to which the state wishes to be involved internationally, there are also specific naval requirements in home waters and the balance between domestic and international tasking is always delicate.

Homeland Security

The events of 11 September, 2001, brought home the inherent vulnerability of our national infrastructure. Although many people had long realized that the economy, and thus our standard of living, could be brought to its knees quite easily by well-orchestrated acts of violence just as easily as natural disasters, they were reluctant—at least until 11 September—to think of national security in those terms. Homeland security has now risen to the top of the security agenda in many states, including Canada. But despite calls for greater action to increase homeland security within days of the incident, subsequent actions have been reactive to the events rather than proactive in making genuine improvements in national security. In concert, a misguided belief has prevailed that the military can easily handle the new threats and thus does not require additional resources.

In fairness, though, the responses in Canada have been partly conditioned by two entrenched, but false, beliefs: one, that the end of the Cold War removed the threat of massive violence being perpetrated against Canadian territory or its citizens; and two, that terrorist acts would not be committed against Canada—the “it can’t happen here because we are not Americans” syndrome. While 11 September made it quite clear that massive violence is no longer the exclusive purview of military forces, those events did little to dissuade people from believing that not being American made them safe. As in 1946, when Canada and the United States agreed to continue cooperation in defending the North American continent because of shared and largely indivisible national security concerns, the recent attack on North America did not discriminate in its impact on the Canadian and American economies. We should not expect future attacks to discriminate either; geography and partnership in the global economy make Canada and the United States one

⁸The basic missions which navies may be expected to undertake in the future can be described broadly as: strategic deterrence and compellence; power projection; sea control; naval diplomacy; security of the homeland and constabulary missions; and humanitarian assistance. These six mission categories are as applicable to war-fighting as they are to crisis management or to any other naval operation in a non-war setting. Another point is that a high degree of overlap exists among these mission categories, which allows ships, submarines, and—to a lesser extent—naval aircraft to be designed as “multi-purpose” platforms.

entity in the eyes of an adversary. Moreover, the insidious nature of the new global terrorist threat means that internally mounted threats cannot be discounted. As with organized crime, the enemy is within as well as without.

What, then, are the realistic threats to homeland security at and from the sea? In answering this question, one fact stands out: Those who would use violence against Canada are no longer just the military forces of another state; the new aggressors may have military training and use military equipment but they are much more likely to be members of terrorist, criminal, or other subversive groups motivated by the desire to inflict terror and instability. Although written almost 20 years ago, the following summary of the politics of terror and criminal coercion still makes sense:

...terrorist activities are expressly designed to produce psychological and symbolic effects rather than to attain physical or material gains. Attacks aimed at innocent victims—for example, a rig crew or living resources in the ocean—could be especially effective in that these victims would become highly salient pawns in a tense bargaining situation. As a consequence, such perceptions could engender sympathy from the public and, coincidentally, increase pressure upon governmental authorities to succumb to the terrorists demands. herein is couched the catch-22 paradox associated with terrorism generally. On the one hand, if a government reacts too vehemently or capriciously against terrorist activities (e.g., by suspending civil rights and liberties), then it may appear to the citizenry as being overly repressive and authoritarian. On the other hand, should a government's policy toward terrorism be perceived as weak, indecisive, or non-assertive, then very likely that response might foster further attacks over the short term.⁹

Unfortunately, we cannot afford to overlook the fact that Canada's relative emptiness outside the main population centres provides easy venues for supporting and launching terrorist and criminal activities against not only our own cities but also those of the United States. Ideally, a state would prefer to prevent terrorist incidents from taking place, but this is an impossible undertaking. Some threatening situations can be contained or even avoided by preventive measures such as greater redundancy or through increased physical security or, under limited circumstances, by the careful application of economic assistance to countries and regions under stress. A great deal can also be done by greater surveillance.

The Naval Dimension of Homeland Security

Before 11 September the accepted view was that threats to national security were predominantly non-military, with more public concern over the illegal use and abuse of our waters than about any potential violent challenge. Now, with terrorist threats to North America a reality, we have begun to look at the maritime dimension of homeland security in a very different light. Our domestic national security can be challenged in many ways and in many places. For the most part these places are enormously vulnerable because we simply have not put in place the necessary processes and systems to guarantee their safety. This is not the result of negligence;

⁹Christopher C. Joyner, "Offshore Maritime Terrorism: International Implications and the Legal Response" *Naval War College Review*, July/August 1983, 16-31.

rather, it is a reflection of the lower security priority assigned to those places and installations. In the contemporary security environment, there are six primary maritime concerns.

- safety of shipping (including cargoes) using Canadian waters, including cruise ships which are particularly attractive terrorist targets;
- vulnerability of port complexes and their related transportation networks;
- security of off-shore installations, especially oil rigs;
- safe operation of the fishery and other economic activities in the Exclusive Economic Zone (EEZ) and adjacent waters;
- security of isolated and remote communities and installations as well as the security of uninhabited areas of the coast; and
- security of under-sea cables (now almost entirely fibre-optic) and their shore-side terminals.

To some, this approach to security will be seen as a siege mentality, but the reality of the present situation is that being secure requires a reduction of vulnerability. In this, the heart and soul of effective maritime security lies in knowing exactly what is happening in waters under Canadian jurisdiction. To do this, three criteria must be met:

- know exactly who is using those waters;
- maintain an unequivocal expression of government authority in those waters; and
- be able to respond quickly and effectively to violations of the law or threats to national security.

Perhaps better known by the phrase, “surveillance, presence, and response” this concept has withstood the test of time. A report in the January 1992 edition of *NAVY International* made the point succinctly:

*Coastal and offshore protection is a complex scenario demanding constant attention. It cannot be easily dismissed as requiring just a few old patrol craft gleaned from the scrap heap and a few redundant aircraft hastily fitted out for maritime patrol. On the contrary it requires a very carefully thought out mix of forces deploying sea, land and air platforms equipped with suitable sensors and weapons, the whole being sensitively coordinated by a combined maritime headquarters.*¹⁰

The same report established that the primary requirements for any vessel engaged in offshore protection operations were:

- adequate sensors for carrying out reconnaissance, target identification, and tracking;
- appropriate command, control, and communications systems to exchange information with other forces on patrol and the maritime command headquarters;
- the ability to loiter in a patrol area for extended periods; and
- the ability to operate in all types of weather conditions.

¹⁰“Coastal & Offshore Protection” *NAVY International* , January & February 1992, 9-14.

These are requirements well within the capabilities of a modern diesel-electric submarine.¹¹ The submarine's ability to remain on patrol for 4 or 5 times as long as a single surface ship makes it particularly attractive in the comprehensive surveillance role. A submarine can also carry out the "presence" role if stealth is not required.

Submarine Crisis Management Roles

Submarines will continue to be strategically important in both international crisis management and homeland security roles because of a series of interrelated facts:

- Through stealth and endurance a submarine can provide an un-alerted presence to conduct a wide range of covert operations including insertion and recovery of special forces, conducting information warfare operations, and non-provocative surveillance and reconnaissance.
- Stealth and endurance allow submarines to be "first in, last out".
- Through endurance submarines can provide 24-hour a day coverage in all weather conditions while remaining ready for new tasking.
- Through design and on-board equipment submarines have the versatility to counter threats to themselves as well as provide protection for adjacent friendly forces.
- Versatility gives submarines the capacity to embark and operate new payloads such as remotely operated and unmanned underwater vehicles (ROVs and UUVs) as well as other unmanned sensors in a wide range of tasks.

These attributes make modern submarines unique and explain why those vessels remain in the forefront of both naval and joint force planning. Whereas submarine operations could once be categorized as either offensive or defensive, a third concept of operations now exists in which submarines are widely used to support operations on land and at sea, particularly in international crisis management operations. It is this dimension of submarine operations, especially when integrated with new and emerging technologies, that hold enormous promise for the future.

Much has been written on the versatility of the modern submarine. One example is provided by Admiral William A. Owens, US Navy, in his thought-provoking book *High Seas: The Naval Passage to an Uncharted World* in which he states,

¹¹Enforcement and response are becoming highly specialized operations in which naval forces play a major but not the only role. Other government organizations are invariably involved at just about every level of homeland security operations and depend upon one another for support. For instance, although the law can be enforced at sea by the Coast Guard, as the "marine delivery arm" of the Department of Fisheries and Oceans (DFO), it can really only be credible when supported by the superior force and authority implicit in the Navy. Similarly, even though the Navy has a port defence capability, it cannot function in isolation, it must coordinate its activities with other organizations. Just as respect for our sovereignty is a function of the respect for our ability to use force as the means of last resort, law enforcement requires that there be sufficient force available to compel compliance with the law.

*Submarines may increasingly contribute to larger-scale amphibious operations also, for covert surveillance of an opponent's mine operations can locate mine fields long before we have to cross them. In the future it would not be surprising to rely on submarines to neutralize mine fields. Indeed, submarine-controlled unmanned underwater vehicles can already provide mine detection and plotting, and the same technology shows promise for mine clearing and destruction. Submarines are probably our best weapons against the source of most mine fields-the minelayers themselves. U.S. submarines can also play a direct strike role in disrupting or defeating an opponent's ground operations. The submarine's vertical launch tubes, for example, could prove valuable for battlefield fire support.*¹²

Even though Owens does make direct reference to the intelligence, surveillance, and reconnaissance (ISR) capability of modern submarines in this particular section, he does so elsewhere. The important point he makes is that we should look upon the submarine as a force multiplier rather than as a legacy system.

FUTURE SUBMARINE CONCEPTS AND TECHNOLOGIES

We should not be surprised that forward thinking on submarine employment in Britain and the United States emphasizes both collective and joint operations under a range of scenarios, most of which embrace some aspect of crisis management. This is completely logical as it reflects American and British national strategies and the overarching concern for maintaining stability in the international system.¹³ Nor should it be a surprise that these new concepts embrace new and emerging underwater technologies as well as the overarching operational concept of Network Centric Warfare (NCW). Although predominantly directed at the nuclear-powered submarine (SSN), some of these technologies have the potential to be applied to non-nuclear submarines.

In emphasizing the inherent “virtues” of submarines: flexibility, mobility, stealth, endurance, reach, autonomy, and punch, the British see their SSNs playing major roles in future joint operations in three main areas:

¹²Admiral William A. Owens, US Navy, *High Seas: The Naval Passage to an Uncharted World* (Annapolis: Naval Institute Press, 1995), 107-9.

¹³The dominant American document is the July 2000 *Report of the Submarine Future Studies Group (FSG): Submarines...The Road Ahead* (Washington, DC: Chief of Naval Operations, July 2000), a copy of the Report's Executive Summary is attached to this paper. The British future concepts were outlined in a paper by Commander Nick Harrap “The Submarine Contribution to Joint Operations: The Role of the SSN in Modern UK Defence Policy” to the University of Lancaster's September 2000 conference commemorating 100 years of the submarine in Royal Navy service; a copy of that paper is also attached.

- what the RN refers to as “indicators and warnings” to cover the whole intelligence, surveillance, and reconnaissance (ISR) field including working with special forces;
- offensive ASW, especially as a function of direct support of a battle group; and
- land attack, using *Tomahawk* TLAM missiles.

New technologies are the means by which those tasks can be done more efficiently. One RN officer summarized his Navy’s view of the future of the submarine in saying:

*The SSN is not a legacy of the Cold War. Its attributes and abilities reflect exactly modern maritime doctrine. The SSN has broad utility and offers a wide range of options to politicians and campaign planners, at low risk. It can deploy early and quickly, exercise full freedom of the sea, changing role and area of operation at will. This posture can be maintained almost indefinitely. It can be an instrument of diplomacy, coercion or war-fighting employed directly or obliquely. The multi-faceted capabilities of the SSN, in contributing to the overall effort in both political and military ‘battle-spaces’, are dependent on remaining abreast of current technological advances. Failure to invest in the future has the potential to sideline a capability that offers the widest ranges of strategic, operational and tactical choice.*¹⁴

The USN’s view is virtually identical, as their recent future submarine study shows:

*Extending the submarine’s reach, fully netting the submarine with national and theater networks, and enhancing submarine adaptability to be responsive to the full range of theater tasking are essential to achieving the future vision. These capabilities will greatly enhance the submarine’s ability to gain and sustain access, develop and share knowledge, project power ashore, and deter and counter weapons of mass destruction – with the ultimate goal of providing Joint Force Commanders with unique and complementary capability essential to achieving their objectives. Revolutionary capabilities are necessary to achieve the future vision. Offboard vehicles and sensors are key to extending submarine reach. Innovative connectivity approaches and dramatic processing improvements will be required to become fully netted to national and theater networks. And finally, payload modularity is the key to future submarine adaptability. The challenge lies in developing the technologies to deliver the revolutionary capabilities needed.*¹⁵

The future roles of SSNs seem clear, as does the fact that new and emerging technologies are fundamental to those roles being conducted efficiently. What is not clear is the level to which

¹⁴Commander Nick Harrap “The Submarine Contribution to Joint Operations: The Role of the SSN in Modern UK Defence Policy” a paper presented to the University of Lancaster’s September 2000 conference commemorating 100 years of the submarine in Royal Navy service.

¹⁵Executive Summary to *Report of the Submarine Future Studies Group (FSG): Submarines...The Road Ahead* (Washington, DC: Chief of Naval Operations, July 2000), ES-4/5.

those technologies or even those roles are applicable to non-nuclear submarines. However, the difference between SSN and modern diesel-electric submarine requirements for ISR and self-defence systems is not as large as it used to be. As a fairly recent analysis of submarine sensor technology explained,

Submarines, perhaps more than any other manned platform, depend on their sensors for survival and to perform their missions. Although above-water sensors—notably periscopes, complemented by radars and electronic-warfare (EW) systems—have equipped submarines for decades, the emphasis until lately has increasingly swung towards sonars for operation at long ranges in the ocean. Now that as much attention is being focussed on submarines as intelligence, surveillance and reconnaissance platforms in littoral waters, above-water sensors can make an important contribution. Operations close to shorelines bring land-based targets within range of electro-optical (EO) and radio-frequency (RF) sensors, permitting covert observation and intelligence gathering. As proved on many occasions in its over 100-year history, the submarine is ideal for this role, being inherently stealthy and able to transit undetected over long ranges. The requirement for even nuclear-powered attack submarines (SSNs) to spend long periods at or close to periscope depth—some current equipment specifications ask for 12 hours of such operation continuity—results in heavy reliance on sensors for situational awareness. NATO navies now routinely operate submarines (including SSNs) in waters that are too shallow for them to “go deep” as a means of evasion, forcing them to stand and fight in much the same way as surface ships.¹⁶

As this and several other recent analyses make absolutely clear, the modern submarine is becoming a major force multiplier under conditions where its inherent stealth, endurance, and flexibility make it a preferred member of a modern naval task force. The challenge for the future is to exploit those natural attributes through the application of new and emerging technologies.

What we need to do now is take a closer look at the various technological advances and see what is applicable to non-nuclear submarines. What follows is a brief review of the new and emerging submarine-related technologies in three general categories: propulsion; sensors and communications; and weapons and payloads. Some comments on operational and political implications of the new technologies are included as well as some thoughts on personnel implications.

Propulsion

Advances in propulsion technology are being made in several areas. As always, R&D continues on propeller design (mainly in the interests of improving stealth), on electric motors, and in concepts of electric drive. Although much of the motivation for this work is to improve the performance of the SSN fleets, there will be spin-offs for non-nuclear submarines. Other than for propellers, the new design concepts are more suited to new construction rather than the modernization of existing systems. The other two fields of research and evaluation, Air

¹⁶Mark Hewish, “Snooping above the waves”, *International Defense Review*, 1 August, 2001.

Independent Propulsion (AIP) and battery technology and design, have distinct application in modernization programs for diesel-electric submarines.

AIP Systems

AIP systems are not new, dating back to the closed-cycle engines and the use of hydrogen peroxide by the Russians and Germans respectively during the Second World War. After years of “on-again, off-again” research (accompanied by what could be called destructive testing) and the advent of nuclear power, interest in AIP was renewed and work is now being done on four types of AIP: fuel cells, closed-cycle engines, the Stirling engine, and steam turbo-electric systems.¹⁷

¹⁷The information on AIP systems is drawn from an excellent article by Don Walsh, “The AIP Alternative. Air Independent Propulsion: An Idea Whose Time Has Come?”, *Sea Power*, December 1999. Although dated, this paper remains the best technical description of the various systems.

- **Fuel Cells.** Some of the most advanced work on submarine fuel cells has been carried out by the German company Howaltswerke-Deutsche Werft (HDW) in Kiel in conjunction with Siemens Electric. “The HDW fuel cell is scheduled to enter fleet service in 2003 on German Submarine Consortium’s (GSC) new 1,800-ton 212-class submarines. This AIP system also will be a ‘hybrid,’ with the submarine retaining a basic diesel-electric propulsion system. A fuel cell cannot deliver sufficient electrical output for high-speed operations, but the conventional storage battery can (for a short period of time, after which the fuel cell can recharge the battery as well as provide energy for low-speed operations).” HDW estimates that a Type-212 submarine with its AIP system will be able to remain submerged for more than a month and to cruise (at four knots) for over 3,000 miles. The new Type-214 submarine, essentially an improved version of the 212 with greater diving depth (said to be over 1,400 feet), has a newer dual-fuel-cell design providing even greater endurance. In North America, Ballard Power Systems of Vancouver has developed a fuel cell that provides motive power to a Vancouver bus and although discussions have taken place on extending this to submarine use, it remains at the theoretical stage. Another Canadian firm, Stuart Energy Systems, recently announced a new joint venture with Ford Motor Company and Ballard to develop hydrogen-fuelled power systems for the global back-up power generation and other power markets on the basis of a new hydrogen-fuelled internal combustion engine developed by Ford. In view of the intended application of the new systems to hospital and large building emergency power systems, submarine options should not be ruled-out.¹⁸
- **Closed-Cycle Systems.** Thyssen Nordseewerke’s closed-cycle diesel (CCD) system uses liquid oxygen, diesel fuel, and argon gas to fuel its AIP system. The oxygen and argon gases are combined to make “artificial air” for the diesel. Argon, an inert gas, is recovered and continuously reused. The same diesel is used as a conventional air-breathing engine for main propulsion on the surface or when snorkeling. TNSW’s CCD AIP system is considered to be particularly cost-effective for the retrofit of existing diesel-electric submarines, and it also can be installed in a new-construction submarine.
- **The Stirling Engine.** The Swedish Stirling cycle engines, which use liquid oxygen and diesel oil, supplement the conventional diesel-electric system with the Stirling engine turning a generator that produces electricity for propulsion and/or to charge the submarine’s batteries. The Swedish Navy first tested the system in the *Näcken* in 1989. Submerged endurance, without snorkeling, for the 1,500-ton submarine is said to be 14 days at five knots.

¹⁸Stuart Energy Systems Corporation Press Release of March 25, 2002 stated that Stuart Energy would integrate its proprietary hydrogen generation technology with Ford Power Products’ hydrogen-fueled internal combustion engine generator package which is being jointly developed by Ford Power Products and Ballard Power Systems’ Electric Drives and Power Conversion Division. Stuart Energy expects to install the first hydrogen back-up power system at its head office in Mississauga, Ontario in the fall of 2002 as a prototype for commercial operations in Hong Kong by spring of 2003. The first systems are expected to be commercially deployed by the end of 2003.

· **Steam-Turbine System.** In France, the DCN International naval shipbuilding company has developed the *Mesma* (Module d’Energie Sous-Marine Autonome) AIP steam-turbine system, which burns ethanol and liquid oxygen to make the steam needed to drive a turbo-electric generator. DCNI offers the *Mesma* option for its *Agosta 90B* and *Scorpene* classes of submarines. The company claims that its AIP option increases submarine underwater endurance by a factor of 3 to 5. The design of the *Mesma* system permits it to be retrofitted into many existing submarines simply by adding an extra hull section.

In addition to the builders of the four Swedish submarines and the GSC and DCNI submarines, there are other “players” who have done considerable R&D work on AIP systems. Russia is offering a fuel-cell option for its “improved” *Kilo*- and *Amur*-class attack submarines. Although none have yet been built with an AIP system, reports suggest that China may add an AIP unit to one of its Project 636 Kilos. The Netherlands’ RDM submarine shipyard offers its “Spectre” CCD option for the yard’s 1,800-ton *Moray 1800 H* submarine; none have been built yet, but RDM estimates that a hybrid-powered *Moray* could remain submerged for 20 days while cruising at two knots. The average cost of a *Moray* is estimated to be about \$250 million. The Japanese Maritime Self-Defense Agency has undertaken studies to add AIP systems to its latest models of diesel-electric submarines; the leading candidate systems are the Swedish Stirling engine and the German HDW fuel cell.

It is estimated that 100 - 150 diesel submarines will be purchased in the next 10 years. As Don Walsh points out, “Naval experts, and shipbuilders, throughout the world are closely monitoring the operations of the Swedish Navy’s four AIP submarines and eagerly await the first GSC-Type 212 submarine. By 2005 there should be sufficient fleet operating experience to determine what are the most likely operational and cost benefits that can be derived from shifting to AIP systems. By then the unit cost for a modern diesel-electric submarine should be between \$200 million and \$300 million. Paying only 15 percent more to add or retrofit an AIP unit—a relatively small cost for greatly improved submerged performance—should be a very attractive option, therefore.”¹⁹

Walsh’s conclusion, albeit somewhat controversial in terms of operating in marginal ice and his emphasis on choke points, is that:

AIP submarines could be a particularly formidable threat when operating in coastal waters, marginal ice zones, or maritime straits and other global “choke points.” Add to that the virtual certainty that new underwater weapons will help equalize the performance disparity between AIP boats and nuclear-powered submarines and it may well happen that the U.S. Navy will want to reassess the desirability of developing an AIP submarine of its own, if only to learn how to counter this new and potentially revolutionary undersea challenge.

¹⁹The technological evolution of German submarines has drawn much interest of late. For instance see: Joris Janssen Lok, “Germany’s submarines combine export success with propulsion progress”, *International Defense Review*, January 2002; and Klaus Jacobsen, “The German submarine force: now and tomorrow”, *Jane’s Navy International*, June 2001.

Obviously, AIP is becoming reliable submarine technology with the potential to improve the patrol capability of diesel-electric submarines. It will not help in making long transits, nor will it obviate the need to switch to the main battery if high speed is required, but it is a technology that should not be overlooked in any modernization program. Although much of the focus is on endurance, AIP has obvious advantages in exploiting stealth.

New Battery Technology

Battery manufacturers have always sought to make improvements in their products. These take two forms: improvements to existing concepts, and the development of new chemical processes. At the moment most of the R&D is directed to the latter area, particularly in developing better light-weight, compact cells for use in conjunction with micro-systems and in developing an efficient and cost-effective battery for motive power. Four types of heavy-duty battery are currently available:

- the traditional lead-acid cell used in submarines and many other higher power applications;
- the silver-zinc cell being used by the US Navy in NR-1;
- a nickel-cadmium cell under R&D for industrial traction; and
- lithium batteries which are already in use in the automobile industry (particularly the *Zebra* battery).

At the moment, the lead-acid battery has a distinct advantage in cost, longevity (hence cost-effectiveness) and resilience. However, it is heavy and produces hydrogen. The silver-zinc battery is far safer to operate and is very much lighter, with 4:1 equivalent weight/space/energy factor to its lead-acid counterpart; the disadvantage is that it only has a life-span of about 2 years, and it is expensive. By far the most interesting aspect of emerging battery technology is the lithium cell. Already in production as the *Zebra* battery and in use in European automobiles, it has the potential for even wider use and possibly in submarines. The advantages are the lower weight and smaller size. It has a longer life-cycle than the silver-zinc battery by a factor of 2 to 3. That it is a high temperature battery has not been a problem in automobiles (the excess heat can be re-used in heating systems, etc.), but this aspect has not been given much thought in terms of submarine use. Overall, it is just too early to assess whether a cost-effective alternative to the submarine lead-acid battery will appear; the lithium battery certainly show promise, but it will several years before an answer will be known. In the meantime, lead-acid battery manufacturers will continue to improve their product making this the only realistic submarine battery for some years to come.

Sensors and Communications

The “information revolution” has begun to make its mark at sea through concepts such as Network Centric Warfare (NCW)²⁰ and in turn this concept is having widespread effects on submarine operations.

²⁰See, Vice-Admiral Arthur K. Cebrowski and John J. Garstka “Network-Centric Warfare: Its Origin and Future;”, *Proceedings*, January 1998, 28-35.

*Emergent information technologies are in the midst of an elemental shift from platform- to network-centric systems. By exploiting advances in information processing and dissemination techniques, distributed sensors, weapons and their associated command mechanisms are being integrated into a unified operational framework—a ‘system of systems’—upon which future engagements will be managed.*²¹

As stated earlier, “Submarines, perhaps more than any other manned platform, depend on their sensors for survival and to perform their missions.” With attention now focussed on submarines as intelligence, surveillance and reconnaissance platforms in littoral waters, above-water sensors are increasingly important. As a result, improvements are being made constantly to the entire family of submarine sensors and communications equipment. Much of the driving force behind this cycle of change can be attributed to miniaturization and the use of fibre-optics. Looking at this vast field of technological development, it can be reviewed in a few distinct categories: periscopes, sonar, radar, electronic intercept, and communications. It goes without saying that all these systems are integrated within a comprehensive data processing and management system.²²

- **Periscopes.** Over the years, periscope technology has made remarkable progress. No longer are submarines necessarily constrained to a monocular periscope where information is collected and recorded manually. The modern periscope, which does not even have to pierce the hull, can incorporate a host of imaging technologies including, low-light television, infra-red, lasers, digital TV, and so on, all of which can be electronically recorded for later analysis and display. The availability of this information in electronic format reduces exposure time. The trend, almost entirely in new construction submarines, is to non-hull-penetrating masts.
- **Sonar.** Sonar improvements continue to increase detection ranges and allow better frequency analysis. Linking sonar systems to high-speed computer systems provides quick contact analysis. Towed array technology likewise continues to evolve to provide the submarine with even better information sources. The integration of remotely operated vehicles and other unmanned and autonomous underwater vehicles into the submarine’s sensor suit allows the use of side-scan sonar as well as synthetic aperture sonar. Simply, there are many options for creating a first-rate submarine sonar package.
- **Radar.** There are those who will argue that radar merely compromises the submarine’s position, yet radar remains a useful operational system. Situations will undoubtedly exist in the future where obtaining information of the movement of surface vessels or the shipping patterns in a particular body of water override the need for stealth. In such situations, radar may be the best sensor. However, it is unrealistic and certainly poor management to require an operator to sit in front of a radar display for hours on end. Modern systems, such as that in the US Navy Virginia-class SSN (AN/APS-137) can be integrated into the submarine’s combat system and, like a sonar set, be programmed to perform the function of the human

²¹“The silent service gets vocal”, *Jane’s Navy International*, Feb 2000.

²²The article by Mark Hewish, “Snooping above the waves”, *International Defense Review*, 1 August, 2001 provides an good overview of the new ISR technologies.

operator. In submarines such as the *Victoria*-class, where space is at a premium, it makes infinite sense to adopt automated radar systems.

- **Electronic Intercept Systems.** Not a great deal can be said about intercept systems that has not already been said about other sensors. Miniaturization and fibre-optics have made it possible to mount a wide range of electronic intercept equipment in a single mast, frequently in the main periscope. With increasing emphasis on the ISR role for submarines, intercepting radio traffic from the shore will be an important part in providing early warning and in preparing for the deployment ashore of the initial response units. However, the increasing emphasis on intercept systems, especially in the electronic intelligence gathering role, leads to a requirement for even great signal processing capacity.
- **Communications.** As with all other electronic systems, the march of progress is constant, driven forward by the application of new components and new antenna designs. When submarines become integrated into the NCW concept their communication requirements increase enormously thereby increasing bandwidth requirements. To some extent, the demand for bandwidth is a function of the actual tasking and the size of the formation being supported, but the need for information coordination still imposes considerable bandwidth requirements. Even a submarine on independent surveillance operations will need to communicate across a wide range of channels. In this, the greater use of buoyant antenna, especially when linked to satellites. For instance, a recent US report noted that, “The communication capabilities of the “silent service” will be further enhanced in 2003, when the Navy begins fielding a floating wire antenna for its sub fleet. The new antenna system will give submerged submarines, even those travelling at full speed, most of the communications capability they now have at periscope depth. While the systems’ data rates will be lower than those at of a submarine operating today at periscope depth, they will still be “very robust”.²³ Hence, a key aspect of a submarine’s communications suite is its integration into a task force as this will demand specific communications capabilities. These requirements are discussed in greater detail later as a “national” issue.

²³John G. Roos, “Weighing the Options: US Navy Faces Tough Choices In Modernizing its Attack-Sub Fleet” *Armed Forces Journal International*, April 2001, 56. As Mark Hewish’s article (“Snooping above the waves”, *International Defense Review*, 1 August, 2001) explains, the UK Defence Evaluation and Research Agency (DERA) “is developing a Recoverable Tethered Optical Fibre (RTOF) system that would...allow a deeply submerged submarine to conduct covert two-way communications. A boat operating at maximum depth or any intermediate level releases the RTOF vehicle from an on-board housing, typically at the rear of the sail. A computer-controlled winch deploys the unit, which ascends under its own buoyancy, at a variable rate to ensure negligible tension in the Kevlar-reinforced fibre-optic cable. The vehicle then remains stationary at the surface, with no wake or plume, acting as though it were an expendable buoy. The submarine can continue to maneuver while RTOF operates, spooling out additional tether (which is typically 2km long) as necessary, then recovers the device once communications have been completed.” The Americans are developing similar systems.

It is reasonable to state that systems integration has become a growth industry, especially as submarine sensor suites become more diverse and far more capable. The promotional explanation of a new European system sums up the concept and the intent,

*SUBTICS offers high operational performance in the form of long-range capacity, both in detection and weapon-launching. Based on more than 20 years of experience, SUBTICS offers the optimum balance between advanced automated processing and sophisticated interactive tools. This well-balanced data integration ensures that the crew is in constant control of the information starting from surveillance and threat assessment through to weapon-launching. The Commanding Officer has a constant, global and integrated vision of the tactical situation, facilitating his capacity to make critical and timely decisions.*²⁴

One of the under-examined aspects of the business end of the information revolution, and thus NCW and the emerging ISR roles of the submarine is the impact on the operators and decision-makers. Traditionally, submarine operations have placed heavy emphasis on sonar systems with periodic augmentation by optical and radio signal intercept. This concept of operations was not enormously demanding on system operators or on the command team because information was presented simply. During the Cold War, much of this simplicity was a function of the nature of the patrol where the mission was antisubmarine and invariably conducted in an information-impooverished environment. Information overload was not an issue. Today, and in the future, the ISR role will require that submarine sensor operators handle vastly larger amounts of data from a range of sensors, and that the command team may have to mentally integrate information from a battery of displays, even though some data will have been refined, and raw data inputs such as periscopes. As one observed noted,

*the littoral environment presents the epitome of information overload. Contact management...stresses, and often exceeds human cognitive, memory, and attentional abilities. All of these factors influence situation awareness. When situation awareness is compromised, inevitable human errors increase...*²⁵

This, of course, addresses one of the less-well documented aspects of the so-called Revolution in Military Affairs (RMA)—people are often the weakest link in a system. It makes sense that submarine modernization and new construction programs embodying a wide array of sensor and data management equipment take account of operator and command team requirements, especially the implications of information overload. While it may be possible to ease the impact of this problem by improved data management and filtering systems, training and experience will play a major part in off-setting the consequences.²⁶ It may well be that submarine sensor

²⁴Internet description (www.naval-technology.com/contractors/data-management/uds/) of the system offered by a consortium of UDS International, DCN and Thales. Several other almost identical promotional web pages can be found.

²⁵Lt Katherine K. Shobe, MSC, USNR, “The Role of the Human Operator in the Submarine”, *The Submarine Review*, October, 2001, 59. Lt Shobe is a research psychologist specializing in submarine issues.

²⁶Anthony Preston, “Submarine Command Systems”, *Armada International*, August/September 2001, 30-32, explains this as a paradox, “the ever-growing demand for information is gradually being satisfied by modern sensors, but in parallel, the flow of information is becoming difficult, not to say impossible to manage. The solution,” he points out, is

operators will require different training to their surface fleet counterparts, if for no other reason than there are fewer of them to “man” the equipment. Working conditions in a modern submarine are very likely to be more stressful than in surface ships.

Weapons and Payloads

The debate on future weapons, other than TLAMs, has a number of interrelated issues that must be addressed. The first issue concerns the provisions of international law and the legally complex situations under which many operations at sea will be conducted. Outside the relatively unambiguous “right” of direct self-defence (as opposed to the enormously difficult situation of defence against “hostile intent”) the targeting of ships, submarines, and military facilities ashore will be politically constrained. It is improbable that submarines will be allowed to sail with freedom to fire on any vessel found in a war zone. Not only is the requirement for positive identification almost mandatory now, but the approval to fire is likely to be controlled within a larger crisis management situation.

The second issue is that of self-defence weapons. Essentially, if a need for self-defence arises, the mission has been compromised, albeit perhaps only temporarily. The operational concern therefore is for the restoration of the mission and its integrity. In other words, the attacker (because it is a self-defence situation) must be destroyed or evaded. Depending on the importance of the mission, the self-defence weapon load may have to be large. Suggestions have been made that a smaller, shorter-range torpedo be developed for self-defence. If half the size of a standard torpedo, say a Mk. 48, the basic load of these new torpedoes could be much larger. Conversely, the smaller torpedo would make it possible for a reasonable number of torpedo tube-launched UUVs/AUVs to be carried without taking away from the submarine’s self-defence capability or its ability to switch missions to defence of the surface formation. New technologies, especially in the AUV field, would make other areas such as mine countermeasures, either in self-defence or in support of other operations, feasible.

The third concern is also a function of mixing loads. If a submarine is sent on an anti submarine or anti-shipping mission, it will be difficult to be given either new missions or concurrent missions because of both load limitations and the need to carry a heavyweight torpedo with a larger warhead. In some ways though, this is a slightly circular argument because legal and strategic requirements for positive identification will lead to shorter firing ranges and this might also make the smaller torpedo feasible.

What all this means for the longer-term is that the payload for a specific mission will require careful consideration. With limited stowage for reloads, the merits of new, smaller torpedoes should be reviewed especially when torpedo tube-launched AUVs/UUVs enter service. The legal and political requirement for positive identification in limited war situations has many implications and will be a major factor in determining both sensor and weapons upgrades.

that “while smart displays come to the rescue up to a certain degree, automation (though disliked) appears to be a sine qua non.”

AUVs/UUVs

This section will be much shorter than the complexity of the subject may warrant. The extent of R&D is mind-boggling, as are some of the new capabilities being developed. Underwater vehicle technology has now made its way from the research laboratory to the operations arena.

Naturally, developers of underwater vehicles realize that the ultimate potential of their systems can only be achieved through use of communications technology that allows near real-time monitoring of data from the vehicle's sensors, and the ability to control or redirect the vehicle in response to that data. As the resolution and range of the vehicle's sensors improve in the future, there will be an even greater need to share this information with other undersea systems and shore or fleet-based controllers. Some of the vehicles are destined for the Navy's Special Warfare Community to locate and identify mines, and to collect data in advance of divers and special operations teams. The US Navy desperately wants to show that AUVs can extend the survey capabilities of traditional data-collection vessels, and can detect mines.

One of the significant recent advances has been in the size and efficiency of the vehicles. In fact, the rule for all of the new AUVs is lighter and smaller with more sophisticated sensors. For instance, one new Hydrographic Reconnaissance Vehicle is 7.5 inches in diameter, 62 inches long and weighs 80 pounds. The smaller size was accomplished by reducing the length and reducing its weight. The changes also have made the vehicle faster. The top speed of the original vehicle was about 3.5 knots, and it now able to operate in excess of 5.5 knots.

A modern vehicle consists of a payload nose section and a propulsion tail section, which can be fitted together in a few minutes. The vehicle is 7 to 10 feet in length and weigh 500 to 1,200 pounds, depending on payload, with a depth rating of 300 metres. The speed range is 1.5 to 4.5 knots with a standard battery capacity of two kWhr. Up to 2kWhr of additional energy can be provided by the attachment of a mid-body section containing eight battery packs. The tail section houses the vehicle components necessary for basic operation including: the nickel-cadmium battery, control systems, a tracking transponder; an acoustic modem; a module housing the rudder and stern-plane mechanisms and motors; a thruster motor; and the main pressure vessel, which houses the system electronics. The nose section provides space for payload configurations of various types. The system is designed such that a payload can be attached, and the integration checked out in very little time, once the initial systems integration has been debugged. There is a single cable connection between the payload and the AUV. This connection provides both power and communication. More than a dozen types of payloads have been integrated into this vehicle including a high frequency side scan and a very high frequency side scan sonar. In addition to the side scan systems, each of these payloads also includes a video camera, a long baseline (LBL) navigation transducer/electronics and a drop weight. Some vehicles have the ability to send data via satellite to a hub ashore, and the data is then interfaced to the Internet.

The US Navy are completely sold on the concept. As Admiral Bowman, Director Naval reactors, said recently:

...these UUVs and UAVs are the payloads that don't explode, that have to find a home onboard our submarines and be launched and recovered onboard the submarine, for us to achieve dominant knowledge. We need to expand the horizon of the submarine. Today,

*we are the great intelligence exploiters of the ether that we can see or hear from the masts that are raised two or three feet above the water. We need to do much better than that. We need to get the surrogate (unmanned) vehicles and sensors off the ship, over the land, over the mountains, far inland, reporting back to the submarine and networking with the submarine to establish the dominant knowledge that we previously discussed. It is not dominant today. It is unique. No other platform today can bring back some of the information that we have. The good news is that we have already shown the ability to control UAVs from periscope depths on submarines. We have done this twice over San Clemente island (CA). We know that we can both control the UAV and receive intelligence information from the UAV flying far inland.*²⁷

The problem is that the rest of world does not yet have any indication as to when all this will become fully operational. Yes, a UUV or an AUV can be launched and controlled from a submarine, but as many senior naval officers have been quick to point out, recovering the vehicle requires extensive re-engineering of the submarine unless swimmers are used to dock the vehicle. If data is not recovered acoustically or through a dedicated fixed link, docking a vehicle may be necessary to recover the data. As far as being a viable payload for the *Victoria*-class, UUVs, let alone AUVs, are a long way into the future. An enormous amount of R&D and basic platform engineering will have to be done to convert what are primarily SSN payloads for use by diesel-electric submarines.

Tactical Guided Missiles

With the emphasis on self-defence and mission security, the old idea of a submarine-launched anti-aircraft guided missile (formerly known as SLAM) has re-surfaced. A German-Norwegian consortium is developing a new missile system capable of being launched by a submarine that allows self-defence against both aircraft and warships as well as having a limited land attack capability against targets such as coast artillery and harbour facilities. Known as *Triton*, the system has its origins as a land-based system firing a fibre-optic guided missile with a range of up to 60km for use by day or night. This system has not yet been tested from a submarine but clearly holds promise of meeting a prevailing deficiency.²⁸

CANADIAN OPTIONS AND ISSUES

The rationale for acquiring the four *Victoria*-class submarines has its roots in the 1994 Defence White Paper, which established that:

²⁷From an exclusive interview with Admiral Frank L. Bowman, Director Naval Reactors, in *Armed Forces Journal International*, November 2001, 37.

²⁸Internet site (www.naval-technology.com/contractors/missiles/eads/) 10 March 2002.

The Special Joint Committee on Canada's Defence policy found that submarines can conduct underwater and surface surveillance of large portions of Canada's maritime areas of responsibility, require relatively small crews, can be operated for roughly a third of the cost of a modern frigate, and work well with other elements of the Canadian Forces. It also recommended that, if it should prove possible in the current environment of military downsizing around the world to acquire three to six modern diesel-electric submarine on a basis that was demonstrably cost-effective (i.e., that could be managed within the existing capital budget), then the Government should seriously consider such an initiative. The United Kingdom is seeking to sell four recently constructed conventional submarines of the Upholder-class, preferably to a NATO partner. The Government intends to explore this option.²⁹

A DND paper written in May 1995³⁰ provided a more precise statement of operational requirements:

- surveillance of national waters;
- retaining an underwater warfare capability within the collective security environment especially with the United States;
- training for both Canadian and allied forces, particularly those of the United States; and
- leverage with allies for intelligence and information sharing concerning submarines.

Without additional explanation, this even this rationale was a tough sell politically. The paper continued, stating that "Submarines have several distinct advantages of government policy, both nationally and internationally. They may be prepositioned in an area of interest, overtly or covertly. They enjoy an unparalleled degree of freedom of action and independence. Finally they can be easily withdrawn without diplomatic cost or commitment." The same can actually be said for most naval forces except that a submarine has the unique advantages of stealth and extended endurance. The point being made was that submarines were able to conduct surveillance, presence, and response tasks thereby meeting the basic criteria of sovereignty protection, which today is inseparable from the primary naval activity in homeland security.

Since then, the world has changed and defence priorities have been adjusted to reflect new security concerns and concepts. Today, the functions of the submarines are:

- intelligence, surveillance, and reconnaissance (ISR) operations;
- contributing to deterrence;
- providing training support for antisubmarine warfare at the formation level;
- maintaining a submarine proficiency; and
- supporting underwater research and development.

Yet, measured against the international trends in submarine employment and development, these tasks do not adequately project the increasing strategic and operational importance of submarines, let alone the longer-term potential. Unfortunately, the popular concept, prevalent in

²⁹Canada, National Defence. *1994 Defence White Paper* (Ottawa: Minister of Supply and Services, 1994),47.

³⁰DND briefing note "The Upholder Option" of May 1995. (Obtained through Access to Information)

Canada, of the submarine is of a fundamentally evil system which is an extension of the World War II German U-Boat or, at best, a legacy system of the Cold War. In fact, the evolution of the modern submarine is an excellent case study in the way the march of technology can quickly get ahead of public opinion. What has to be explained widely, is that the modern submarine provides a fleet and thus a state with a wide range of unique capabilities that exploit three features of a submarine: stealth, endurance, and versatility.

It is also most important that any future public discussion on Canadian submarine requirements and capabilities emphasise the fact that the modernization of the *Victoria*-class offers a unique and considerable opportunity for technological innovation. In fact, the modernization program has the potential to transform many aspects of the RMA at sea from theory to practical application. For instance, several new opportunities exist to work directly with Canadian industry in developing new applications of new technology. Air Independent Propulsion (AIP) and system integration are immediate candidates, but there will also be opportunities to examine many aspects of the personnel aspects of new technologies. Transforming the *Victoria*-class into modern submarines with a mission specialty in ISR will also have widespread implications on the Canadian underwater R&D community. A natural synergy will exist between the submarine service and the scientific community; this has enormous potential.

Operational Concepts

The recent explanation of Canadian naval strategy, *Leadmark: The Navy's Strategy for 2020*, is not specific in establishing roles for Canada's submarines. Instead, it develops broad-brush concepts within which submarines are expected to fit. Based on the philosophy of "medium" naval power, *Leadmark* calls for a naval structure based on the "task group concept - the task-tailored mix of capabilities brought together in a variety of surface, sub-surface and aerial platforms." because the task group provides "the framework within which the technical, doctrinal and organizational elements of the RMA can best be realized in a naval context. Such a structure provides the Canadian navy with the flexibility required to contribute most effectively to the success of the missions that it will be assigned well into the 21st century." Continuing in general terms, *Leadmark* then defines "core competencies" to guide future development of the fleet:

- to generate and maintain credible combat forces;
- to be able to provide sea-based service support and co-ordination; and
- to know what is going on in real time and to be able to act with a wide range of conventional force options.

In many respects, these are "motherhood" statements that can be summed up in the traditional naval requirement that ships be able to float, move, and fight under a wide range of situations, individually and in company including being able to influence events at a distance from home.

Clearly, this is as applicable to submarines as it is to all other naval vessels. Unfortunately, *Leadmark* is not adequate as long-term guidance. The section on "Future Naval Capability Requirements" provides some guidance on key capabilities, especially C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance),

applicable to submarine operations. In general, though, one has to pick through the text to find references to generic capabilities that might be applicable to submarines. However, *Leadmark* is not intended to be either a specific force development document or a concept of operations; rather, it is the point of departure from which those plans take shape.

Reading between the lines of *Leadmark* and mindful of the nature of the future international situation, it would make sense to assume that future Canadian submarine roles, for which they would be required to maintain proficiency—the maintenance of “core” capabilities to echo *Leadmark*—would be:

- conducting intelligence, surveillance and reconnaissance (ISR) tasks in support of both domestic and international operations under a wide range of situations;
- conducting anti-shipping and antisubmarine defensive operations in distant support (as opposed to close support) of national and international formations;
- supporting special forces operations in counter-terrorist and counter-insertion operations in Canadian waters as well the provision of support to special forces in joint international operations;
- conducting “presence” operations in northern and other remote Canadian waters; and
- providing ASW training for national and international formations.

In addition, Canadian submarines would be expected to undertake their own proficiency training as well as provide support to national underwater R&D programs.

It is difficult to be more specific in these tasks because not only are threats not specific but also because broader scenarios cannot be predicted. We live in a potentially unstable yet unpredictable world and must accept some lack of precision in contingency planning. However, one of the dominant lessons of the last ten years of international relations is that no two crises are the same and each calls for a different response. The only commonalities are those mentioned previously that early response pays dividends and that navies are invariably the only forces able to make effective initial responses. Coupled with the need for both early warning and pre-deployment intelligence, the modern submarine is an essential part of the initial response to crisis. This means that submarines must remain as versatile as possible in remaining effective in their surveillance, presence, and response roles.

What, then, needs to be done to exploit the inherent capabilities of the submarines so that they can be integrated into the broader naval vision provided by *Leadmark*? There is, perhaps, a danger in seeing the *Victoria*-class in terms of the analogy of the dog which finally catches its own tail: “Now that I have it, what do I do with it?” Those who are inclined to think along those lines simply do not understand the emerging role of the submarine in both contemporary and future naval strategic thinking. What they may also fail to appreciate is that in many respects the submarine has become symbolic of the naval dimension of the RMA.

That said, though, a problem does exist because the submarine appears caught between two dominant strategic concepts. On one hand, the Joint Task Force concept, as outlined by *Leadmark*, is becoming the principal instrument of collective crisis response operations. We have already seen submarines integrated into the NATO Standing Naval Force and we saw the

enormous value the British were able to get from their submarines during the 1982 Falklands War, albeit operating short of total integration. On the other hand independent submarine operations are still necessary in homeland security operations, sovereignty operations, ISR roles, and special forces operations. A key point here is that Canada already has experience in operating submarines in a multilateral system and thus becomes a preferred partner. That the *Victoria*-class have the ability to conduct a range of underwater operations thus makes them preferred partners in a multinational formation. But these are qualities that do not detract from their capability to conduct national operations; the *Victoria*-class submarines are as potentially useful in multinational and joint operations as they are in homeland security.

Modernization Options

What are the modernization options? In putting these ideas forward both the technological and the operational aspects have to be presented. In some cases, it is even necessary to introduce the political factors, for it is they that may eventually determine what capabilities are maintained.

Endurance

Whether operating as part of either national or international operations, Canadian submarines will be faced with the need to make long transits and to remain on patrol for periods of 30 or more days. Hence, operating efficiency becomes a prime consideration. There is absolutely no point in attempting to establish a patrol or undertake an extended operation in an area that is so far distant that management of the submarine's fuel state becomes a constraint. At the moment the *Victoria*-class submarines have fuel limitations that constrain patrol areas and duration. Refuelling in transit or close to the area of operations is feasible but doing this obviously has security and stealth implications. It would be much better if some way could be found to increase the submarine's fuel capacity. The other dimension of this problem is to incorporate one of the forms of air independent propulsion (AIP). The success achieved by the Germans and Swedes in AIP systems is encouraging, especially when AIP would make it possible for a submarine to conduct the greater part of a surveillance patrol on that system. In concert, new battery technology will lead to better performance especially time between re-charging. By 2010, both technologies, AIP and battery, should be well advanced and easily acquired for installation. But at the moment, it is simply too early to predict which AIP system will be the best or what precise advances will be made in battery design. However, it should be possible in a few years to estimate whether installation will require that the hull be cut and a "plug" inserted (as in the present French concept of MESMA) or if reductions in size and weight of AIP systems and batteries will have reached the point where the existing spaces are adequate. For planning purposes, it may be prudent to have the cost of inserting a plug estimated. The key point in the endurance debate is that there is very little to be gained by installing improved sensors and payloads if the submarine does not have the "legs" to exploit those technologies to the full. Nor should we overlook the fact that an AIP system adds to the submarine's stealth capacity. In summary, the fitting of AIP will almost certainly pay the greatest dividend, closely followed by the use of new battery technologies. If fuel capacity can be increased, this too would be a major benefit.

Sensors and Communications

If the inherent capabilities of the submarine (stealth, endurance, and versatility) are to be exploited, regardless of whether the task is national or international, there must be an onboard system to integrate, synthesize, analyse, and disseminate raw information collected from the various sensors. This requires both people and systems. While much of the basic collection and presentation can be done automatically, classification and prioritizing invariably call for a human input. *Leadmark* puts this in rather more technical terms, “There is a tremendous synergy to be derived from the fusion of the separate capabilities of the elements of C4ISR and the coincident fusion of doctrine and technology. Success in optimising it will be perhaps the single most important capability that will allow Canadian naval forces to provide viable support to national and multinational objectives.”

Obviously, the heart of the modern submarine’s combat system (also used for ISR operations) is the command, control, communications, and computers (C4) system. In all probability, such a system needs to be purpose-built to meet the unique requirements of the *Victoria*-class. Canada has a long and excellent reputation in systems integration and such a project would not present any great technical difficulty. The lead criteria are, however, the various sensors to be integrated. Hence, the decision on what new equipment will be fitted must be made ahead of the integration process.

As discussed earlier, virtually every submarine sensor—sonar, radar, electronic intercept, periscope, AUV/UUV—is under R&D somewhere. Because funding is always limited, the acquisition decision will probably become a function of operational tasking priority. Here, it is fairly evident that the ISR role has the largest and most immediate political return on investment. In fact, it is probably fair to say that the domestic ISR tasks will be more in demand than those for international operations. There are, after all, many submarines from other navies available for international tasks. Nevertheless, a well configured *Victoria*-class may be as attractive to international naval planners as the *Coyote* land surveillance vehicle has become. It would make sense, therefore, to invest in the best possible sensor suite. In a break with tradition, it is very likely that fire-control systems will receive a lower priority than data analysis equipment because the tasking for ISR operations is likely to form the greater part of the submarine’s activity. That said, though, such a consideration must not lose sight of the fact that a need still exists for weapons and fire control systems for self-defence and for collective defence tasks. In the end, it will be a function of what can be acquired within the budget.

As *Leadmark* again explains:

A significant national application would be to upgrade the Recognized Maritime Picture (RMP) that the navy presently produces and makes available to various other government departments. The growing array of asymmetrical threats to North America will require the development and distribution of this national Common Operating Picture, along with the existing NORAD system, into a truly comprehensive continental network. Such a COP will require that future C4ISR systems and sensors be multi-dimensional and networked. This will allow for inputs from a variety of air, sea and space-based assets, their processing as an integrated data stream for the automated development of a fused picture, and the provision of a transparent and seamless transfer

medium to users. Advances in decision-making technology will convert this information data into true “knowledge”. As with all C4ISR systems, they must adopt an open architecture design to ensure interoperability with land and air forces (joint), allies (combined) and OGDs. They must also incorporate a potential for growth to ensure that they are not rapidly outdated.

In other words, the use of the submarines to develop the national maritime “picture” is likely to become a high priority. Moreover, that is a task which requires little selling politically.

Determining the ideal communications suite, however, presents a slightly different problem because it requires a decision on the degree of integration into national and international task groups and fleets. The idea of integrating a diesel-electric submarine, irrespective of any enhanced propulsion systems, into a surface task force in direct or close support is questionable. The submarine is not able to keep up with the SOA of the fleet, even under a sprint-and-drift concept, the fuel demand and the time needed to recharge are simply prohibitive. Where a diesel-electric submarine can be gainfully employed in joint and combined operations is as a long-range picket or as part of a defensive barrier. The other joint and combined tasks are reconnaissance and special forces operations. In other words, diesel-electric submarines should be employed in distant rather than close support operations. Regardless of the actual distant support function, a requirement exists for real-time, reliable communications, and so the submarine needs to have the ability to send and receive satellite communications. Without extensive communications equipment enhancement, including reliable satellite communications capability, the submarine could not copy all task force broadcasts or even have access to the full spectrum of direct communication links. This would put it at a tactical disadvantage. Hence there is a need to be able to accommodate the same bandwidth as the surface forces. In this respect, priority should be given to the acquisition of effective satellite communications facilities for use at all depths; the work being done on the RTOF-type system.

In summary, investments in improved sensors will only pay dividends if the C4 system is also improved to provide the best possible integration of all sensors and allow the rapid processing and analysis of data. Communications equipment must be similarly integrated into the functioning of the ISR equipment so that information can be passed to supported formations and headquarters. *Leadmark* offered some thoughts on the potential problems of designing future ISR capabilities, “The vast size of the Canadian area of responsibility in home waters alone will challenge the development of a comprehensive ISR capability...naval forces will require versatile and easily deployable surveillance and reconnaissance systems.” The answer may be a submarine, but it has to be the right submarine. A modernized *Victoria*-class submarine can meet that requirement.

Payloads and Weapons

The question of new payloads is probably the most controversial aspect of modernization. R&D on autonomous and remotely-operated underwater vehicles has so far been limited to SSNs and to the surface mine warfare community. The development of the submarine-launched missile (like the *Triton* system), on the other hand, has obvious applications to diesel-electric submarines. Even though the indications from AUV/UUV research and evaluation are very

promising there are a number of problems to solve before any of the UUVs or AUVs could be contemplated for the *Victoria*-class. The first of these is that of matching the vehicle to the submarine and developing the necessary operating procedures. Other than for vehicles launched from a standard torpedo tube or decoy launcher, there would have to be an extensive trial period to perfect the way by which the vehicle is launched from its “nest” in the casing or in the fin superstructure. If the decision is made that these vehicles must be recovered then that procedure would need similar trials. The state of the engineering to support recoverable remotely-operated and autonomous vehicles from submarines lags the development of the actual vehicles, and short of surrendering one submarine to R&D periodically and spending a great deal of money on the concept, it does not seem likely that the desired system will be available by 2010. If the ability to operate remotely-controlled or autonomous vehicles from the *Victoria*-class, is deemed operationally necessary, it would seem that on the basis of existing technology, the best option is for a non-recoverable, tube-launched system. It is quite possible that significant advances will be made in the next 3-4 years to make it cost-effective to acquire such a system.

In the future, antisubmarine operations will be an important submarine task in joint operations, especially in the littoral. As Admiral Owens explained, “We cannot avoid the littoral just because an opponent’s submarines may be present.” He also makes the point that littoral ASW operations are not identical to those in the open ocean. What he does not say is that it is in these waters that a diesel-electric submarine, especially one with enhanced battery capacity, or an AIP system, has several advantages over the larger nuclear-powered submarine. Hence, there will always be a requirement for torpedoes, but for reasons outlined earlier it is believed that the anti-shiping role of the submarine will take a lower priority than ASW operations. The growth of the world diesel-electric submarine fleet, particularly in some of the less stable regions, might lead to a requirement for the ASW defence of an intervention force.³¹ Hence, it makes sense to ensure that the *Victoria*-class remain competent in the ASW role, but it should be emphasized that this role cannot be undertaken without appropriate communications. ASW defence is very likely to be conducted under the aegis of NCW.

³¹For a useful summary of world submarine developments see A.D. Baker, III, “World Navies in Review”, *Proceedings*, March 2002, 33-36. For a good review of the Asia-Pacific submarine situation see, Prasun K. Sengupta, “Submarine Fleet Build-up in Asia-Pacific”, *Asian defence Journal*, August 2000, 26-32.

Several problems exist in the integration of submarines into the architecture of network centric warfare (NCW).³² One problem that stands out is the need to “tether” the submarine to the task force communications system in order to ensure continuity in the chain of command and also to include it in the fire control coordination network. This becomes a serious operational restriction. Until technology moves ahead to the next step in underwater communications (such as RTOF) the demands of NCW require the submarine to keep an antenna up almost continuously. Education will solve some problems, especially once the task force staff acknowledge the requirement to filter the submarine’s traffic.³³ While part of the solution is technical, there is also a considerable intellectual dimension to the solution. Admiral Woodward’s unique approach to command and control and waterspace management in the 1982 Falkland’s War was only made possible because he denied the submarines the right of attacking underwater contacts.³⁴ This, I suggest, is not an exception; in today’s complex and tightly politically controlled world crisis management, authority to fire at will is unlikely to be granted. Tethering becomes a political necessity, Canadian submarines will not be given an ASW role unless they have the necessary communications equipment.

The requirement for self-defence weapons raises a number of complex issues. The right of self-defence if attacked is not in doubt, but the decision to attack an aircraft, warship, or another submarine on the basis that it threatens the integrity of the mission creates political and legal problems today. The traditional justification for such a pre-emptive, but essentially defensive, attack has been the authorization, through rules of engagement, to attack units deemed to be showing “hostile intent”. In wartime, or when war seems imminent, such attacks are justifiable, but in the complex world of crisis management, or limited war as it is sometimes called, they are not necessarily justified. While this may not make operational sense, it makes absolute political sense. From this unfortunate perspective, programs to buy seemingly ambiguous self-defence weapons, such as anti-aircraft missiles (the *Triton* system), are likely to receive less political support than proposals for sophisticated evasion systems. However, when taken as a multipurpose system, their political acceptability may improve considerably.

Unlike the British and US SSNs, which are expected to have the capability for offensive operations, the diesel-electric submarines of the “medium” power navies (in which grouping Canada counts itself) generally have to operate under greater political constraint—such is the political reality of “medium” power. But defensive tasks are quite acceptable. This political reality lies at the heart of Canadian defence policy and thus cannot be overlooked.

Special Operations

For good reason, a degree of scepticism exists over diesel-electric submarines undertaking special forces operations. Not only is there a space problem which may limit the size of

³²Again, space does not permit me to elaborate on NCW. For those needing to know more, I suggest they begin with the article by Vice-Admiral Arthur K. Cebrowski and John J. Garstka “Network-Centric Warfare: Its Origin and Future”, *Proceedings*, January 1998, 28-35, and then continue with the sequence of articles in *Proceedings* it spawned, especially those critical of the concept.

³³Rear-Admiral William J. Holland, US Navy, “Subs Slip Through the Net”, *Proceedings*, June 1998, 28-30.

³⁴Admiral Sandy Woodward, *One Hundred Days* (London: Fontana Books, 1992), 122-124.

operation, but these are also high risk operations requiring a lot of prior training. The use of a submerged lockout is not easy and needs practice to ensure basic safety. It is also a slow process. Although the older method of “launching” swimmers or small boats from the casing is faster and safer, it still requires that the submarine surface with the risk of being seen from the shore. The importance of training is often down-played in the planning process in the misplaced belief that a submarine can just pick up a special forces team and go. Not only do the special forces personnel need several days of training to become familiar with the lockout procedures and in fetching their equipment from its stowage in the submarine’s casing or fin, but the submarine’s crew has to practice lockout procedures and the handling of the submarine itself.

If the national requirement, for instance, is to have this capability available at short notice, a submarine will have to be held ready at all times and a special forces team will also have to be immediately available. All this requires near-continuous training. This is enormously expensive and quite possibly a misuse of valuable resources. Nevertheless, being able to support special forces operations is a potentially useful capability and thus adds to the overall versatility of the submarine, but it should not be allowed to become a misunderstood capability. The need for dedicated training in mounting this type of operation, often at the expense of other tasking, should not be forgotten.

People

The adoption of new technologies in the *Victoria*-class will have widespread implications on just about every aspect of support infrastructure as well on the personnel system. If one looks upon the modernization of the *Victoria*-class as part of the so-called Revolution in Military Affairs (RMA) the significance of this opportunity is, perhaps, easier to comprehend. The RMA is a phenomena that few people understand completely. It has been embraced by many military forces without fully grasping that its longer-term impact extends far beyond just military systems and organizations. As Eliot Cohen explained:

Such a revolution would touch virtually all aspects of the military establishment. Cruise missiles and unmanned aerial vehicles would replace fighter planes and tanks as chess pieces in the game of military power. Today’s military organizations—divisions, fleets, and wings—could disappear or give way to successors that would look very different. And if the forces themselves changed, so too would the people, as new career possibilities, educational requirements, and promotional paths became essential. New elites would gain importance: information warriors, for example, might supplant tankers and fighter pilots as groups from which the military establishment draws the bulk of its leadership.³⁵

This form of revolution, as a function of radical change, just is not going to happen overnight or even in a matter of a few years, it will take decades to introduce fully and set to work. However, the process has begun and new technologies are indeed playing a greater role in planning the military forces of the future. And information technologies in particular are playing a significant role in shaping the way military operations are conducted. In the process, the military has to rely

³⁵Eliot A Cohen, “A Revolution in Warfare”, *Foreign Affairs*, Vol. 75, No. 2, (March/April 1996), 37.

increasingly on the private sector to provide the necessary technical support. Hence, one of the implications of the RMA is the removal of military “exclusivity” whereby the services were formerly self-sufficient industrially and could function independently of the private sector. Unless the military assumes responsibility for its own technological base, at a mind-boggling cost, greater privatization of many military functions is inevitable. The so-called revolution, as Cohen pointed out, is much broader in scope than technology alone. Not only are there extensive social implications, there are also widespread political implications. Stephen Blank put it well, “a true RMA transcends technology, engendering changes in organization, doctrine, and strategy. These changes have consequences that may affect all of society and accordingly must be taken into account by planners.”

The Canadian submarine branch has been plagued with personnel problems since its inception. Of these, two stand out: First, is the necessity of trade integration with the surface fleet which frequently requires that submariners must return to the frigates and destroyers to qualify for advancement. Also, there are some trades in which advancement is impossible purely within the submarine branch. The effect of these constraints is a higher turn-over of personnel in the branch than ideal. Second, there has always been a recruiting problem. The reasons for this are complex and linked to the former issue as well as to the basic lack of understanding of submarines within the Canadian Navy as a whole. Simply, the submarines have never enjoyed a high profile within the fleet, being seen instead as novelties operated by extroverts. The modernization of the *Victoria*-class offers a unique opportunity to address these problems.

Cohen’s observations about the deeper implications of the RMA apply to the submarines in particular. If we make the assumption that the object of the modernization program is to transform the submarines into sophisticated platforms specialized for ISR operations but with the capability to undertake other tasks such as defensive ASW and supporting special forces operations, a number of observations can be made:

- the submarine’s crew essentially divides into two broad categories: system operators and platform operators with the latter requiring extensive knowledge of the submarine’s operating systems while the former will require highly specialized data processing skills;
- in both cases, the knowledge and skill levels are no longer parallel to the trade requirements for surface ships;
- thus, submarine training will take individuals away from the mainstream of the naval trade structure; and
- submarine training will of necessity be lengthy and highly specialized.

While a degree of trade commonality may exist between surface ship and submarine ISR systems operators, almost no parallels can be drawn between the submarine platform specialists and their surface counterparts. Hence, the opportunity offered through the modernization program is to create at least two dedicated submarine trades: ISR systems operator and submarine systems operator. These would be self-contained trades similar to Naval Aircrewmen trade prior to unification or the Clearance Diver trade. The major shift in philosophy would be in the submarine systems operator who would assume responsibility for all systems in the submarine including torpedo tubes, power distribution, propulsion, and other operating systems. Taken as a community, the submarines provide a full range of career progression with enough shore

positions to allow for a reasonable rotation. The second category, ISR system operator, also has enough depth to provide a full career progression with the submarine community while also having opportunities for employment outside the submarine community, largely within the intelligence framework—many aspects of the actual jobs are common. Should deep specialists, such as linguists, be required for ISR tasking, options exist for either using them as “passengers” or of training submarine qualified personnel. The uniqueness and importance of the submarine tasks envisaged and the necessary technological transition required to make this happen, indeed provide an opportunity to resolve traditional personnel problems in a way that is completely consistent with the broader concepts of the RMA.

CONCLUSIONS

This paper has covered a lot of ground in attempting to show that the world is changing and that the industrialized states, such as Canada, have an obligation to help prevent and contain instability as well as be responsible stewards of their own maritime domains. In this, naval forces, especially submarines, have a unique role as the centre pieces of the initial response to crisis and also in providing early warning and pre-deployment intelligence. The four *Victoria*-class submarines have the potential to become invaluable players in the new crisis management strategies at home and as part of multinational operations.

To recap, the future roles of the submarines are considered to be:

- conducting intelligence, surveillance and reconnaissance (ISR) tasks in support of both domestic and international operations under a wide range of situations;
- conducting anti-shipping and antisubmarine defensive operations in distant support (as opposed to close support) of national and international formations;
- supporting special forces operations in counter-terrorist and counter-insertion operations in Canadian waters as well the provision of support to special forces in joint international operations;
- conducting “presence” operations in northern and other remote Canadian waters; and
- providing ASW training for national and international formations.

To be fully effective in these roles, the modernization program should attempt to accomplish the following:

- Increasing the submarines’ endurance, with priority going to the introduction of an AIP system that would allow the submarine to conduct the greater part of a 30-day ISR patrol on that system to increase stealth as well as conserve diesel fuel; advances in new battery design should be monitored with a view to incorporating them if they prove cost-effective.
- Acquiring a sophisticated C4 system that is capable of integrating all sensor inputs, providing the capability for data processing, and providing real-time information to supported formations and headquarters—reliable satellite communications in particular; a parallel requirements exists to ensure interoperability with supported formations for those situations where other support tasks are undertaken.
- Acquiring state-of-the-art sensors primarily to support the ISR role; in this, consideration should be given to the acquisition of UUV/AUV systems—while these systems are still in

their infancy as far as application to diesel-electric submarines is concerned, there is enough promise to warrant their consideration in the longer-term, however, it is believed that on-board systems will remain the primary means of gathering information.

- The modernization program should be used as an opportunity to create dedicated submarine specialist trades; doing this would have many advantages not least of which is the ability to have full control of the training system.

As stated before, the real determinants of what changes can be made will political acceptance of those changes and the allocation of sufficient funds.

To close, two important concepts require consideration. First, the opportunity to use the *Victoria*-class submarines as part of the process of implementing the RMA in the Canadian military (as well as in much of the R&D community) should not be dismissed. A potentially powerful synergy exists between the submarine and the scientific communities, especially in areas of underwater survey and exploration and in the related process of experimentation. The AUV and UUV have widespread applications in both military and scientific work and it makes sense to exploit that potential jointly. To this end, it would be logical to offer, periodically, a submarine to the scientific community (including the Defence Research establishment) to support their R&D and experimentation. Second, with so much technological innovation going on in the world's submarine fleets, it is important that this work be closely monitored in Canada. This serves three purposes: one, in being able to assess what new technologies and equipment have the potential for retro-fitting in the *Victoria*-class in order to maintain their effectiveness; two, for determining whether specific technologies warrant Canadian experimentation or research; and three, to begin building an inventory of emerging submarine technologies that can be applied to the next generation of Canadian submarines.