THE UNITED STATES NAVY'S ABILITY TO COUNTER THE DIESEL AND NUCLEAR SUBMARINE THREAT WITH LONG-RANGE ANTISUBMARINE WARFARE AIRCRAFT

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ABSTRACT

THE UNITED STATES NAVY'S ABILITY TO COUNTER THE DIESEL AND NUCLEAR SUBMARINE THREAT WITH LONG-RANGE ANTISUBMARINE WARFARE AIRCRAFT by LCDR Jason T. Jorgensen, 108 pages.

The threat of the Soviet Union and Communism to the United States diminished with the end of the Cold War in the early 1990s. Instead, the asymmetric threat of terrorism has spread throughout the world and become a grave danger to American citizens at home and abroad. Throughout these changes in global landscape, the US Navy has adapted and given new emphasis to a variety of missions during these times of fiscal challenge. However, one of the most dangerous weapons of the Cold War, the submarine, still exists and is being proliferated widely today. Once the primary ASW aircraft used in the prosecution of submarines, the P-3C *Orion,* has added new equipment to perform its added warfare missions. Thus, the central focus of the thesis: Does the US Navy have the airborne capability to defend itself from current as well as projected submarine threats? The thesis will examine the relevancy of ASW today and determine whether current and future submarines pose a threat to US, its interests as well as its military. The final analysis involves an evaluation of P-3C *Orion*'s capability to detect adversary submarines in the contemporary as well as future operating environment.

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ACRONYMS

AAW	Antiair Warfare
ACES	Active Capable Expendable Surveillance
AIMS	Advanced Imaging Multi-spectral Sensor
AIP	Air Independent Propulsion
AIP	Antisurface Warfare Improvement Program
ASM	Antiship Cruise Missile
ASW	Antisubmarine Warfare
ASuW	Antisurface Warfare
BMUP	Block Modification Upgrade Program
CG	Chairman's Guidance
CINC	Commander in Chief
CJCS	Chairman, Joint Chiefs of Staff
CMDS	Countermeasures Dispensing System
CNO	Chief of Naval Operations
CPA	Chairman's Program Assessment
CPR	Chairman's Programming Recommendation
CVBG	Carrier Battle Group
DF	Direction Finding
DOD	Department of Defense
DPG	Defense Planning Guidance
EER	Extended Echo Ranging
ESM	Electronic Support Measures

EWO	Electronic Warfare Operator
FE	Flight Engineer
HDW	Howaldtwerke
IFT	In-flight Technician
IRDS	Infrared Detection System
ISAR	Inverse Synthetic Aperture Radar
ISR	Intelligence, Surveillance and Reconnaissance
JPD	Joint Planning Document
JROC	Joint Requirements Oversight Committee
JSCP	Joint Strategic Capabilities Plan
JSPS	Joint Strategic Planning System
JSR	Joint Strategy Review
JWCA	Joint War-fighting Capability Assessment
MAD	Magnetic Anomaly Detection
MET	Mission Essential Task
MWS	Missile Warning System
NATO	North Atlantic Treaty Organization
NATOPS	Naval Air Training and Operating Procedures Standardization
NAV/COMM	Navigator/Communicator
NCA	National Command Authority
NDC	Naval Doctrine Command
NFO	Naval Flight Officer
NMS	National Military Strategy

NTA	Naval Tactical Military Tasks
NTTL	Naval Tactical Task List
ONI	Office of Naval Intelligence
OP	Operational Level Military Tasks
POM	Program Objective Memorandum
QDR	*Quadrennial Defense Review*
ROE	Rules of Engagement
RWR	Radar Warning Receiver
SAM	Surface-to Air-Missile
SAR	Synthetic Aperture Radar
SASP	Single Advanced Signal Processor
SECDEF	Secretary of Defense
SLAM	Standoff Land Attack Missile
SLOC	Sea Line of Communication
SN	Strategic Level National Military Tasks
SSBN	Fleet Ballistic Missile Submarine
SSGN	Guided Missile Nuclear-Powered Submarine
SSK	Diesel Submarine
SSN	Nuclear-Powered Attack Submarine
ST	Strategic Theater-Level Military Tasks
TACCO	Tactical Coordinator
TSNW	Thyssen Nordseewerke
UJTL	Universal Joint Task List

UNTL	Universal Naval Task List
US	United States
USA	United States Army
USMC	United States Marine Corps
USN	United States Navy
USS	United States Ship
UUV	Unmanned, Underwater Vehicle
WMD	Weapons of Mass Destruction

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CHAPTER 1

INTRODUCTION

> The submarine challenges that face the US Navy today is more diverse and complex than those faced during the "Cold War." These challenges now encompass both the open ocean and the littoral. They range from stealthy, highly capable, and modern Russian submarines in open-ocean at one end of the spectrum to relatively unsophisticated, North Korean conventional submarines operating in shallow and acoustically demanding coastal waters at the other. The proliferation of submarine technology is the most significant long-term submarine challenge facing the US Navy as we approach the 21st century. (US Congress, Senate 1997)

Rear Admiral Michael W. Cramer

Introduction

The US is still reeling from the terrorist attacks of 11 September 2001. In the span of moments, the nation watched in horror as two symbols of American power, the World Trade Center and the Pentagon, were attacked during arguably one of the worst days in American history. Consequently, homeland defense is the new priority. The US is focused on a new and different threat that is affecting every American citizen around the world. Although the US and its citizens may be threatened by terrorists domestically as well as abroad, the US military cannot discount the more traditional threats that have and continue to confront the nation.

Despite the end of the Cold War, the submarine remains one of many dangerous threats to the US security as well as the US Navy. Since the end of the Cold War, the US Navy has turned its focus away from the prevention of the spread of Communism. Funding allocated to the Department of the Navy by Congress has changed. The Navy has gotten smaller in number of ships, aircraft, personnel, and bases as it struggles as a service to "do more with less." While, technology can be attributed to a portion of the transformation of the sea service, the bottom line is that the US no longer feared the Soviet Union's desire to spread communism throughout the world. No longer would the Soviet Union would not get her submarine fleet underway and swarm the oceans of the world in a prelude to a third world conflict. However, the lack of a peer competitor for the US did not make the world that much less of a dangerous place. That is no more evident than in the threat presented by today's modern submarine.

This thesis will explore the threat presented by diesel and nuclear submarines to the global operations of the US Navy in support of US national interests. The research will seek to determine whether submarines are still a threat now and in the future. Finally, the thesis will evaluate the capabilities of the Navy's long-range, antisubmarine warfare (ASW) aircraft represented by the P-3C *Orion*. By conducting comprehensive research on these topics, a determination will be able to be made on whether this aircraft, the P-3C *Orion*, is capable of performing this warfare mission.

The Research Question

The primary thesis question is: Does the US Navy have the airborne capability to defend itself from current as well as projected submarine threats? In order to understand the foundation of this question, it will be important to look at how the end of the Cold War changed the US military's policy towards ASW and to look at what changes took place in the global environment to shape the Navy into its present state.

Next, the thesis will illustrate that submarines are still a threat to US interests as well as the US Navy by asking several secondary and tertiary questions. What is the current submarine threat? What nations currently have diesel or nuclear submarines in their inventory? What makes these submarines dangerous? How can the US' adversaries use submarines to hinder US interests? Why is the proliferation of submarines dangerous to the US? Finally, is ASW still relevant today?

Concentrating on the current state of the submarine threat would severely limit the scope of research for this thesis. A comprehensive examination of the technological revolution being experienced in submarine development will exhibit the depth of this problem for the US Navy. What advances are taking place with diesel and nuclear submarine technology? How could this prove perilous for the US? Why would the sale of this technology cause potential problems for the US and its allies? By addressing these questions, the research will demonstrate that submarines will continue to represent a major threat to the US.

Finally, the thesis will focus on what core competencies that the ASW aircraft of the Navy must possess in order to detect and defeat submarines now and in the future. How does that aircraft measure up to the requirements set forth for meeting the threat of submarines?

By systematically addressing each of the secondary and tertiary questions during the research process, a qualitative answer to the thesis question will be determined.

Background

The US Navy is operating around the world in support of the national military strategy (*NMS*). To comprehend the impact of the end of the Cold War and its effect on the *NMS*, one needs to look no further than the change in force structure for the ASW aircraft of the US Navy. In 1990, there were twenty-four active duty P-3C *Orion* squadrons. By the mid-1990s, there were half as many squadrons (Doney and Deal 1999, 104). In a similar manner, the S-3 *Viking*, a carrier-based, ASW aircraft, stopped being funded to perform the ASW mission in 1998 (Doney and Deal 1999, 103). Why did this force structure change? With the US no longer facing the threat of Russian submarines crowding the Atlantic and Pacific oceans and hunting NATO shipping, it was quite simple for a budget conscious Congress as well as the Navy to save money by reducing platforms that apparently were not as critical. That left the P-3C *Orion* as the remaining fixed-wing, ASW aircraft and the S-3 *Viking* as the aircraft carrier's antisurface warfare and a refueling aircraft. The end of the Cold War was the catalyst for the change in operations for naval aviation.

With the US Navy's ASW aircraft force structure changes came changes in aircraft missions also. The harsh, funding-competitive environment of the Department of Defense forced the Navy to find new missions that would justify the existence of the various platforms and programs. Thus, the Navy began using its aircraft for other missions throughout the world. The P-3C *Orion* could be found supporting the war on drugs in the Caribbean, enforcing United Nations sanctions against Iraq in the Persian Gulf, flying in support of NATO in the Adriatic, as well as numerous other small-scale operations worldwide. During the period of expanding roles, the *Orion* was modified with an Anti-Surface Warfare Improvement Program (AIP) sensor package to make it a more effective surveillance and strike aircraft. The requirements to maintain ASW proficiency never went away; however, training to face the evil enemy lurking beneath the high seas was no longer the primary focus. The men and women flying the P-3C *Orion* were now training for challenging missions in antisurface warfare (ASuW); strike; and overland intelligence, surveillance, and reconnaissance (ISR).

However, this shift in priorities for the naval aircraft did not mean the threat from submarines had ended. To the contrary, the threat from submarines may have become even more sinister. The absence of a peer competitor for the US did not change the threat of submarines to the US and her Navy. In fact, it could be easily argued that the lack of a peer competitor has made the world that much more of a dangerous place. The US's new friend Russia was offering to sell platforms from her diesel submarine fleet to nation-states like Iran, who have no diplomatic relationship with the US. In addition, many nations, like Germany and Sweden, were selling extremely capable submarines to any nation throughout the world for a price. In addition, regional powers, like China and Russia, continue to construct new design hulls that are increasingly more capable for their own fleets.

The map in figure 1 depicts nations that operate diesel submarines and the number of diesel submarines in that nation's inventory. The map easily demonstrates that the US Navy has significantly more potential adversaries in the year 2002 than during the Cold War. Any of these nations possessing a diesel submarine could prevent US military or merchant shipping passage through a strategic choke point. The US's ability to freely maneuver the high seas to transport commercial goods or act militarily could be severely damaged by the presence of even one submarine. A relatively small nation with little or no military strength could influence events in a region by obtaining a submarine. For example, a submarine could be used to prevent the United States from entering the Persian Gulf. On the other hand, a submarine could be used to disrupt the commercial transport of oil throughout the world by sinking merchant shipping. The prospect of not having access to ports throughout the world would be a cause of great concern for the US.

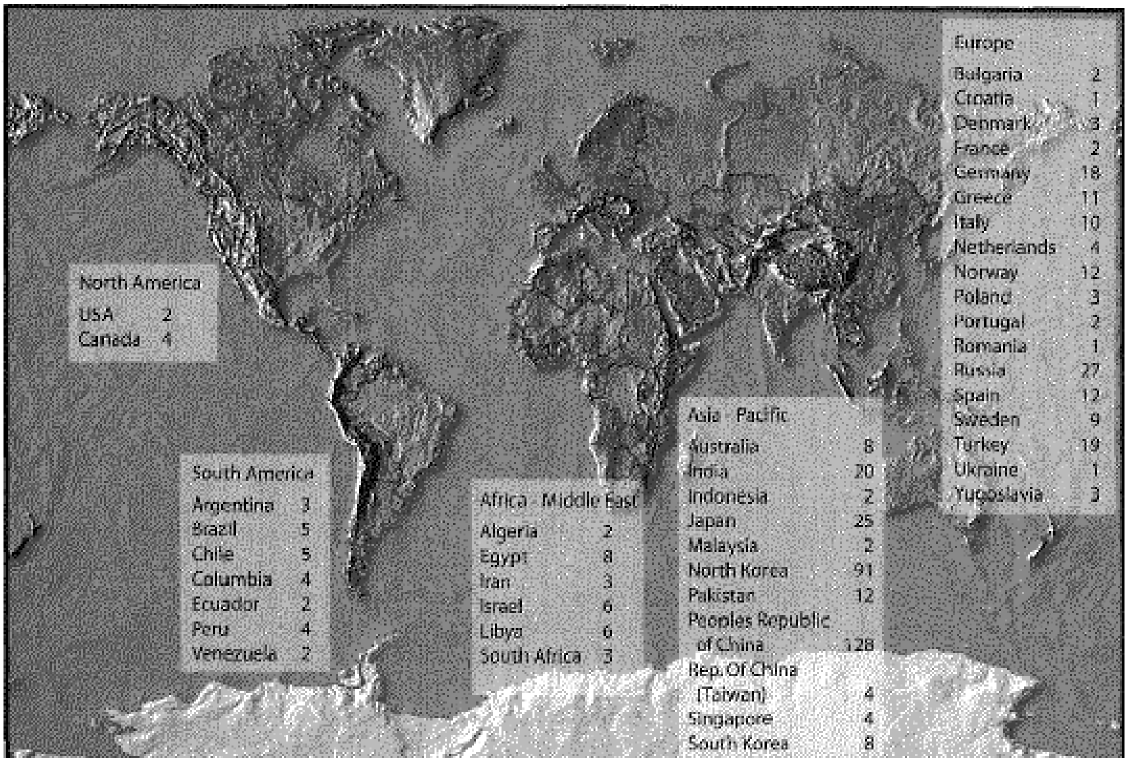

Figure 1. World Diesel-Electric Attack, Coast, Dry Special Operation and Minisubmarines Order of Battle. *Source:* Sherman 2001.

It is this alarming specter of submarines threatening US national interests that proves the importance of ASW. At the end of this research, this thesis will determine if the Navy's airborne, ASW aircraft, represented by the P-3C *Orion*, has the capability to meet the challenges represented by today's submarine as well as the submarine of the future.

Assumptions

An assessment of the US Navy airborne, ASW aircraft's adequacy in prosecuting diesel and nuclear submarines is paramount to the success of this research. The first assumption made will be that the P-3C *Orion* will remain the only airborne platform suited to prosecute submarines. This is not intended to slight the men and women of the helicopter squadrons or detachments that operate from the US Navy's ships or aircraft carriers. It is the *Orion*'s unique ability to operate forward and independent of the battle group that sets it apart from the ASW helicopters of the Navy. The research will focus on the *Orion* because it truly represents the concepts of a Naval expeditionary force or a force that is able to operate forward of a significant American logistics base independently.

Quantifying the capabilities of the P-3C coupled with a comprehensive examination of the submarine threat using open source materials is possible. This assumption is critical to the parameters of the research. A qualitative measure of effectiveness for P-3C *Orion* sensors can be made by examining aircraft equipment and general operator training. An analysis of this crucial assumption will be further detailed in the third chapter of the thesis aptly titled methodology.

Definitions

Air Independent Propulsion (AIP). A means of propelling a diesel submarine through water without diminishing the battery charge or surfacing (Edmonds 2000).

Antisubmarine Warfare (ASW). Operations conducted with the intention of denying the enemy the effective use of his submarines (US Government Accounting Office 1999, 2).

Antisurface Warfare (ASuW). Operations conducted against enemy surface forces.

Asymmetric Warfare. To attack an adversary's weaknesses, avoiding his strengths, while preventing him from doing the same, using asymmetric means (US Congress, Senate 1998). Example is terrorism.

Blue-Water ASW. ASW conducted in the open ocean or non-littoral environment with the intention of denying the enemy effective use of his submarines.

Brown-Water ASW. ASW conducted in coastal waters from the shoreline to twenty-five miles offshore. Currents and thermal disturbances cause poor sound propagation conditions that characterize the water mass. In addition, the bottom of the water is typically mud and littered with debris that further reduces sound propagation (Edmonds 2000).

Cueing. Cueing is "the ability to detect the presence of a submarine in a general area by national or theater sensors (i.e., tactical units)" (Naval Doctrine Command 1998).

Choke Point. A sea-based, trade route whose geographic location and surrounding features allow access to be controlled with relative ease. Three principles must exist for an area to be designated a choke point: no alternative route is available, freedom to use the waterway must be vitally important, and the forces of an aggressor must be able to block the geographic point (Haydon 1993, 20).

Choke-Point Operations. Tasks that are required to ensure choke points are maintained free of submarines that would deter or prevent the passage and freedom of navigation through any restrictive or strategically significant geographic location (Naval Doctrine Command 1998).

Classification. The "ability to discriminate a contact as either a submarine or nonsubmarine and if a submarine, determine its identity" (Naval Doctrine Command 1998).

Coastal Defense. To hold naval forces at risk while posing a difficult challenge for ASW forces (Naval Doctrine Command 1998).

Counteraccess. Mission designed to deny US and allied forces easy access to key theaters, ports, bases, facilities, as well as air, land, and sea approaches (US Congress, Senate 2001).

Cruise Missile. A "guided missile, the major portion of whose flight path to its target is conducted at approximately constant velocity; depends on the dynamic reaction of air for lift and upon propulsion forces to balance drag" (Chairman, Joint Chiefs of Staff 2000a, 119).

Detection. The recognition "of contact indications that may be a submarine" (Naval Doctrine Command 1998).

Diesel Submarine. This type of "submarine relies upon diesel engines to drive generators to charge submarine batteries or to drive the propellors. A diesel-powered submarine commonly uses a snorkel device to receive air for diesel engine operation, thus reducing the submarine hull's exposure to radar, infrared and visual sensors. Once operating on batteries, this submarine can be very quiet" (PMA-264 2001a).

Fleet Ballistic Missile Submarine. The fleet ballistic missile submarine or SSBN is "a nuclear-powered submarine designed to deliver ballistic missile attacks against assigned targets from either a submerged or surfaced condition" (Chairman, Joint Chiefs of Staff 2000a, 178).

Full-Spectrum Dominance. The ability of US forces, operating unilaterally or in combination with multinational and interagency partners, to defeat any adversary and control any situation in the domain of space, sea, land, air, or information military operations (Chairman, Joint Chiefs of Staff 2000b, 6).

Green-Water ASW. ASW conducted in waters of the continental shelf. The water mass is characterized by a mixture of drifting water bodies with variations in salinity and temperature that cause poor sound propagation (Edmonds 2000).

Infrared Detection System (IRDS). The IRDS is a nonacoustic, infrared system that searches all around the P-3C *Orion* for infrared emissions (PMA-264 2001a).

Intelligence. "Information and knowledge about an adversary obtained through observation, investigation, analysis, or understanding" (Chairman, Joint Chiefs of Staff 2000a, 228-229).

Line of Communication. "A route, either land, water, and/or air, which connects an operating military force with a base of operations and along which supplies and military forces move" (Chairman, Joint Chiefs of Staff 2000a, 268).

Littoral. 1. The region contains two parts. The first part is the area seaward from open ocean to the shore, which must be controlled to support operations ashore. The second part is the landward area inland from the shore that can be supported and defended directly from the sea (Chairman, Joint Chiefs of Staff 1997a, 464).

2. Regions relating to or existing on a shore or coastal region that are within direct control of and vulnerable to the striking power of naval expeditionary forces (Naval Doctrine Command 1998).

Littoral Antisubmarine Warfare. Elimination of the submarine threat in a littoral environment (Naval Doctrine Command 1998).

Magnetic Anomaly Detection (MAD). The MAD is a nonacoustic aircraft sensor that “senses disturbances in the Earth’s magnetic field produced by the passage of large ferrous objects (e.g., submarines)” and is typically a short-range sensor (PMA-264 2001a).

Mine. It is an “explosive device laid in the water with the intention of damaging or sinking ships or of deterring shipping from entering an area” (Chairman, Joint Chiefs of Staff 2000a, 296).

Mine Warfare. “The strategic, operational, and tactical use of mines . . . to degrade the enemy’s capabilities to wage land, air, and maritime warfare” (Chairman, Joint Chiefs of Staff 2000a, 297).

Neutralization. The action taken by ASW forces “to render submarine’s influence on military operations ineffective by any means available” (Naval Doctrine Command 1998).

Nonorganic Aircraft. A fixed-wing aircraft or helicopter that is flown from a land-based airfield and shifts operational control to become an airborne asset that works in support of the carrier battle group.

Nuclear Submarine. This type of “submarine relies upon nuclear reaction to create heat which drives steam turbines. These turbines provide electrical power as well as drive the propellors. Since it does not require to snorkel, this submarine can operate virtually unseen” (PMA-264 2001a).

On-station. The period of time where a naval aircraft performs an operational mission in support of national objectives in a specific geographic area. The time period does not include the time to transit to or from the aircraft's operating area.

Organic Aircraft. A fixed-wing aircraft or helicopter that flies to and from an aircraft carrier or ship and is considered an airborne asset of the carrier battle group.

P-3C *Orion*. The *Orion* is "a four-engine, turboprop, all-weather, long-range, land-based antisubmarine aircraft" flown by the US Navy (Chairman, Joint Chiefs of Staff 2000a, 340). The aircraft is capable of performing ASW; ASuW; overland and sea strike; mining; ISR; and fleet support missions.

Power Projection. A self-sufficient platform that is able to operate stealthily in forward areas. A submarine can project military power ashore by covertly landing special operations forces or by attacking key targets with cruise missiles armed with a variety of munitions, including weapons of mass destruction (WMD) (Naval Doctrine Command 1998).

Radar. Radar is "a radio detection device that provides information on range, azimuth and/or elevation of objects" (Chairman, Joint Chiefs of Staff 2000a, 375). The radar is a nonacoustic sensor used by "ASW aircraft to scan for surfaced or snorkeling submarines as well as submarine periscopes" (PMA-264 2001a).

Reconnaissance. A mission conducted to "obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area" (Chairman, Joint Chiefs of Staff 2000a, 383).

Sea Control Operations. Tasks required to gain adequate control of the seas in the US maneuver area and thereby secure US objectives in regional operations (Naval Doctrine Command 1998).

Sea Denial. Covert surveillance, mining, and attack in busy shipping channels or maritime choke points (Naval Doctrine Command 1998).

Sonobuoy. A sonobuoy is a type of expendable aircraft ordnance used "to detect submerged submarine sounds. Current sonobuoys are classified as passive (listen for sounds), active (transmit sounds and listen for echoes) and special purpose (communications and temperature measurement)" (PMA-264 2001a).

Strike Warfare. Warfare in which attacks are "intended to inflict damage on, seize, or destroy an objective" (Chairman, Joint Chiefs of Staff 2000a, 441).

Submarine. A submarine is "a warship designed for under-the-surface operations with primary mission of locating and destroying ships, including other submarines," and is capable of other various naval missions (Chairman, Joint Chiefs of Staff 2000a, 442).

Surveillance. A mission performed by the P-3C *Orion* that involves "the systematic observation of aerospace, surface or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means" (Chairman, Joint Chiefs of Staff 2000a, 447)."

Target Identification. Action taken by ASW forces to "determine the threat of a target to a force or unit" (Naval Doctrine Command 1998).

Targeting. The ability of ASW forces to be "prepared to make an appropriate response to a submarine's hostile or threatening actions, taking into account ROE (rules of engagement), operational requirements, and capabilities" (Naval Doctrine Command 1998).

Undersea Warfare. The segment of naval warfare that involves sensors, weapons, platforms, and targets in the subsurface environment (Naval Doctrine Command 1998).

Limitations

The research will be confined to unclassified sources only. There are numerous technical capabilities concerning diesel and nuclear submarines that will be addressed or researched using unclassified sources for the scope of this thesis. In addition, the technical specifications of the Navy's long-range ASW aircraft, represented by the P-3C *Orion*, will be limited to open source materials. Finally, the tactical application for prosecuting submarines will be addressed in general terms and remains unclassified. The self-imposed requirement for the thesis to remain unclassified will not affect its overall impact.

Delimitations

The time frame of the thesis will begin at the end of the Cold War in the early 1990s. This time was chosen because it is universally considered the time that the heightened tensions between the US and the Soviet Union ended. The end of the Cold War signified the US no longer fearing the hordes of Soviet submarines swarming into the Atlantic as the country shifted its priorities elsewhere. The time frame covered by this thesis will run through the year 2001.

There are many types of submarines. For the purpose of this thesis, the types of submarines detailed in the thesis will be limited to diesel and nuclear submarines used for military purposes and exclude research and commercial submersible vessels. In addition, submarines used by the North Atlantic Treaty Organization (NATO) countries and allies of the US will not be noted, as they are not considered a threat to the US Navy or US maritime interests. Using that same logic, the thesis will focus on nations considered unfriendly to the US, its allies, and their interests since the end of the Cold War. Although the terrorist attack on the US has united Russia, China, and even Iran against terrorism, all three nations along with North Korea will be reviewed. Also, the threat posed by fleet ballistic submarines (SSBN) can affect the very survival of the US and is not debatable. Therefore, the SSBN and its nuclear weapons will not be the focus of the thesis. Finally, submarines used as a special operations force insertion and extraction platform, while a definite threat, will not be examined, as the focus will be on the maritime aspect of ASW and not the use of Special Forces personnel.

The US has had three principal airborne ASW aircraft during the last ten years. The aircraft are the SH-60B/F *Seahawk* helicopter, the S-3B *Viking*, and the P-3C *Orion*. The S-3 *Viking* is a carrier-based aircraft that was capable of performing the ASW mission as an organic, air asset from the aircraft carrier. The S-3 stopped being funded to perform the ASW mission in 1998. The SH-60B/F helicopter is a ship-based helicopter. The Bravo version is flown from the US Navy's cruisers, frigates, and destroyers and uses sonobuoys to localize, track, and attack submarines. The Foxtrot version is found on the aircraft carriers of the Navy and uses dipping sonar as well as sonobuoys to localize, track, and attack submarines. Both are extremely capable airborne platforms, but have a limited endurance. While the *Seahawk* is capable of prosecuting submarines, its limited sonobuoy and weapon payload and endurance hinder its overall effectiveness in a search for diesel submarine in a challenging acoustic environment.

The remaining aircraft of the three mentioned is the P-3C *Orion*. The *Orion* is a shore-based military aircraft and is considered non-organic to the aircraft carrier battle group (CVBG) as well as other US naval vessels. The *Orion* is the only long-range, airborne, ASW aircraft in the US Navy inventory. The Navy depends on this forty-year-old aircraft to be its airborne defense from all undersea threats. The ASW capabilities of the *Orion* will be one of the focal points of the thesis. The *Seahawk* and the *Viking* will be discounted as one platform is incapable of operating autonomously from the aircraft carrier while the other has been retired from the ASW mission, respectively.

This research conducted for this thesis recognizes that the weapon payload of a submarine can be quite deadly. To narrow the scope of the research, the thesis will review the potential weapons and technology that are available to be loaded on board a submarine. However, the research will not address every weapon that is currently available for purchase in the world arms market. Instead, it will focus on the mines, torpedoes, and antiship and or cruise missiles that can be quite deadly to the US Navy and on how that could affect naval operations.

The last critical item to be restricted in the thesis is technology. Due to the complex system of getting equipment added to Navy platforms and funded by Congress, the thesis will focus on capabilities that currently exist on the P-3C *Orion*. Potential ASW equipment that may be added but is not yet funded for the P3 will not be noted. Credible research cannot be completed on equipment that may never be part of the *Orion*'s ASW equipment suite. Finally, any potential replacement aircraft for the P3 will not be addressed because the different airframes are simply proposals designed to replace the nearly four-decade-old *Orion*. It will be several years before the proposed airframes would be added to the fleet's inventory of ASW aircraft. The replacement aircraft will be more than just a blueprint if and only when Congress decides to fund, design, and test this new aircraft using the US government's acquisition process.

In direct contrast, the technological advancements currently underway with submarines, notably the diesel variant, will be addressed. This technology has evolved significantly since the conclusion of the Cold War. Advances in submarine propulsion systems as well as batteries will allow a diesel submarine to operate significantly longer and quieter underwater. Russia is selling these advanced diesel submarines to the highest bidder. In addition, several commercial companies have made highly advanced, diesel submarines available to whatever nation-state is willing to pay the price. The proliferation of these submarines poses the largest threat to the US. The submarines are dangerous to US and allied warships and are extremely challenging for ASW aircraft to prosecute.

The last item to be delimited is the new tactics, techniques, and procedures used to prosecute submarines. Due to the relatively new procedures involving low frequency active acoustic sensors and the classification of such sensors and techniques, systems, such as extended echo ranging (EER), active capable expendable surveillance (ACES), and unmanned underwater vehicles (UUVs), will not be addressed.

Significance of the Study

The importance of this study is clear. The lack of an adversary for the US on the world stage has not changed the threat of submarines. Submarines operating throughout the world today are quieter and can carry deadlier payloads than anytime in history. These submarines are operating in extremely challenging, littoral environments with propulsion systems that increase the submarines ability to remain submerged significantly longer than ever before. Iran, North Korea, China, and Russia are just a few of the nations deploying these highly effective submarines. It is of utmost importance that the US Navy maintains the capability to defend itself and protect American interests from the current and future submarine threat. The US must once again emphasize the importance of ASW with an enthusiasm, funding, and support not evident since the conclusion of the Cold War. In order to meet the ASW challenges of today and in the future, the US Navy must ensure that its ASW aircraft possess the capability to counter and defeat submarines in any environment.

CHAPTER 2

CURRENT THREAT, CAPABILITIES, AND REQUIREMENTS: A REVIEW OF LITERATURE

> ASW is not an end in itself, it is a means through which we are able to conduct the missions required of us in this new world. In literally all our deliberations-joint strike, for instance--there is a discussion of ASW. In carrying out a joint-strike mission, we must be able to put our forces into position where they can make a meaningful contribution. That could mean sortie of our aircraft, or the ability to bring Tomahawk missiles into a theater of operations. And that, of course, relates directly to our ability to attain battle-space dominance in the area-and that means ASW. (Morton 1993)
>
> Vice Admiral William A. Owens

This chapter will focus on the literature in circulation on antisubmarine warfare (ASW) and the Navy's shore-based, airborne, ASW capabilities represented by the P-3C *Orion*. The intent of this chapter is to acknowledge the literature documenting the amazing transition that took place regarding the submarine threat at the conclusion of the Cold War and to establish an understanding of how these changes shaped the US Navy airborne ASW capabilities. Information on submarines, ASW, and the P-3C *Orion* ASW capabilities were reviewed from the following sources and references: *Quadrennial Defense Review*, *National Security Strategy*, *National Military Strategy*, naval doctrine publications, Department of Defense publications, government documents, professional organization document summaries, related topic master's theses, books, and various articles from a diverse number of sources. An extensive amount of information regarding the thesis topic is available. This thesis will attempt to recognize the variety of opinions presented throughout the material and place them into perspective. The consideration of this data will assist in determining whether the Navy possesses the airborne ASW capabilities to meet the challenges of the submarine threat.

Is ASW Relevant?

After the terrorist attacks of 11 September 2001, the nation went to war in Afghanistan with Osama Bin Laden, the Taliban, and the Al Qaeda terrorist organizations that they sponsor. The US was attacked and thousands of innocent American men, women, and children as well as foreigners were killed. In light of this American tragedy, how could ASW and submarines be a priority for the Department of Defense when the terrorism presents a clear and present danger to the Americans at home and abroad?

The answer to that question is found in the fabric of the nation's well being. The US is dependent on imported petroleum products to supply 40 percent of its energy needs with nearly one-half of the oil demands being met by oil imports from overseas (White House 2000, 34). These oil imports are brought to the US by oil tankers. The US receives just 15 percent of these oil imports from the Persian Gulf while US allies in Europe and Asia receive 80 percent of their oil imports from the Persian Gulf (White House 2000, 34). Closure of the Persian Gulf by a nation, like Iran, would cause minor problems to the US, which could be resolved by purchasing oil from other oil-producing nations, like Venezuela or Mexico. However, US allies in Europe and Asia would experience an energy crisis if they do not receive their required oil to meet their citizen's demands, which could trigger an economic crisis. An economic crisis in Europe and Asia would affect the US. That makes the Persian Gulf one of many critical regions throughout the world.

How important is it to maintain the flow of oil throughout the world? The 1997 *National Military Strategy* addressed four strategic concepts. One of these concepts was overseas presence. The *National Military Strategy* describes overseas presence as "the visible posture of US forces and infrastructure strategically positioned forward, in and near key regions" (Chairman, Joint Chiefs of Staff 1997, 6). This concept illustrates the US' requirement to have military forces forward deployed throughout the world to protect its interests, which include geographic transit points (see Table 1). The deployment of sailors and soldiers throughout the world demonstrates the US's resolve to protect her interests and allows the US the capability to defend those interests. Given "the global nature of our interests and obligations, the US must maintain its overseas presence forces and the ability to rapidly project power world-wide to achieve full spectrum dominance" (Chairman, Joint Chiefs of Staff 2000b, 6).

Table 1. Oil Flow Through Significant World Transit Points

Geographic Transit Point	Oil Flow (million barrels/day)	Primary Oil Destination	Significance of Oil Transit Point
Bab el Mandeb	3.3	Europe, United States, & Asia.	Closure would raise transit time and shipping costs.
Bosporous	1.4	Western and Southern Europe.	Difficult to navigate
Panama Canal	0.6	Atlantic & Pacific Transfer Point	Closure would impact shipping costs and transit time.
Strait of Hormuz	14.0	United States & Western Europe	Closure would raise shipping costs if alternative routes were available.
Strait of Malacca	8.2	South Korea, Japan, China & Pacific Rim Nations	Closure would raise shipping costs.
Suez Canal	3.1	Europe & the United States	Alternative route is around south tip of Africa.

Source: Energy Information Administration 1997.

The *National Military Strategy's* military requirement to have access throughout the world is not just to protect American economic interests. In times of conflict, the US traditionally transports 95 percent of its military cargo by sea to the area of operations (Brigger 2000, 52). This cargo is the equipment and supplies that are used in theater to by forces as they move into theater and then to resupply the air and ground forces as operations are conducted. This astounding percentage of cargo shipped by sea only reinforces how critical it is for the US to have access to any theater in order to conduct operations. What would have happened in the Gulf War if the US was not able to operate inside the Persian Gulf because the Strait of Hormuz was blocked? Maintenance of the sea lines of communication (SLOC) is critical to the success of the US during any conflict. Failure to protect the SLOC could cause the US delays in entering theater and ultimately change the entire outlook of any future conflict.

The importance of SLOCs to US military operations is no more evident than the military operations currently being conducted in Afghanistan. Admiral Dennis Blair, Commander-in-Chief, US Pacific Command, explained the reason for the protection of supply ships in an article appearing in an article of the *International Herald Tribune* on 3 December 2001. Admiral Blair stated that the operations were being done to guard against potential terrorist attacks on supply ships transiting through the Strait of Malacca, a major international shipping lane linking the Pacific and Indian Oceans (Richardson 2001, 4). There are Muslim, extremist groups that operate in the Philippines and Malaysia that could disrupt US military action in Afghanistan with a terrorist attack. This type of attack by terrorists as well as the defense to protect against it proves how important maintenance of security in the SLOC is for US military operations. If the US military fears an attack from terrorists, then a stealthy submarine could prove to be even more dangerous.

A rather simple way to block a SLOC is at a geographic point where a waterway is constricted by the geography of the land. This geographic point is a called a choke point. There are several choke points depicted in figure 2. Freedom to maneuver through these choke points is critical for the US Navy. Obviously, the US is more vulnerable at these points around the globe, and it is at these points where any potential adversaries can inhibit US interests. Vice Admiral Charles W. Moore, the Commander of all American naval forces in the US Central Command, reaffirmed this point during his testimony to House Military Procurement Subcommittee on 29 February 2000. During his testimony, he stated that that he considers "the Strait of Hormuz as my most critical" choke point and that "protecting the sea lines of communications is a historic and enduring naval mission" (US Congress, House 2000).

The Department of Defense's 2001 *Quadrennial Defense Review* (*QDR*), released after the terrorist attacks in September 2001, recognized many threats in addition to terrorism that can inhibit US interests. "Future adversaries could have the means to render ineffective much of our current ability to project military power overseas (DOD 2001, 31)." The *QDR* continued by defining three specific threats that could jeopardize the US ability to project power ashore: diesel submarines, antiship cruise missiles and mines (US DOD 2001, 31). These three items are all interconnected as the submarine can be a delivery platform for both mines and anti-ship cruise missiles. It is somewhat ironic that despite all of the US' military might, the US is still vulnerable to traditional threats, like submarines in addition to terrorism. However, submarines are a threat that the US must be wary of and ASW must be a priority.

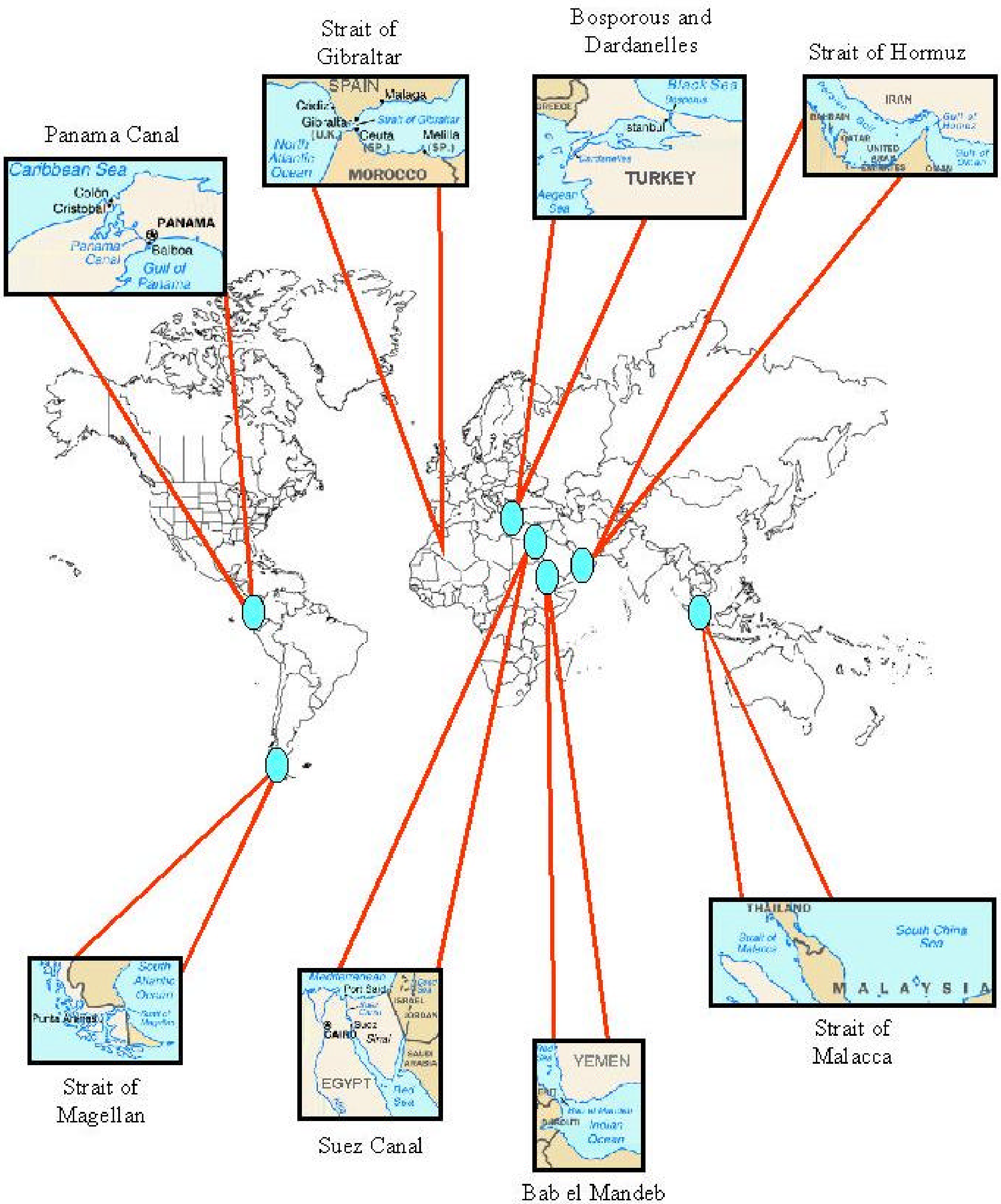

Figure 2. World Choke Points. World map from http://www.graphicmaps/aatlas/worldout.htm and inset maps from http://geography.miningco.com/library/weekly/aa052597.

UNTL: The Threat Translated for the US Navy

The submarine threat has been articulated for joint force and naval commanders through a list of war-fighting requirements presented in the *Universal Naval Task List* (*UNTL*). The *UNTL* identifies tasks that the US Armed Forces need to be proficient in and is a derivative of the *Universal Joint Task List* (*UJTL*) created by the Chairman, Joint Chiefs of Staff (CJCS). The Naval Doctrine Command describes the *UJTL* as a "comprehensive list of tasks at the strategic and operational levels of war" (CNO 1996, 1-3). The UJTL does not address which branch of the service is responsible for the various tasks or how to accomplish them. The Chief of Naval Operations (CNO), along with the Commandant of the Marine Corps and the Commandant of the Coast Guard, produces the *UNTL* that details tasks specific to the sea service profession.

This list is divided into two specific war-fighting segments. The first segment is the "Naval Tactical Task List" (NTTL). The NTTL is an inclusive catalogue of tactical tasks that required at the tactical level of war (CNO 1996, 1-1). The tactical level of war involves individual units engaged against an enemy's force or forces. The second portion of the UNTL is the UJTL. The UJTL is a summary of the warfighting requirements at the strategic and operational levels of war. Tasks at the strategic level ensure the security of a nation or an alliance is met while tasks at the operational level of war link tactical tasks to the essential objectives at the strategic level. The NTTL and UJTL together form the UNTL and establish the war-fighting requirements for the US Navy and joint force commanders.

The development of the UJTL was in response to a desire of the US military's Joint Community to refine training for joint operations (CNO 1996, 2-1). The foundation of the UJTL is the Mission Essential Tasks (METs), which set a standard for the completion of an assigned objective. The METs are divided up into four separate categories for the three levels of war consisting of strategic national, strategic theater, operational, and tactical tasks. The joint theater commanders develop strategic theater tasks while operational and naval component commanders develop tactical-level tasks (CNO 1996, 2-1).

Table 2 is a summary of the UNTL for all tasks involving ASW and submarines. Table 2 demonstrates how submarines and ASW affect the US armed services at the strategic, operational, and tactical levels. Whether naval forces are operating against land forces in a littoral environment, conducting a forced entry through a controlled choke point, or ensuring that the sea lines of communication are maintained, the submarine can pose a threat to US forces. ASW is a critical skill for the US Navy and the other services to maintain.

Table 2. Antisubmarine Warfare and the Universal Naval Task List

Strategic level national military tasks (SN)		
SN 3 Employ forces		
	SN 3.1 Coordinate forward presence of forces in theaters	SN 3.1.1 Station forces in theaters.
	SN 3.4 Protect strategic forces and means	SN 3.4.10 Protect the national sea frontiers
Strategic theater-level military tasks (ST)		
ST 1 Deploy, concentrate, and maneuver theater forces		
	ST 1.3 Conduct theater strategic maneuver	ST 1.3.3 Synchronize forcible entry in theater of war
		ST 1.3.5 Coordinate show of force/demonstration
		ST 1.3.8 Establish water space management
	ST 1.6 Control and dominate strategically significant area(s)	ST 1.6.3 Gain and maintain maritime superiority in theater of war
ST 3 Employ theater strategic firepower		
	ST 3.2 Attack theater strategic targets	ST 3.2.1 Conduct lethal attack on theater strategic targets
ST 6 Provide theater protection		
	ST 6.2 Provide protection for theater strategic forces and means	ST 6.2.6.3 Secure and protect theater air, land, and sea LOCs
ST 8 Develop and maintain alliance and regional relations		
	ST 8.1 Foster alliance and regional relations and security arrangements	ST 8.1.1 Enhance regional politico-military relations
		ST 8.1.2 Promote regional security and Interoperability
Operational level military tasks (OP)		
OP 1 Conduct operational movement and maneuver		
	OP 1.3 Provide operational mobility	OP 1.3 Overcome operationally significant barriers obstacles, and mines
	OP 1.5 Control or dominate operationally significant area	OP 1.5.2 Gain and maintain maritime superiority in theater of operations/JOA
OP 3 Employ operation firepower		
	OP 3.2 Attack operational targets	OP 3.2.1 Attack operational land/maritime targets
		OP 3.2.5 Interdict operational forces/targets
		OP 3.2.5.2 Conduct surface/subsurface firepower interdiction of operational forces/targets

Table 2--Continued		
OP 6 Provide operational protection		
	OP 6.5 Provide security for operational forces and means	OP 6.5.4 Protect and secure air, land, and sea LOCs in theater of operations/JOA
Naval tactical military tasks (NTA)		
NTA 1 Deploy/conduct maneuver		
	NTA 1.1 Deploy naval tactical forces	NTA 1.1.2.2 Establish naval control and protection of shipping (NCAPS)
	NTA 1.2 Navigate and close forces	NTA 1.2.1.1 Establish water space management
	NTA 1.5 Dominate the combat area	NTA 1.5.4 Conduct undersea warfare
NTA 3 Employ firepower		
	NTA 3.2 Attack targets	NTA 3.2.1 Attack enemy maritime targets
		NTA 3.2.1.1 Attack surface targets
		NTA 3.2.1.2 Attack submerged targets
Naval tactical military tasks (NTA)		
NTA 6 Protect the force		
	NTA 6.3 Provide the security for operational forces and means	NTA 6.3.1 Protect and secure air, land, and sea LOCs in area of operations

Information from the UNTL in appendix B OPNAVINST 3500.38.

Why is a Submarine Dangerous?

> The threat of submarine forces to conventional shipping has long been a major concern to all nations and navies. With the disintegration of a two-superpower world, however, a new dimension has been added to the submarine threat. 'Long the weapon of choice for inferior seapowers, a submarine of any variety can delay and perhaps even thwart efforts of a superior naval power.' This means that navies that otherwise would receive little thought have to be respected if they possess submarines-especially if they are in a position to control important choke points. (1999)
>
> Jeb Scott Lyne

As of 2001, there are forty-five countries that possess a total of 550 submarines in their naval inventory throughout the world (Jane's Information Group 2001). Today's modern submarine is divided into two major classes based on the ship's propulsion system. The first type of submarine class is the nuclear-powered submarine. A nuclear-powered submarine is propelled through the water by a nuclear reactor located on board the submarine. The submarine relies on a nuclear reactor to create heat that will drive the steam turbines and propel the submarine through the water. In addition, the reactor supplies power to operate the electrical equipment of the submarine. A nuclear submarine is able to operate stealthily for extended periods of time underway. The limiting factor in time underway for a nuclear submarine is the needs of crew.

The second type of submarine is the diesel electric submarine. The diesel electric submarine uses its diesel engine to propel itself through the water or to drive a generator that will charge its batteries. When recharging its batteries or snorkeling, a diesel submarine is susceptible to visual, infrared, or radar detection from airborne or surface forces. A diesel submarine is vulnerable to surface detection while snorkeling because a submarine must be able to provide air obtained from a snorkel to operate its diesel engines. A diesel submarine compensates for its weakness while operating its diesel engines by operating virtually silent while on battery power.

While differing in propulsion systems, both the diesel and nuclear submarines are able to perform ASW, ASuW, mining, surveillance, and reconnaissance roles. The primary differences between the two platforms are in underwater endurance and how each submarine is operated tactically. This topic will be covered in depth later in this chapter.

The Nuclear Submarine

There are three major types of nuclear submarines. The first type of submarine is a nuclear-powered, ballistic missile submarine or SSBN. The SSBN is a strategic platform that carries ballistic missiles. The second type of submarine is the nuclear-powered attack submarine or SSN. An SSN is capable of conducting ASW, ASuW, mining, surveillance, reconnaissance, as well as operations with special operations forces. The last type of nuclear submarine is the guided missile nuclear-powered submarine or SSGN. The mission of this submarine is to strike at either of both enemy warships and merchant ships with long-range, antiship cruise missiles (ASM). While Russia is the only nation currently possessing a SSGN class submarine, the USN plans to convert four of its *Ohio* class SSBNs into SSGNs that will be capable of launching the Tomahawk cruise missile. Finally, all three types of submarines have torpedo tubes and can be launch torpedoes and sometime mines allowing the submarine to be capable of performing multiple missions. Currently, the US, Russia, China, France, and the United Kingdom have nuclear submarines in their inventory. Intelligence analysts estimate that India and Brazil will have added a nuclear submarine capability to their naval inventory by 2015 (Jane's Information Group 2001). There are 145 total nuclear powered submarines operating in the world (Jane's Information Group 2001). Table 3 annotates the classes of nuclear submarines operated by the five nations in the "nuclear club."

China and Russia could pose a significant threat to the US and its interests. Russian and China both have a notable number of capable nuclear submarines that could be used to deter American interests. Furthermore, both nations are currently designing new generation submarines that will remain a credible threat for the foreseeable future.

Table 3. World Nuclear Submarine Order of Battle

	Class of Submarine					
Nation	SSN	No.	SSBN	No.	SSGN	No.
China	*Han* *Type 093*	5 bldg	*Type 094*	1	*Golf*	1
France	*Rubis*	6	*Le Triomphant*	2		
Russia	*Akula I/II* *Sierra II* *Severodvinsk* *Victor III*	9 1 bldg 6	*Bory* *Delta IV* *Typhoon* *Delta III* *Delta I*	Bldg 7 2 6 2	*Oscar II*	7
United Kingdom	*Trafalgar* *Astute* *Swiftsure*	7 bldg 5	*Vanguard*	4		
US	*Seawolf* *Los Angeles* *Virginia*	2 51 bldg	*Ohio*	18		

Source: Jane's Information Group 2001.

China currently has two operational classes of nuclear submarines. The *Han* class, a SSN, currently consists of five submarines while the *Xia* class, an SSBN, consists of a single platform (Jane's Information Group 2000a, 115). The Chinese are actively pursing newer submarine platforms. The Chinese are working on a new SSBN, Project 094, as well as a new SSN, Project 093 (Toppan 2001a). Analysts estimate that there will be four to eight Type 094s constructed by China and that it will be capable of carrying sixteen JL-2 ballistic missiles with a range of 4,900 miles (Jane's Information Group 2000a, 127). The Office of Naval Intelligence (ONI) estimates that the JL-2 will give the Type 094 the nuclear strike capability against the US while operating off of the Chinese coast (World Submarine Developments n.d.).

Similar to the Chinese, the Russians are extremely active in nuclear submarine construction. The Russians are developing the first unit of the new *Borey* class SSBN, the *Yuriy Dolgorukiy* (Toppan 2001d). In addition to a new SSBN, the Russians are building a new class of SSN, the *Severodvinsk* (Jane's Information Group 2000c, 494). Both classes of submarines are stretching the limited financial resources of the Russian Navy (Toppan 2001d). However, the addition of these two new classes of submarines will make an already formidable nuclear fleet consisting of SSBN classes *Typhoon*, *Delta III*, and *Delta IV*; SSN classes *Akula I*, *Akula II*, *Sierra I*, *Sierra II*, and *Victor III*; and SSGN class vessels *Oscar I* and *Oscar II*, even deadlier.

The Diesel Submarine

Proliferation of diesel submarines, or SSKs, is much more extensive than nuclear submarines. Currently, forty-three countries share 405 SSKs or small special purpose submarines in their naval order of battle (Jane's Information Group 2001). The US Navy is not included in this group of nations. This dramatic difference in numbers between nuclear submarines and diesel submarines is due to cost as well as availability. France, Germany, Sweden, and Russia are the major producers of diesel submarines with China, Iran, and North Korea among some of most active nations making procurements in the last decade (Edmunds 2000, 79).

The submarine has proven to be a powerful tool for a nation-state to exert its influence in a region. "Smaller navies have been quick to grasp this point, too, seeing the submarine as a weapon with a power and strategic flexibility unequaled by other maritime systems" (Jane's Information Group 1997). Similar to a SSN, a SSK may be used to conduct ASW, ASuW, mining, surveillance, reconnaissance, or support special operations forces. The cost of a diesel submarine is quite small compared to the gain in regional influence that a nation may gain by acquiring a submarine. Also, an equally troubling aspect of the proliferation of submarines is that the sale of diesel submarine "frequently involve(s) the transfer not only of vessels but also of production equipment and know-how for building submarines" (Revelle and Lumpe 1994). This leads to more competitors in the world arms market attempting to sell these extremely capable weapons platforms. Some of the major classes of diesel submarines exported are the *Kilo* and *Type 209* classes. These two classes of submarines are two of the most popular as shown in table 4.

Table 4. World SSK Order of Battle

Navy	Number	Class	Remarks
Algeria	2	*Kilo*	Refitted 1990s
Argentina	2	*TR 1700*	
	1	*Type 209*	Modernized in 1990s
Australia	6	*Collins*	Two more being built
Brazil	4	*Type 209*	
Bulgaria	1	*Romeo*	Obsolete
Canada	2	*Victoria*	
Chile	2	*Type 209*	Modernized in 1990s
	1	*Oberon*	To be replaced
China	2	*Song*	Three additional being built
	4	*Kilo*	May acquire more
	40	*Romeo*	Aging. Some obsolete
	20	*Ming*	Continuing construction
Colombia	2	*Type 209*	Refitted 1990-1991
Denmark	2	*Narhvalen*	Modernized 1993-1998
	3	*Type 207*	Modernized 1992-1993
	1	*Nacken*	Purchased in 2001
Ecuador	2	*Type 209*	Undergoing refit
Egypt	4	*Romeo*	Modernized in mid-1990s
Germany	12	*Type 206A*	
Navy	Number	Class	Remarks
Germany continued	2	*Type 205*	Obsolete
Greece	8	*Type 209*	In process of modernizing fleet
India	10	*Kilo*	Refitted for new weapons
	4	*Type 209*	Two more being built
	3	*Foxtrot*	Obsolete
Indonesia	2	*Type 209*	
Iran	3	*Kilo*	
Israel	3	*Dolphin*	
Italy	8	*Sauro*	In process of modernizing

Table 4--Continued.

Japan	4	*Oyashio*	Construction continuing
	7	*Harushio*	
	6	*Yuushio*	New sonars fitted
Libya	2	*Foxtrot*	Obsolete
The Netherlands	4	*Walrus*	
North Korea	22	*Romeo*	Obsolete
	26	*Sang-O*	Continuing construction
Norway	4	*Type 207*	
	6	*Ula (Type 210)*	
Pakistan	1	*Agosta 90B*	Two more being built
	2	*Agosta*	
Pakistan continued	4	*Daphne*	
Peru	6	*Type 209*	Obsolete
Poland	1	*Kilo*	
	2	*Foxtrot*	
Portugal	2	*Daphne*	Obsolete. To be replaced
Romania	1	*Kilo*	
Russia	9	*Kilo*	Construction for export only
	2	*Lada*	
	4	*Tango*	Obsolete
	2	*Foxtrot*	Obsolete
Singapore	4	*Sjoormen*	Acquired 1997
South Africa	2	*Daphne*	Modernized, extends life to 2005
South Korea	9	*Type 209*	Early boats need refit
Spain	4	*Agosta*	Being Modernized
	4	*Daphne*	Refitting for new torpedo system
Sweden	3	*Gotland*	AIP installed
	4	*Vastergotland*	
Taiwan	2	*Hai Lung*	Modernized to launch SSMs
	2	*Guppy II*	Obsolete
Turkey	10	*Type 209*	
	2	*Tang*	Obsolete
	1	*Guppy IIA*	Obsolete
Ukraine	1	*Foxtrot*	Obsolete
Venezuela	2	*Type 209*	Modernized 1992-1993
Yugoslavia	1	*Sava*	Obsolete

Source: Jane's Information Group 2001.

Submarine Vulnerabilities

Both nuclear and diesel submarines can be a lethal platform when they operate against surface vessels. Both types of submarines do have some weaknesses that aid airborne platforms in detecting subsurface threats. A submarine is most vulnerable to detection while it is surfaced (Mazumdar 2001, 30). A submarine will surface for several different reasons. First, any time a submarine has any part of its mast surfaced, it is susceptible to visual detection and radar detection. The mast or periscope presents a detectable radar cross-section to most military radar systems. Also, any part of the submarine above the surface can leave a wake or "feather" behind it that aids in detection.

Next, any time a submarine operates its radar or uses its communication equipment, these signals can be intercepted and used to localize submarine contact by using friendly electronic support measures (ESM) equipment or direction finding (DF) equipment. The ESM equipment is used to detect and identify radar emissions while DF equipment can give a bearing in the direction to the communication source.

The last weakness that nuclear and diesel submarines share in common is acoustic detection by sonobuoys delivered by aircraft. Sonobuoys were designed to identify sounds emitted by submarines. Today's sonobuoys are able to detect submarines passively or actively. A buoy that can detect noise in the water by simply listening does passive detection. Active sonobuoys can detect a submarine by transmitting "sounds and listening for the echoes" (PMA-265 2001a). The ambient noise buoy and the bathythemograph sonobuoys are available to measure the ambient noise, which is "background noise" in the water, and temperature respectively. Both of these values are significant to ASW platforms and help in prosecuting a submarine by determining the sound properties of the water.

Diesel submarine vulnerabilities. The diesel submarine has one flaw that it does not share with its nuclear powered counterpart. A diesel submarine must recharge its batteries by operating its diesel engines on the surface. The evolution must be completed for the diesel submarine to operate effectively on station. To counter this weakness, diesel submarine commanding officers will try to recharge their batteries during periods of poor visibility, rain, and moderate sea states or in the presence of other surface ships. All of these tactics are used to decrease the submarine's probability of detection by ASW platforms and cause confusion during the ASW detection and localization phases for the airborne crews.

Diesel submarines vulnerability solutions. To decrease the submarine's probability of detection, two dramatic changes in technology have been added to submarines to transform the diesel submarine into an even more dangerous platform. These advances in technology were designed to decrease the submarine's need to recharge its batteries. A submarine is vulnerable to detection while recharging its batteries on the surface. In order to minimize the diesel submarines time on the surface to recharge its batteries, air independent propulsion (AIP) and improvements in battery technology were the response to a need to remain submerged longer. Both of these topics will be covered in greater detail in the following paragraphs. The results for these technological changes created significant differences in how the diesel submarine was used operationally.

By far, the most significant change is the addition of AIP to the diesel submarine. The "AIP system acts as a low capacity battery charger or provides limited power in parallel with the batteries, thereby extending the submarine' submerged endurance" (US

Congress, Senate 1999a, 3). Instead of having to recharge the submarine's battery every three to four days, a submarine commanding officer now can remain submerged for two to three weeks, a significant improvement over its previous propulsion system (US Congress, Senate 1999a, 3). This change allows the submarine commanding officer to operate his submarine stealthily in a littoral environment with less danger to himself and the crew by limiting the exposure time dramatically to surface and airborne forces. Thus, the submarine stealth has been improved by minimizing its weaknesses to detection by ASW forces.

"For nearly 100 years a primary goal for ship designers has been to increase the range and submerged-time capabilities of submarines" (Walsh 1999). The development of AIP stemmed as an alternative to nuclear powered submarines. While nuclear submarines have increased range and submerged time capabilities, their significant cost of over $1 billion is not affordable to most nations. On the other hand, AIP, priced at paltry $200 to $300 million, provides a diesel submarine with an extended underwater endurance similar to a nuclear-powered submarine at a fraction of the cost.

Many nations are actively involved or interested in the development of AIP. Today there are five companies in four different countries that are actively involved with commercial AIP development: Kockums of Sweden, Howaldtswerke (HDW) and Thyssen Nordseewerke (TSNW) of Germany, DCN International of France, and RDM of The Netherlands are all offering AIP systems, "either for installation in new-build submarines or as 'plugs' for insertion in existing hulls" (Jane's Information Group 1997). In addition to those four nations, Russia "is offering a fuel-cell option for its 'improved' *Kilo*- and *Amur*-class attack submarines" (Walsh 1999). China, Egypt, Greece, Italy, Japan, and Pakistan have also expressed interest in acquiring AIP capable submarines (Walsh 1999).

In addition to the introduction of AIP, battery technology has changed dramatically. New batteries available for use on board a submarine are capable of being charged faster than their predecessors (Jane's Information Group 2001). This increased charging rate of the battery will allow the submarine to replenish its depleted batteries faster. Thus, when the battery does need to be recharged, the time that submarine is exposed to airborne and surface platforms is greatly diminished. Finally, by increasing the size of the battery compartment on board a submarine will also increase the submarine's endurance underwater (Jane's Information Group 2001). Expansion of the battery compartment will further take advantage of this capability by having "bigger" batteries on board. Overall, these two additions to the diesel submarine make it an even more-challenging target for ASW forces to prosecute.

The Submarine's Weapons

Along with advances in submarine propulsion technology have come advances in submarine-launched weapons. There are four distinct types of weapons launched by submarines that this research will focus on. Torpedoes, mines, cruise missiles, and antiair missiles have become more lethal to surface and air platforms, making the submarine a dominant force for any navy. Wake-homing torpedoes, "intelligent" mines, long-range cruise missiles, and antiair warfare (AAW) weapons are available on the global arms market for nations to purchase.

Submarine Torpedoes

"Improved torpedo systems and technologies significantly boost a submarine's combat capabilities" (US Congress, Senate 1999a, 4-5). The torpedo is the primary weapon for the submarine. Although it can be used against subsurface and surface targets, this research will concentrate on weapons used against surface targets. The torpedo has had two dramatic increases in technology that makes the torpedo an extremely powerful antiship weapon.

The first change was brought about by Russians experimenting with the capability of a torpedo to attack ships by homing in on the wake of the ship. The wake homing torpedo can be fired into the wake of a ship. The torpedo "will execute a zigzag pattern across the wake following the narrowing width of the wake as it gets closer to the ship until it no longer detects the wake and then detonates" (Watts 1998, 209). This type of weapon is exported in a package with the Russian *Kilo* Class submarine and "greatly reduces the amount of training and tactical proficiency required to effectively conduct torpedo attacks against surface ships" (US Congress, Senate 1999a, 4-5). A wake-homing torpedo launched by a poorly trained submarine crew can have a devastating effect on merchant shipping or naval forces.

In addition to wake-homing torpedoes, the Russian Navy has developed the Shkval, a lethal version of torpedo that no surface ship could outrun. The Shkval is a submarine-launched, rocket-propelled torpedo that can attack other submarines at speeds up to 200 knots (Watts 1998, 216-217). Intelligence analysts believe that the Russian Navy is developing a version of the Shkval that will conduct an acoustic search at 60 knots and be able to attack surface ships at speeds in excess of 300 knots (Brigger 2000, 51). Philip Howe's rendition of the Shkval from Steven Ashley's *Scientific American* article is illustrated in figure 3. Advances in weapon technology will continue to make the submarine increasingly more dangerous to surface forces. A summary of submarine torpedo capability is located in table 5.

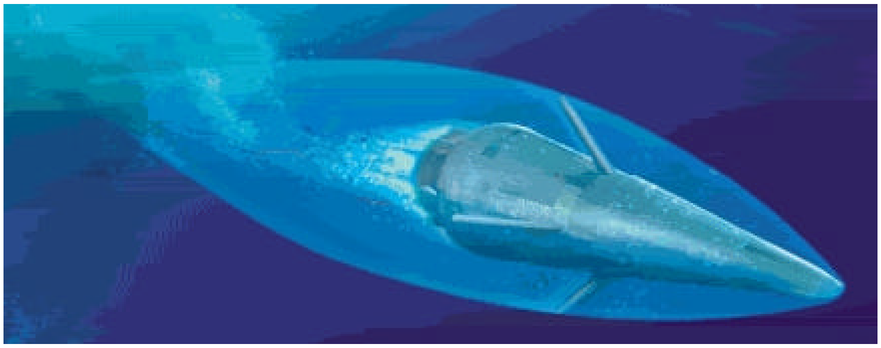

Figure 3. The Shkval supercavitating torpedo. *Source:* Ashley and Howe 2001.

Table 5. Submarine Torpedo Capability Matrix

Model	Country	Role	Guidance	Charge (kg)	Speed (knots)	Operator
Mk 48	US	ASW	Wire-active, passive	267	55	Australia, Canada, Israel, US
Shkval	Russia	ASW			200	Russia
Type 53-65	Russia	ASuW	Passive Wake	305	50	Algeria, India, China, Iran, Libya, Poland, Romania
SAET-60	Russia	ASuW	Passive	205	40	Albania, Bulgaria, China, India, North Korea, Libya, Poland, Syria
Test-71	Russia	ASW	Wire- guided, active, passive	205	45	Algeria, China, India, Iran, Poland, Romania, Yugoslav.

Source: Jane's Fighting Ships 1998-1999 and Jane's Underwater Warfare Systems 1998.

Submarine Mines

> Submarine-laid mines range in sophistication from inexpensive WWII-vintage mines to costly, advanced self propelled-warhead models equipped with encapsulated torpedoes. . . . Used properly, they are extremely effective and the threat they pose is serious. (US Congress, Senate 1999a, 5)

Rear Admiral L. E. Jacoby, USN

Like the torpedo, the mine is an effective, inexpensive weapon that can be employed by a submarine. Iraq was able to use mines with devastating effect during the Persian Gulf War. An American cruiser, the USS *Princeton* worth $1.2 billion, was all but sunk by two Iraqi mines valued at less than $70,000 (Holzer 1998b, 26). Although the mines that damaged the USS *Princeton* did not originate from a submarine, the fact that submarines are capable of covertly deploying mines validates the threat that US Navy vessels face when operating against submarines.

Mines can be used to control access into or out of ports, close choke points, prevent amphibious landings, or disrupt merchant shipping or naval forces. Mines do not need to be actually have to been laid to accomplish the mission of the delivery platform. If the threat of mines exists, the opposing force must counter the threat by expending time and resources to ensure that an area is clear of mines. This translates into delaying operations in order to ensure safe passage of surface forces. By being capable of performing such a variety of missions, the mine is a powerful weapon for the submarine to have in its arsenal. Figure 4 illustrates the challenges presented by different types mines to naval forces at a variety of depths.

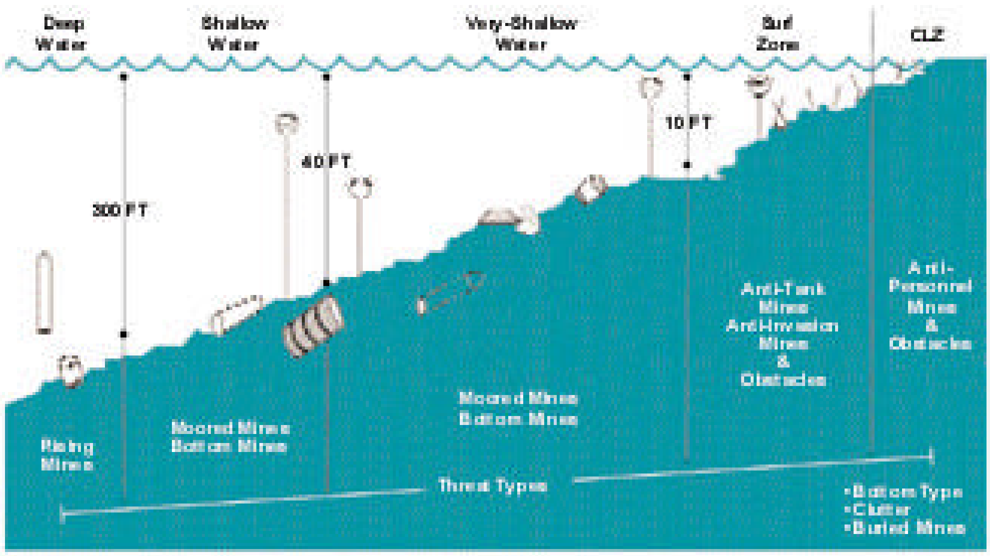

Figure 4. Mine challenge presented to naval forces. *Source*: US Naval Mine Warfare Plan, n.d.

There are five ways that a mine can be detonated. The first method of mine actuation is by pressure. This type of mine contains a pressure sensor made up of piezoelectric materials which are used to identify a decrease in pressure that is caused by the passage of a surface vessel in the vicinity of the mine (Watts 1998, 229). The piezoelectric sensors are able to distinguish between the normal underwater environment and the motion created by the passage of a surface ship.

Another method of mine detonation is by acoustic detection. Again, this mine contains sensors comprised of piezoelectric materials that will detonate the mine when the passage of a surface target is observed in the vicinity of the mine (Watts 1998, 229). This method of mine actuation is susceptible to problems due to the transmission of sound through the water (Watts 1998, 229). Nonetheless, acoustic detection can be an effective way to actuate a mine.

In addition to acoustic or pressure detection, magnetic sensors can actuate mines. This type of mine contains sensors which detect the rate of change in the magnetic field around the mine (Watts 1998, 229). Magnetic sensors are capable of detecting changes in magnetic field caused by passage of a surface ship or changes caused by electrical fields generated by the electrical systems on board the submarine (Watts 1998, 229). These two methods of magnetic detection make magnetic sensors a competent method for detecting surface vessels.

Similar to magnetic detection, mines can also be actuated by electrical field sensors that measure changes in electrical fields. These sensors detect electrical fields made by the equipment, such as the "propeller, machinery, generators, shafts and so on" (Watts 1998, 230). Therefore, this type of sensor uses the operation of target equipment to its advantage.

The final method of actuation is seismic. When low-frequency acoustic energy from a target strikes the seabed, some of the energy is transformed into seismic energy and reflected back into the water (Watts 1998, 229). It is this seismic energy created by enemy platforms that the seismic sensors look to exploit to their advantage.

There are four types of mines that can use any of the above five sensors to detect and detonate. The first type of mine is a moored mine. The moored mine has an anchor box that rests on the ocean floor and a cable that is deployed at a specific depth with the mine attached (Pike 1998a). A second type of mine is the controlled mine. A controlled mine is a mine which is actuated from ashore (Watts 1998, 229). The third type of mine is the bottom mine, which rests on the ocean floor. The final type of mine is the drifting mine. This type of mine floats freely at or near the surface or the water (Pike 1998a). All four types of mines can be used effectively against surface vessels to shape the naval battle.

Submarine-Launched Missiles

Submarine-launched missiles have proven to be extremely effective against surface targets (table 6). The antiship missile was designed to be launched against surface targets. These submarine launched weapons can be extremely effective in striking enemy surface forces at standoff distances. Highly lethal, antiship missiles can pose a serious threat to commercial shipping as well as naval forces. Proliferation of antiship missiles will improve the offensive capabilities of the submarine and make it an even greater threat to all vessels afloat.

Table 6. Submarine-Launched Missiles

Weapon	Country Origin	Range
UGM-84 Harpoon	US	130 km
SM-39 Exocet	France	50 km
CSS-N-4 Sardine (YJ-1/C-801)	China	40 km
Novator Alfa	Russia	****
SS-N-9 Siren	Russia	110 km

Source: Jane's Underwater Warfare Systems 1998, 203-209.

Some Russian submarines are configured to carry the surface to air missiles (SAMs). Intelligence sources believe the *Kilo* is capable of carrying SAN-5/8/10 shoulder-launched surface to air missiles (Watts 1998, 24). In addition to the *Kilo* class, various other sources report that other Russian submarine classes, such as *Lada*, *Typhoon*, *Sierra II*, and *Akula*, are capable of carrying AAW weapons. The addition of this weapon to the submarine's arsenal is significant because it allows the submarine some form of protection to be used against ASW aircraft. Although intelligence experts believe that these submarines must be on the surface to engage an aircraft, there is little margin for error in determining whether this true or not. While the addition of this type of weapon does not make the submarine invincible to ASW aircraft, it does create an atmosphere where the ASW aircraft must be wary when flying into a potential AAW weapon kill zone while prosecuting a submarine.

In addition to the antiair weapons, technological advancements have been made with weaponry that will allow the same weapon to be used for multiple purposes. Currently, the Polyphem Triton multipurpose missile is being tested with the goal to ultimately be used "for self defence against antiair, antisurface threats and coastal targets while staying submerged" (Mrityunjoy 2000a). The Polyphem "uses a fibre optic guidance system enabling high data transmission rates and gives the missile operator the ability to 'see' the target image on board the submerged launch platform which offers considerable tactical flexibility" (Mrityunjoy 2000a). Future proliferation of this type of weapon will make the submarine even a more lethal platform for attacking surface-, airborne- and land-based targets.

Conclusion

The submarine has a wide variety of weapons available to use against surface and air platforms. This wide assortment of weaponry makes the submarine an excellent platform for a navy to influence events in a region by using torpedoes, mines, and cruise missiles offensively. Also, the addition of AAW missiles allows a submarine to defend itself close in from ASW aircraft. The ability of a nuclear submarine to remain submerged for long periods of time remains a great challenge to ASW aircraft.

Meanwhile, changes in technology have made diesel submarines extremely more challenging for ASW aircraft to prosecute. "Submarine forces could have a tremendous effect on US foreign policy simply with one well-placed wake-homing torpedo delivered into the stern of an aircraft carrier or any surface ship" (Doney and Deal 1999, 104). The ongoing proliferation of submarines and submarine-launched weapons as well as technological improvements in weapons technology and submarine propulsion systems make the submarine a threat to the security of the US and its interests.

The P-3C *Orion*

> The P-3C *Orion* is a four-engine, low-wing aircraft designed for patrol, antisubmarine warfare, and fleet support. It is in the 135,000-pound gross weight class and is powered by four T56-A-14 turboprop engines… Distinguishing features of the aircraft include advanced surface and subsurface detection gear, including computer interfacing of the detection systems and the ordnance and armament systems. The P-3C model is readily identified by the installation of sonobuoy chutes, visible in the lower aft fuselage of the aircraft, and three additional small windows on the starboard side of the fuselage. (CNO 1999, 1-1)

The P-3C is an all-weather aircraft whose "primary mission is detection, localization, surveillance, and attack of targets that pose a potential military threat" (CNO 1999, 11-1). These aircraft possess sensors and weapons that make it capable of performing ASW; AsuW; strike; and intelligence, surveillance, and reconnaissance (ISR) warfare missions. To perform these missions, the *Orion* requires a crew of five naval officers and six enlisted sailors. The P-3C crew operates an extensive electronic suite of sensors that allow the aircraft to perform these missions. The *Orion* is the Navy's platform that maintains the airborne ASW as one of its core competencies.

The P-3C is a descendant of maritime patrol aircraft designed to attack German submarines during the World Wars I and II. German submarines attacked Allied shipping and warships in both wars. Maritime patrol aircraft were responsible for sinking or damaging 12 of the 25 total German submarines in World War I and 85 of the total of 245 Axis submarines sunk or damaged in World War II (Maness 1992, 88). The P-3 was designed as a replacement for the P-2V Neptune. The *Orion* became part of the USN aircraft inventory in 1962 (Pike 1999b).

The P-3 has been the sole land-based ASW aircraft for the USN for nearly forty years. Throughout its history, the *Orion* has been involved in conflict throughout the world. There were 377 *Orion* flying during the height of the Cold War in the mid-1980s (Polmar 2000, 87). This high number of airframes was in due in part to the great number of Soviet submarines operating worldwide. Once the Cold War ended, the emphasis on ASW diminished. The Soviets were no longer considered a threat to American national security. This change in aircraft numbers translated into a widening of mission areas for the aircraft. Today, there are only 200 aircraft performing a variety of missions operating throughout the world (Polmar 2000, 87). Currently, there are twelve active duty squadrons and seven reserve squadrons that support the forty aircraft required to operate throughout the world by American military theater commanders (Freeman 1999, 60). The twelve active duty squadrons are equally dispersed between Jacksonville, Florida; Kaneohe Bay, Hawaii; Brunswick, Maine; and Whidbey Island, Washington. The homeports of the squadrons are illustrated in figure 5.

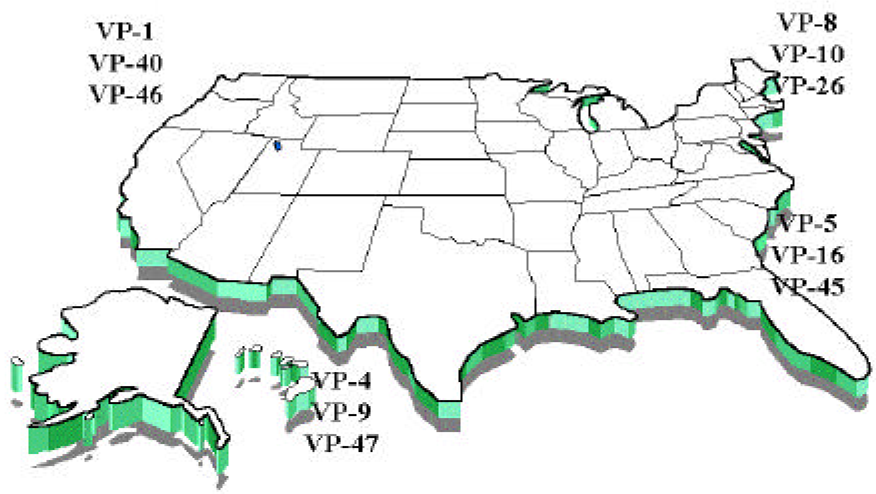

Figure 5. P-3C *Orion* Active Duty Squadron Locations. *Source:* Leidman and Brown n.d.

The Crew. The P-3C *Orion* is capable of carrying twenty-one to twenty-three personnel depending on the aircraft model. However, the aircraft requires a minimum of five naval officers and six enlisted sailors to perform operational warfare missions. Figure 6 illustrates the various crewmember seats throughout the aircraft. The officers consist of three naval aviators (pilots) and two naval flight officers (NFOs). The enlisted crew consists of two flight engineers (FEs), two acoustic operators, one in-flight technician (IFT), and one electronic warfare operator (EWO) or nonacoustic operator. The crew works together using the aircraft sensors to accomplish operational missions.

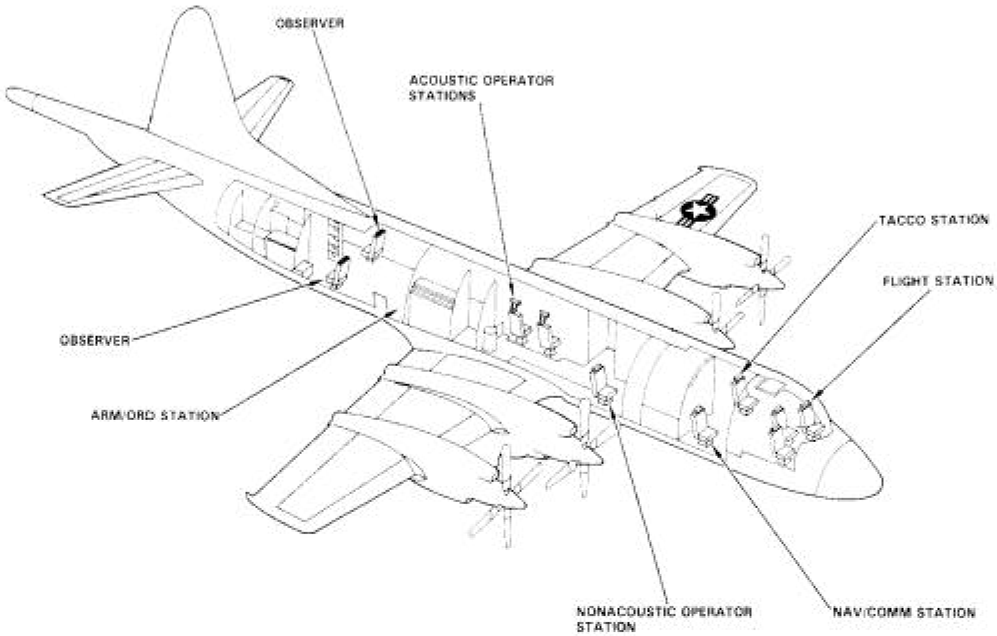

Figure 6. P-3C *Orion* Aircrew Seat Positions. *Source:* CNO 1999, 1-4.

The three pilots are responsible for the safe navigation of the aircraft to and from the operational area as well as safety of flight while on station. The senior pilot is ultimately "responsible for the effectiveness of the aircraft and crew for all matters affecting flight safety" (CNO 1999, 11-3). Although there are only two pilots at the aircraft control at any time, there are three pilots on the crew to ensure that the pilots do not become too fatigued during long missions. Most importantly, the pilots ensure that aircraft maneuvers are coordinated with other crewmembers to assure the effective use of all aircraft sensors and weapons.

The two remaining officers of the crew are the NFOs. The two NFOs are the tactical coordinator (TACCO) and the navigator/communicator (NAV/COMM). The TACCO is the senior qualified NFO on board the aircraft. "The TACCO's function is to employ appropriate tactics and procedures to most effectively carry out the mission of the aircraft and its crew" (CNO 1999, 11-4). The TACCO must coordinate the use of all sensors for each type of mission with pilots to ensure that the sensors are used to their maximum potential. "The NAV/COMM is responsible for navigating the aircraft to and from the specified area, monitoring aircraft position and navigation systems, conducting required tactical communications including authentication, and maintaining tactical records" (CNO 1999, 11-4). In addition to maintaining safe navigation of the aircraft, the NAVCOMM will complete all tactical communications for the crew.

The enlisted crew is made up of six personnel. The two FEs are responsible to the pilots for assisting in the safe operation of the aircraft by monitoring "engine and system flight station controls and indicators" (CNO 1999, 11-3). The in-flight technician repairs any damaged or broken equipment that occurs on the aircraft and assists the TACCO in the deployment of ordnance, such as sonobuoys. The EWO "is to support the mission by utilizing radar, ESM, MAD/SAD, IRDS, and IFF systems and subsystems, as directed by the TACCO, to detect and analyze targets of operational significance and provide radar intercept and navigation information to the TACCO and NAV/COMM" (CNO 1999, 11-4). The final members of the enlisted crew are the acoustic operators. The acoustic operators are responsible to detect, localize, classify, track, and report contact information gained by sonobuoys to the crew (CNO 1999, 11-4).

The men and women of the *Orion* crew use teamwork to accomplish the aircraft's assigned mission. By the crew's effective use of aircraft sensors and weapons, the P-3C *Orion* is able to operate decisively against any military threat.

The Sensors. The P-3C *Orion* sensors consist of two broad areas of sensors to use in the ASW effort. Nonacoustic sensors are those operated by the EWO while the acoustic operators operate the acoustic sensors. The *Orion* also has two sensor suites deployed within the fleet. The older sensor suite is fielded on the P-3C *Orion* Update III aircraft while the newer suite is found on the P-3C *Orion* AIP aircraft. The aircrew can use either sensor suite and both types of sensors to detect, localize, and track a submarine. Figure 7 illustrates the simultaneous use of sensors during the ASW process.

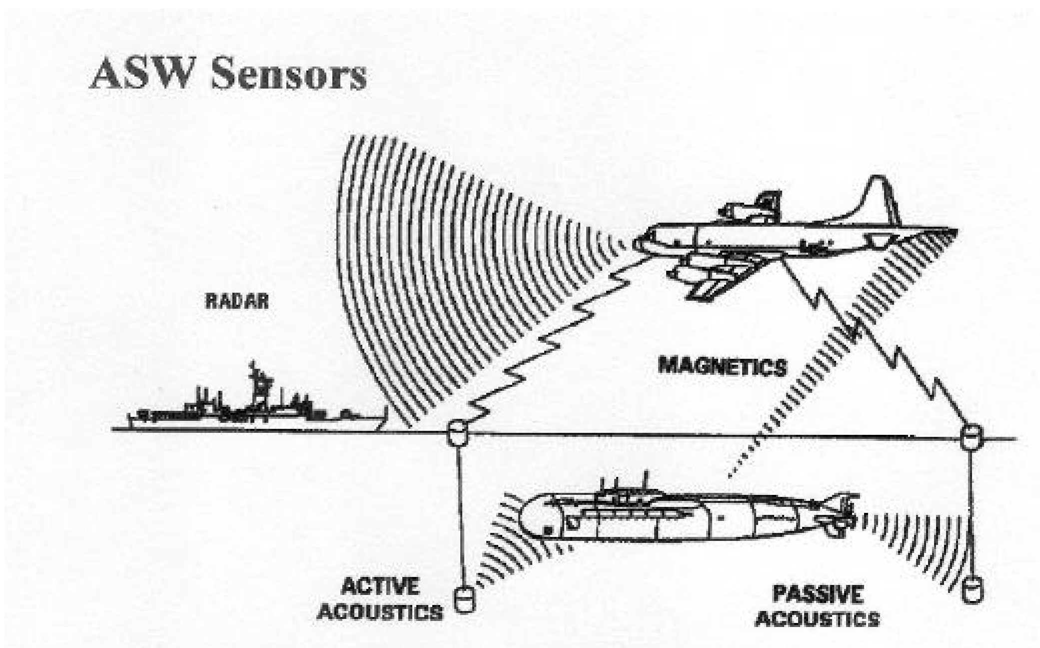

Figure 7. P-3 ASW Sensors. *Source:* Pike 1999a.

The EWO operates the nonacoustic sensors on board the P-3C *Orion*. These sensors consist of APS-115 radar, ASQ-81 magnetic anomaly detecting (MAD) system equipment, AAS-36 infrared detecting set (IRDS), and the ALR-66 electronic support measures (ESM). The Antisurface Warfare Improvement Program (AIP) aircraft has a different complement of sensors. The APS-115 radar has been replaced by the APS-137 inverse synthetic aperture radar (ISAR)/synthetic aperture radar (SAR). The AIP aircraft has replaced the AAS-36 IRDS sensor with the advanced imaging multispectral sensor (AIMS) optical sensor. These sensors work together to cue the aircrew to the presence of a submarine.

The radar is one of the most critical sensors on the aircraft. “The search radar system, APS-115, is the principal airborne surveillance device for observing and detecting surface vessels, submarines operating with a snorkel, aircraft, and other objects of military significance” (CNO 1999, 10-275). While the radar plays an important role in the tactical application of the aircraft, it is also a critical component for the aircrew to use for safety of flight with weather as well as terrain avoidance. The APS-137 found on all AIP aircraft is more technologically advanced than the APS-115 radar. The ISAR mode uses the relative motion of the ship to form a two dimensional image of the target. On the other hand, the SAR mode uses the relative motion of the aircraft to produce an image for ground mapping (Erwin 2000, 23). Both ISAR and SAR imagery are extremely valuable tools for an aircrew to use in an ASW prosecution to detect a snorkeling or surfaced submarine. The ISAR and SAR modes are illustrated in figure 8.

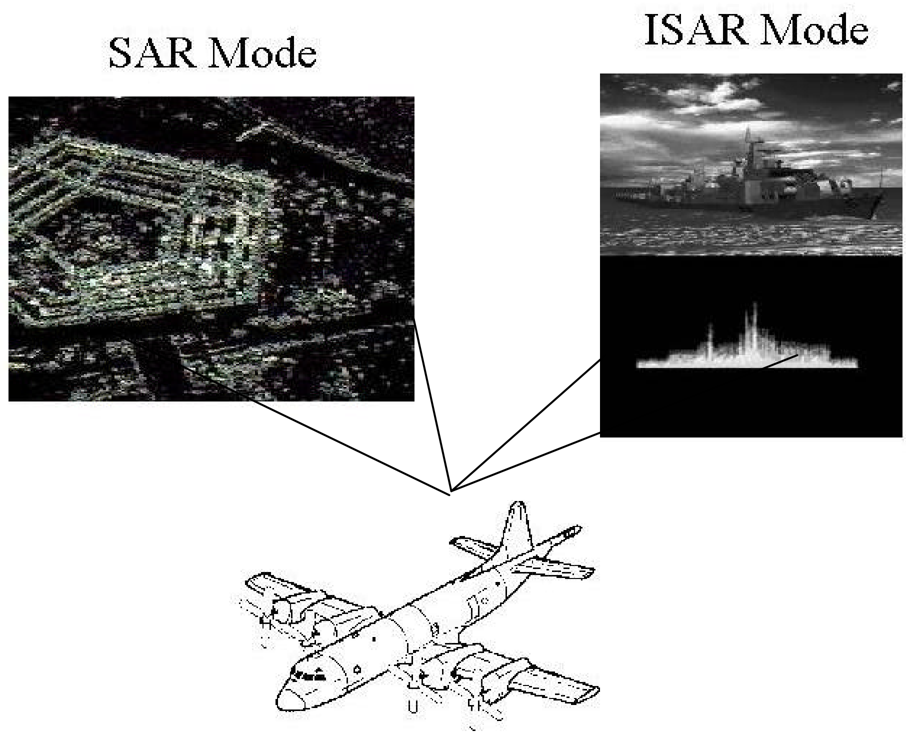

Figure 8. ISAR and SAR Mode of P-3C Orion's AIP Radar. *Source:* Patrol Squadron 30, n.d.

The ASQ-81 MAD system exploits the submarine's metal construction for detection. The *Naval Air Training and Operating Procedures Standardization (NATOPS) NFO Flight Manual* describes the MAD sensors as a system that "employs a helium magnetometer that detects submarines by measuring changes (anomalies) in the Earth's magnetic field caused by the submarine" (CNO 1999, 10-299). The MAD system is complex enough to determine a "submarine anomaly" despite being installed on an aircraft in motion that has its own natural magnetic field. The ASQ-81 is found on both the *Orion* Update III as well as the AIP aircraft. Finally, the ASQ-81 has been replaced on some *Orion* aircraft with a digital MAD system, ASQ-208. The MAD system's sensor location on the aircraft is illustrated in figure 9.

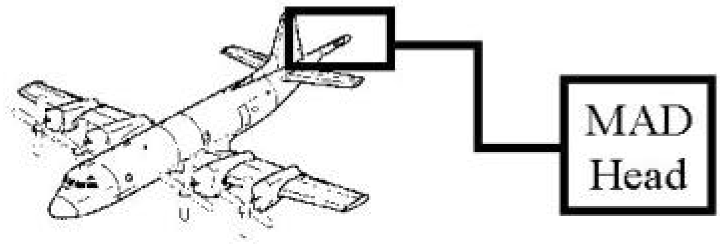

Figure 9. P-3C Orion MAD Head Location. *Source:* Patrol Squadron 30 n.d.

In addition to the MAD system, the P-3C *Orion* can utilize the IRDS to assist in prosecution of a submarine. The IRDS or AAS-36 "converts infrared radiation emanating from a heat source "allowing the non-acoustic operator to view targets outside the aircraft during periods of low visibility or at night" (CNO 1999, 10-336)." The IRDS is capable of detecting differences in temperature. Therefore, a diesel submarine recharging its batteries on the surface would be susceptible to detection via IRDS.

The AIP aircraft has a modified system with the baseline capability of the IRDS as well as additional capabilities. This nonacoustic system is the AIMS. The AIMS is an electro-optical sensor "which provides optical and infrared detection" capability to the *Orion* (Erwin 2000, 23). The device works during the day as well as at night and provides high-quality images for transmission to command elements at sea or ashore. Finally, the AIMS is an excellent standoff sensor for the aircraft. On some early production AIP aircraft, the AIMS is replaced by its predecessor, the IRDS, and an electro-optical sensor, the AVX-1, is located on the port of the left side of the aircraft and provides a similar albeit limited AIMS capability to the *Orion*.

The P-3C avionics suite contains a system called the ALR-66 (V) 3 radar-warning receiver (RWR) which exploits electronic emissions from a submarine. The P-3C *Orion* uses the ALR-66 (V) 3 as it "passively scans the radio frequency spectrum for the intentional electronic transmission from hostile forces" (PMA-264 2001b). Therefore, an *Orion* can identify electronic emissions from a submarine and use that detection to determine a bearing to submarine. If a submarine continues to radiate, it is possible for the aircraft to triangulate the position of the submarine. This passive system is a valuable part of the P-3C's avionics suite.

The acoustic operators utilize the single advanced signal processor (SASP) to process acoustic data. Acoustic information from sonobuoys is transmitted back to the aircraft, where it is processed by the SASP system. The SASP will display the acoustic data to the acoustic operators for analysis. The SASP system can also be programmed to detect submerged contact for the acoustic operators. The SASP is a critical system for the aircrew to use in the ASW fight. The Navy is currently fielding a replacement for the SASP system on the *Orion*. The Block Modification Upgrade Program (BMUP) offers additional processing capability as well as color displays for the acoustic operators. The BMUP program will aid the crew in the prosecution of submarines.

The nonacoustic and acoustic systems on board the *Orion* allow the operators to prosecute a submarine. Whether the submarine is on the surface or submerged, the *Orion* possesses the capability conduct ASW against it.

<u>The Weapons</u>. The P-3C *Orion* is able to carry different types of ordnance which may be used against the submarine. The primary weapons that can be deployed against a submarine are torpedoes, mines, and bombs. In addition to the torpedoes, mines, and

bombs, the *Orion* may be direct against surfaced or docked submarines. The primary torpedoes are the Mark 46 or the upgraded Mark 50. The *Orion* is capable of carrying various mines and bombs. The *Orion* can carry the Maverick, Harpoon, and Standoff land attack missile (SLAM), all of which are missiles. Table 7 documents the *Orion*'s payload for each of these weapons.

Table 7. P-3C Weapon Payload

Weapon	Type	Number carried	Note:
Mk-46	Torpedo	8	N/A
Mk-50	Torpedo	6	Upgrade from Mk-46
Mk-20 Rockeye	Cluster bomb	10	247 bomblets
AGM-65 Maverick	Missile	4	IR weapon
AGM-84 Harpoon	ASuW weapon	6	All weather antiship missile
AGM-84E	Missile	4	Long-range, precision cruise missile
The *Orion* carries various types of bombs			
The *Orion* carries various types of mines			
The *Orion* carries various types of flares or rockets			

Source: CNO 1999, 4-3 – 4-10.

The P-3C possesses sensors and weapons that make it an ideal aircraft to be used for an ASW role. The crew uses its acoustic and nonacoustic sensors to detect, localize, track, and attack enemy submarines. The aircraft is the USN's sole land-based ASW aircraft capable of countering today's submarine threat.

Missile Defense. The P-3C *Orion* is capable of providing itself some defense against an air-to-air missile threat through the AN/AAR-47 missile-warning set (MWS) and the AN/ALE-39 countermeasures dispensing system (CMDS). The two systems work together to "provide protection for the P-3C from missile attacks" (CNO 1999, 10-371). The MWS is designed to detect "radiation associated with the rocket motor" of a

SAM (Pike 2000a, on-line). The MWS will then signal the P-3C *Orion* aircrew of an incoming missile threat as well as the direction of target threat by sector or quadrant. The MWS will also send a signal to the CMDS. The signal sent from the MWS to the CMDS causes the CMDS to disperse 60 passive radar decoy cartridges or infrared decoy cartridges" (CNO 1999, 10-371). The passive radar decoys or chaff are designed to defeat the radar guiding a missile into the aircraft. On the other hand, the infrared decoys or flares are designed to defeat heat-seeking missiles.

Conclusion

This chapter has focused on the literature in circulation on ASW, submarines, and the P-3C *Orion*. Iran's continued operations and training with its Kilo class submarines in the Persian Gulf is causing grave concern within the US Navy. A senior USN officer estimates that Iran will posses the naval capability to deny the US access to the Persian Gulf by 2005 (Jane's Information Group Limited 2001,114). In addition, countries hostile to the US are acquiring technologically advanced submarines that can be used to exert their influence in regions across the world. In addition, Russia is still building submarines and adding these advanced platforms to their naval inventory. While submarines are becoming more dangerous, very few changes have taken place with the P-3 *Orion*. The question remains; Is it enough?

CHAPTER 3

RESEARCH METHODOLOGY

This chapter will address the manner in which the US Navy's airborne, ASW capability represented by the P-3C *Orion* will be examined. The framework for the research will be based upon a portion of the Department of Defense's Joint Strategic Planning System (JSPS). This system has been chosen as the evaluation model because the UJTL is a product that details theater-level and operational-level tasks for all services and is not service specific. The fact that the UJTL is not service specific makes the JSPS the ideal model.

For the purpose of analysis in chapter 4, the tactical tasks pertaining to the ASW indicated in the NTTL will be the framework of the evaluation. The focus of this chapter will be an explanation of the requirements generation process of JSPS and how it applies as the evaluation model. In chapter 2, the literature review documented current information regarding the submarine threat, technology, and proliferation as well as Navy ASW requirements and the P-3C *Orion* sensor capabilities. This chapter will expand upon the previous chapter in order to establish the framework that will allow a conclusion to be reached regarding the thesis question by conducting a subjective analysis of ASW mission requirements and the US Navy's airborne ASW capability represented by the P-3C *Orion.*

Before addressing the analysis in chapter 4, the requirements generation process involved in the JSPS will be reviewed. Joint Pub 5-0 describes the JSPS as "the primary formal means by which the Chairman of the Joint Chiefs of Staff, in coordination with the other members of the Joint Chiefs of Staff and the combatant commanders, carries out his statutory responsibilities required by Title 10, US Code, 6 April 1991, and further delineated in DOD 5100.1, 25 September 1987" (CJCS 1995a, II-4). The purpose of the JSPS is to "describe the future operating environment, provide a long-range vision, articulate a strategy to meet future security challenges and develop a strategy-based planning and programming guidance" (USA CGSC 2001, 2-1V-4). Documents prepared from the Chairman, Joint Chief of Staff (CJCS) and JSPS will be a critical portion of the review. The key documents to be examined will be the *Joint Strategy Review* (*JSR),* *Chairman's Guidance* (*CG*), *Joint Vision 2020*, the *National Military Strategy* (*NMS*), the *Joint Strategic Capabilities Plan* (*JSCP*), *Joint Planning Document* (*JPD*), *Defense Planning Guidance* (*DPG*), *Chairman's Programming Recommendation* (*CPR*), and the *Chairman's Program Assessment* (*CPA*). The framework for the JSPS process is depicted in figure 10.

The initial portion of the JSPS process to examine involves the *JSR* and *CG* documents. "The *JSR* is a continuous process that assesses the strategic environment for issues and factors that affect the *National Military Strategy*" (CJCS 1995a, II-4). The primary function of the *JSR* is "gathering information, raising issues, and facilitating the integration of strategy, operational planning, and program assessments" (USA CGSC 2001, 2-1R-3). The *JSR* is the foundation for plans and programs based on a threat assessment to a point twenty years into the future (USA CGSC 2001, 2-1V-5). If the CJCS observes any changes in the strategic environment, he can present those changes through the *CG*.

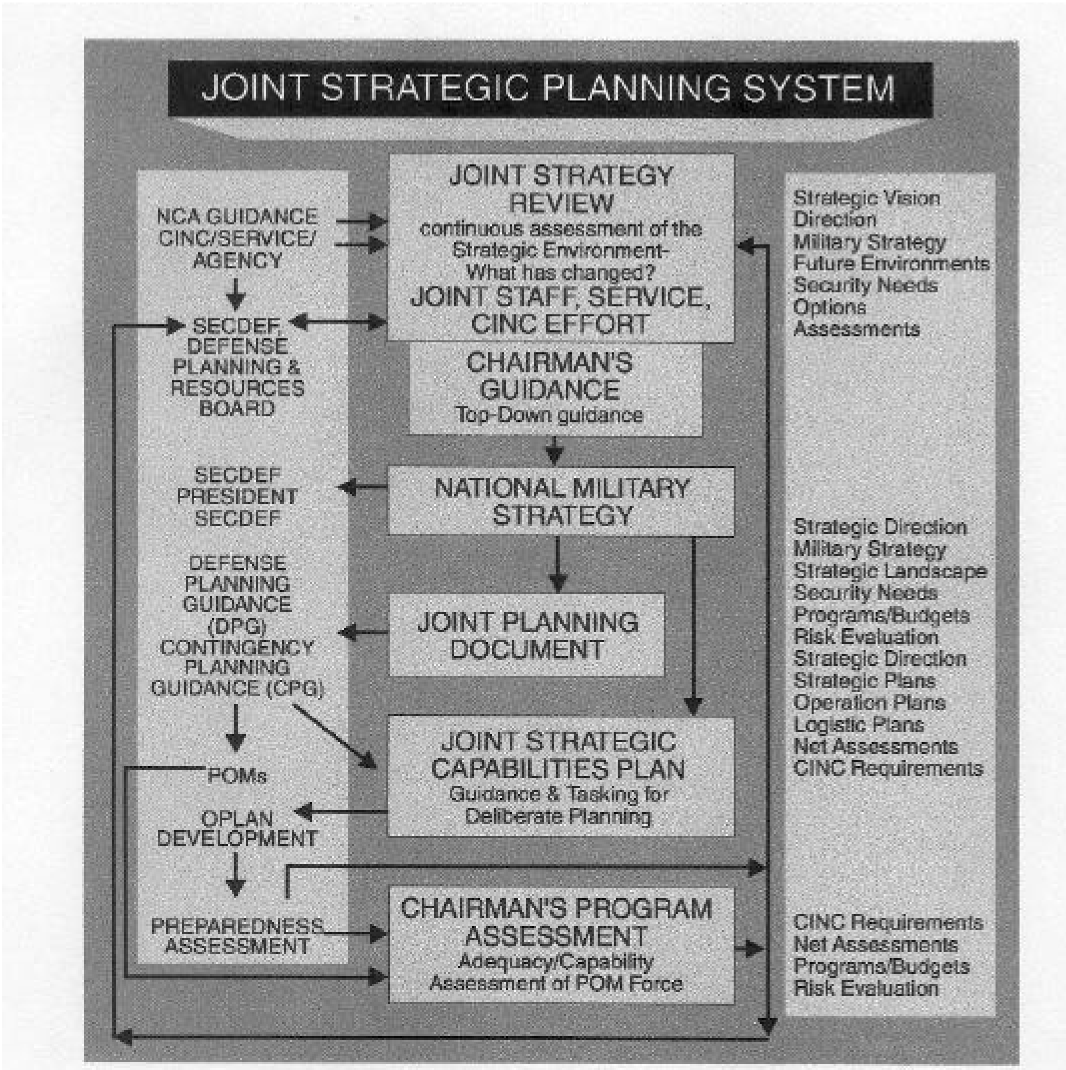

Figure 10. JSPS and CJCS Documents. *Source:* CJCS 1995a, II-6.

The *JSR* and the *CG* are the principal documents that lead to the formation of the joint vision (JV). The *JV 2020* provides each of the services a “conceptual template that provides a common direction and framework” to develop service specific capabilities in order to meet the threats of the future (USA CGSC 2001, 2-1V-6). The *JV 2020* is a “snapshot” into the future which focuses on future force structure as well as the required capabilities leveraged against threats and new technologies (USA CGSC 2001, 2-1V-6).

From the joint vision, *JV 2020* in this case, the CJCS produces the *NMS*. The *NMS* is the first formal document in the JSPS process. The CJCS is required to provide the *NMS* to the President and the Secretary of Defense (SECDEF), as part of his statutory responsibilities (CGSC 2001, 2-1V-6). The *NMS* is a five-year outlook for the US armed forces and provides strategic direction to the commanders of each of the services.

The next item to follow in the JSPS process is the *JSCP*. The *NMS* greatly influences the *JSCP*. The *JSCP* "provides guidance to the combatant commanders and the Chiefs of the Services to accomplish tasks and missions based on current military capabilities" (CJCS 1995, II-5). In addition, "the *JSCP* provides a coherent framework for capabilities-based military advice provided to the NCA" (CJCS 1995, II-5). The *JSCP* is a two-year program that will be used to produce the *JPD*.

The *JPD* follows the *JSCP* in the JSPS process. The *JPD* "reflects the Chairman's planning guidance based on *JV2020*, *JSR*, *NMS*, and *JSCP*" (USA CGSC 2001, 2-1V-8). The *JPD* also identifies shortcomings between theater commander in chief (CINC) requirements and programs previously funded. Finally, the *JPD* "serves as the bridge between strategy and programmatics" and provides proposals for major service acquisitions (USA CGSC 2001, 2-1V-8).

Upon completion of the *JPD*, the *CPR* will commence. The *CPR* is based upon input from the *JPD* and follows the "spirit" of the *NMS*. The *CPR* assesses joint war-fighting needs through the Joint Warfighting Capabilities Assessment (JWCA) created by the Joint Requirements Oversight Committee (JROC) (USA CGSC 2001, 2-1V-8). The "programming priorities, requirements, and advice" contained in the *CPR* will be used for the *Defense Planning Guidance* (*DPG*) for the SECDEF (USA CGSC 2001, 2-1V-8).

The *DPG* is based upon the contents of the *NMS*, *JPD*, and *CPR*. The SECDEF submits the *DPG* to each of the services to be used in the creation of their program objective memorandum (POM). The POM is used by the services for programming and budgeting. The services use the POM to determine their "operating expenses" as well as service "investments" to ensure that each service possess the appropriate capabilities to perform joint missions.

The final portion of the JSPS process is the *CPA*. The *CPA* is an assessment of each of the services as well as theater CINC's POM submission. The *CPA* informs the SECDEF of the adherence of the services and CINCs to the *DPG* and recommends any necessary changes. The CPA also uses the JWCA and JROC "to refine the Chairman's assessments" (USA CGSC 2001, 2-1V-9).

The JROC is one of the key elements of the CPA and will be critical to chapter 4. The JWCA assesses war-fighting capabilities, represents the CINCs operational requirements, assesses requirements for acquisitions programs, assigns joint priority among major valid programs as part of the *CPR*, and assesses service-DOD component program recommendations and budget proposals (USA CGSC 2001, 2-1V-12). The functional areas associated with the JROC are represented in figure 11.

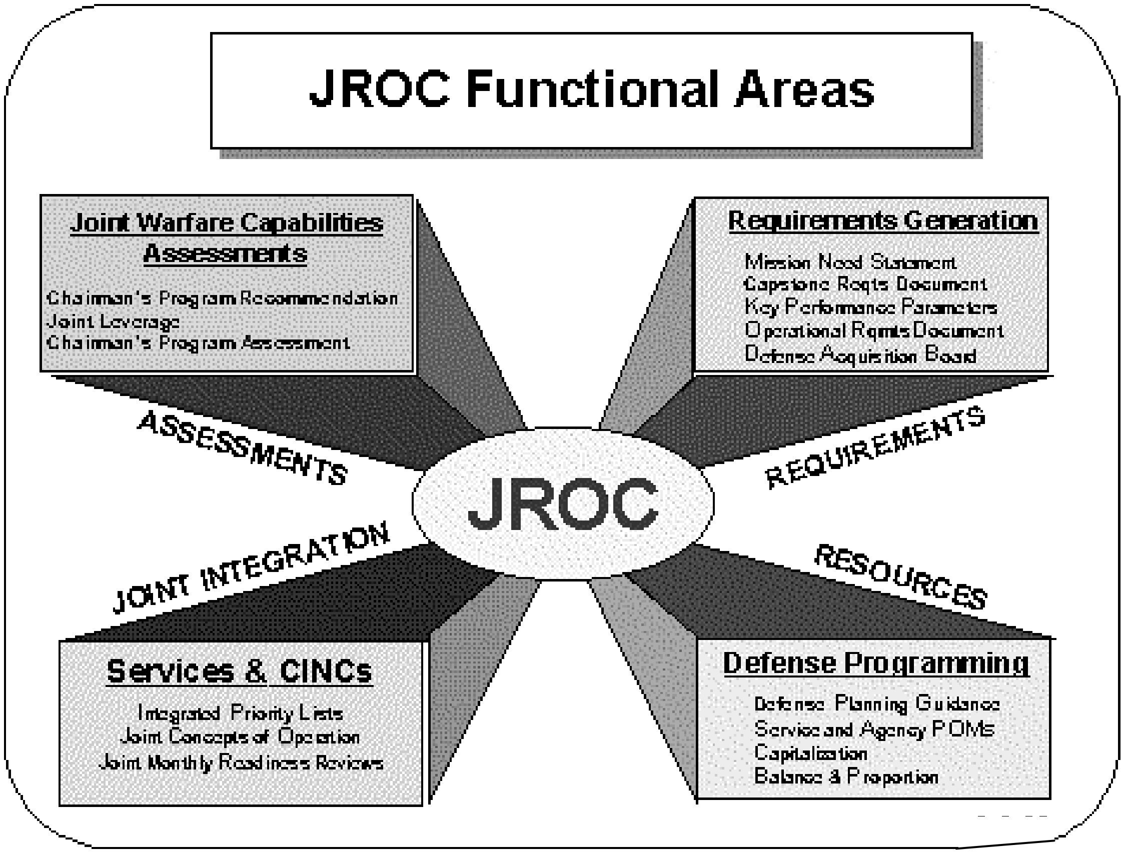

Figure 11. JROC Functional Areas. *Source:* USA CGSC 2001, 2-1V-13.

The requirements generation and JWCA portions of figure 9 will be the central theme of chapter 4. The subjective analysis of the threat facing the US interests will be evaluated by the capabilities represented by the P-3C Orion. The criteria will focus of the skills necessary to conduct ASW. The JWCA assessment areas are represented in figure 12. The evaluation of the US Navy's airborne ASW capabilities will focus along these JWCA assessment areas. The focus of chapter 4 will be on two major assessment areas, land and littoral warfare and the sea portion of sea, land, and space superiority. By a systematic investigation of the ASW portions of the assessment areas, a determination of the ability of the P-3C *Orion* to conduct ASW against current and future submarines will be determined.

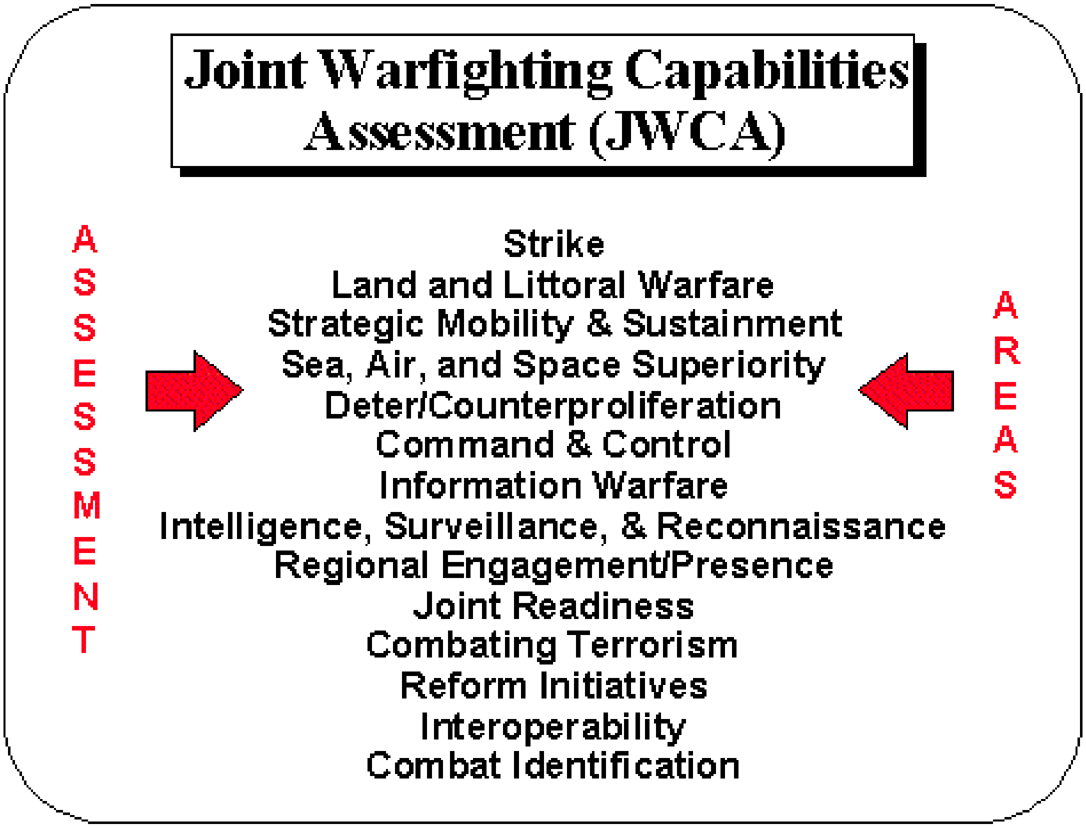

Figure 12. Joint War-Fighting Capabilities Assessment Areas. *Source:* USA CGSC 2001, 2-1V-13.

CHAPTER 4

ANALYSIS

The intent of this chapter is to conduct an in-depth analysis of the US Navy's long-range, airborne ASW capability against current as well as projected submarine threats. The foundation developed in chapter 2 will play a critical role in the subjective review of the USN's lone fixed-wing, ASW aircraft, the P-3C *Orion*. The JWCA detailed in the methodology chapter, chapter 3, will serve as the methodology model against which the P-3C *Orion*'s ASW capabilities will be measured. The foundation illustrated in chapter 2 and the methodology detailed in chapter 3 will form the basis to which the primary, secondary, and tertiary thesis questions will be answered.

This chapter will begin with a review of the JSPS process with respect to the development and relevance of the US Department of Defense's policy concerning ASW. From the JSPS model, a summary of the actual requirements generated will be derived. Upon completion of the requirements generation process, this chapter will review the capabilities presented by both the nuclear and diesel submarine of today and tomorrow. It is the threats that current and future submarines pose to the US and its interests that will be examined. Finally, the capabilities of the P-3C *Orion* will be evaluated against the threats presented by diesel and nuclear submarines. The evaluation will be centered on the general acoustic and nonacoustic tactics employed by the P-3C *Orion* against diesel and nuclear submarines. By analyzing the tactical application of the P-3C *Orion*'s ability to prosecute a submarine in an ASW environment, the thesis questions can be adequately answered.

Is ASW relevant?

Before addressing the primary thesis question, the relevancy of ASW must be addressed. The Chairman of the Joint Chiefs of Staff (CJCS) must be able to articulate threats to the US and its interests. The JSPS provides the CJCS a format in which he can advise the President and the SECDEF on conditions that affect the *National Military Strategy (NMS)*. The *Joint Strategy Review (JSR)* is a continuous process that systematically identifies "current, emerging and future issues, threats, technologies, organizations, doctrinal concepts, forces structures and military missions" (CJCS 1995a, II-4). The JSR is the tool that the CJCS will use to recognize and recommend changes in military strategy to the US political leadership.

The JSPS Process

The events of 11 September 2001 have changed the people of the US as well as its global engagement strategy. The terrorist attacks took place with a new administration barely in the White House eight months. Such a tragic and catastrophic event will have repercussions on the US and its military for the significant future. While there will be some fundamental changes in the manner in which the US defends its borders as well as its forces abroad, there will be several concepts regarding US military operations that will remain arguably constant. These fundamental concepts are articulated in the current versions of the *NMS* and *Quadrennial Defense Review (QDR).* By examining these two documents, the relevancy of ASW can be established.

The *National Military Strategy*

In the most recent *NMS* produced by the CJCS during the Clinton administration during the President Clinton's second term in office, four key concepts that govern the use of military forces are presented: strategic agility, overseas presence, power projection, and decisive force (CJCS 1997b, 14). While ASW is not mentioned specifically in any of these four pillars of the US strategic concepts, the ability of the US to operate freely from any threat is an underlying theme throughout.

Strategic Agility. The *NMS* defines strategic agility as "the timely employment, and sustainment of US military power anywhere at our own initiative, at a speed and tempo that our adversaries cannot match" (CJCS 1997b, 14). Strategic agility ensures that the US military can react to any crisis worldwide and distance, location, or time will not hinder the use of the US military in support of American foreign policy.

Overseas Presence. The *NMS* defines overseas presence as "the visible posture of US forces and infrastructure strategically positioned forward, in or near key regions" (CJCS 1997b, 14). Overseas presence is a fundamental concept of US naval operations. It ensures that the US is able to "show the flag" in order to maintain regional peace, conduct peacetime military engagement with allies, ensure US interests are maintained, and assure US military accessibility throughout the world.

Power Projection. Power projection is defined by the *NMS* as "the ability to rapidly and effectively deploy and sustain US forces in and from multiple, dispersed locations" (CJCS 1997b, 14). Power projection is the foundation from which military power can be applied in support of US interests worldwide. While forward operating bases make life more convenient for the US military, the Navy leads the DOD with its ability to project power from its various naval platforms.

Decisive Force. Decisive force is defined by the *NMS* as "the commitment of sufficient military power to overwhelm all armed resistance in order to establish new military conditions and achieve political objectives" (CJCS 1997b, 15). While this concept of the *NMS* concentrates on the ability of the US to mass its military power decisively against any adversary, it is the ability of US military forces to mass to gain the advantage which is critical to note. To act decisively, the US must have sufficient resources and manpower to have the advantage.

These four strategic concepts of the *NMS* do not specifically address ASW. Instead of ASW, access is the central theme. However, the ability of US forces to operate globally is directly affected by the US's freedom to operate. Adversaries will attempt to impede the US military's ability to operate abroad by various methods. Opponents of the US may use submarines as a means to deny the US entry into a region through a choke point. The use of submarines presents a clear danger to the US Navy and links ASW to the *NMS*.

The Quadrennial Defense Review

The first major document of the JSPS process released after the terrorist attacks of 11 September was the *QDR*. Released just nineteen days after the attack, the *QDR* was designed "to set the conditions to extend America's influence and preserve America's security" (US DOD 2001, III). Among the many topics detailed within the *QDR* by the SECDEF, two significant items were noted. The SECDEF stressed US interests and objectives as well as threats to the United States. In order continue a qualitative analysis of the relevancy of ASW, the events of 11 September must be taken into account.

The *QDR* states that the purpose of the US military "is to protect and advance US national interests and, if deterrence fails, to decisively defeat threats to those interests" (US DOD 2001, 2). There are three national interests that the *QDR* defines: "ensuring US security and freedom of action, honoring international commitments, and contributing to economic well being" (US DOD 2001, 2). Each of the national interests will be examined to determine whether ASW plays a role in this broad overview of military purposed in the *QDR's* military mission statement.

Ensuring US Security and Freedom of Action. The focus of this national interest is to recognize the causes of the tragedy of 11 September. However, the *QDR* illustrates several factors that are also part of this first national interest: US sovereignty, territorial integrity, freedom, safety of US citizens at home as well as abroad, and protection of critical US infrastructure (US DOD 2001, 2). Protection of US citizens against terrorism domestically is just a facet of this national interest. The US must also be able to protect its citizens abroad as well as protect its borders. Whether conducting a noncombatant evacuation operation (NEO) or prevention of either of both conventional and asymmetric attacks against US personnel, the US must be able to maneuver its forces into a position to safeguard these national interests.

Honoring International Commitments. This national interest focuses on "the security and well being of allies and friends, precluding hostile domination of critical areas, particularly Europe, Northeast Asia, the East Asian littoral, and the Middle East and Southwest Asia" as well as "peace and stability in the Western Hemisphere" (US

DOD 2001, 2). This national interest is based upon the US being able to influence events abroad. Honoring international commitments depends on the US freedom to maneuver globally to support allies and the defense of vital US interests.

Contributing to Economic Well Being. "Vitality and production of the global economy, security of international sea, air, and space and information lines of communication" as well as "access to key markets and strategic resources" all contribute to the economic well-being of the US" (US DOD 2001, 2). The literature review of chapter 2 demonstrated the importance of freedom of navigation of the high seas for the US. The ability of US commercial shipping to freely navigate the world allows the US to trade with other nations as well as help the US meet its energy needs. The inability to trade globally or failure to meet these energy requirements could have a direct effect on the US national interests as well as security and has the potential to influence the global economy.

Similar to the *NMS*, there is an implied, ASW undercurrent found within the national interests defined in the new *QDR*. Whether providing security to US territories or American civilians, supporting international allies or maintenance of economic needs globally, the US must retain the ability to protect itself from multiple types of threats. The submarine is one of many types of threats that adversaries of the US can employ to deny the US the ability to pursue its national interests.

While it is important for the US to be able to trade globally, it is equally critical that the US military is able to operate freely throughout the world. The US will send generally 90 percent of its required personnel and equipment via the sea in times of conflict with other nation states or groups. Equally important is the ability of the US to complete military training, port visits, and general peacetime engagement with other nations. Freedom of navigation of the seas is vitally important for the US throughout the world. The US military must retain the ability to counter an antagonist's attempt to prevent the US access to any region around the world. This translates into a requirement for the US military to maintain an ASW proficiency to counter enemy submarine threats.

The Answer

The final validation of the relevancy of ASW can be found in the Universal Naval Task List. The METs delineated in the UNTL support US national objectives at the tactical, operational, and strategic levels of war. The METs were designed to create areas of focus for joint commanders to concentrate on during training and exercises of their units. The METs focused sailors, Marines, airmen, and soldiers on skills that units need to be competent in at all three levels of war. By prioritizing tasks during training exercises, the military is emphasizing the most important skills that its forces must possess in order to support the policies and objectives of its political leaders.

From the literature review in chapter 2, ASW was determined to be one of the common themes found throughout the METs at the tactical, operational, and strategic levels of war. Each of the services is required to maintain proficiency in the war-fighting requirements delineated at each of the three levels of war. Chapter 2, "The Literature Review," identified the ASW specific METs required of the US Navy. The extensive list of ASW war-fighting capabilities, found in chapter 2, table 2, illustrates the importance of ASW to all services. Furthermore, it indirectly establishes ASW as one of the key mission areas for the US Navy and the other sea services.

Are Submarines Really a Credible Threat?

Chapter 2 identified the extensive number of diesel and nuclear submarines currently operating around the globe. While the "nuclear club" remains extremely exclusive due to the expense of obtaining, operating, and maintaining a nuclear fleet, the "diesel club" is growing quickly. The literature review demonstrated that a diesel submarine is an economical way for a nation to purchase a capable weapons delivery platform that can influence a region militarily. A low-cost submarine can allow a nation to have economic, military, and political influence.

The weapons that the submarine can employ make it an extremely formidable opponent for any naval opponent. The ability to employ torpedoes, mines, cruise missiles as well as antiair missiles for defense make a submarine a viable threat against air and surface platforms. Figure 13 demonstrates the lethality of weapons that can be employed by submarines. The top photo of figure 13 is a photograph of the USS *Stark* (FFG-31) after being attacked by an Iraqi aircraft on 17 May 1987. The devastating weapon used by the aircraft was a French Exocet missile, which can also be launched by a submarine. The bottom left photo depicts the USS *Princeton* (CG-51) after striking an Iraqi mine on 18 February 1991. The last photograph, located in the bottom right corner of figure 13, is a picture of the damage caused by a mine to the USS *Tripoli* (LPH-10) after it also struck a mine also on 18 February 1991. An adversarial submarine, whether using torpedoes, mines, cruise missiles, or antiair missiles, is a potent threat against surface and airborne military forces in the littoral as well as open-ocean environment.

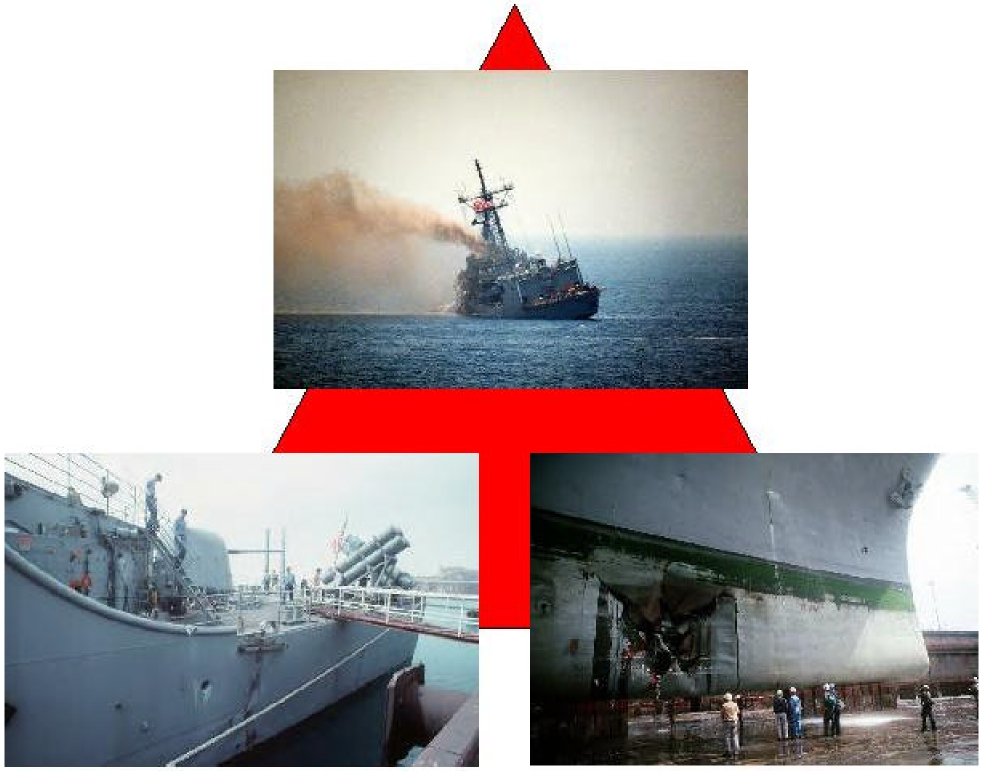

Figure 13. The Effect of Weapons That Can Be Launched by Submarines.
Source: Defense Visual Imagery 1987,1991.

The New Threat

The P-3C *Orion*'s ability to operate forward of USN carrier battle groups in littoral regions against diesel and nuclear submarines introduces new challenges for the *Orion* aircrew. There are two significant threats that face the P-3C *Orion.* First, the *Orion* faces multiple threats from land-based fighter aircraft and SAMs. Naval expeditionary forces, like the P-3C *Orion*, operating forward of the carrier battle group, have little defenses against actual airborne threats. As evidenced by the collision between the Chinese fighter aircraft and the US EP-3 Aries II surveillance aircraft on April 1, 2001, maritime patrol operations in littoral regions can be extremely dangerous.

Additional threats to the P-3C are the weapons on board of a submarine. Infrared SAMs or the optically guided Polyphem pose an immediate threat to the P-3C *Orion* that could severely impact ASW operations. If these types of weapon technologies are proliferated at the same rate as nuclear submarines, it will be increasingly dangerous for the United States to conduct ASW operations.

Capabilities and Requirements

One of the primary objectives of the 2001 *QDR* "was to shift the basis of defense planning from a 'threat-based model' that has dominated thinking in the past to a 'capabilities-based' model for the future" (US DOD 2001, IV). US Secretary of Defense Donald H. Rumsfeld mandated this change in order to ensure the US military maintains its "advantages in key areas while it develops new areas of military advantage and denies asymmetric advantages to adversaries" (US DOD 2001, IV). Simply put, the US military will strive to maintain its technological advantage over its adversaries.

For the final examination of the thesis question, the capabilities of the P-3C *Orion* will be measured against the threat posed by future diesel and nuclear submarines. This would seem to contradict the guidance given by the SECDEF regarding defense planning. However, the Navy is still examining a potential solution to the aging *Orion*. One of the possible solutions to the aging *Orion* is extending the life of the airframe for the aircraft. If, and when a replacement aircraft is chosen, the naval service should concentrate on the SECDEF's guidance. Otherwise, it is prudent and indeed realistic that the equipment found onboard the *Orion* be reviewed against the threat posed by the modern as well as the future submarine. Only then can a determination be made whether the US Navy has the airborne capability to defend itself from current as well as projected submarine threats.

P-3C *Orion* Sensor Tactics

Before evaluating the ASW capability of the P-3C *Orion*, an analysis of the general tactics used to prosecute a submarine must be addressed. Other than visual detection, the P-3C *Orion's* acoustic and nonacoustic sensors are the primary means used by an *Orion* aircrew to detect a submarine. After the comprehensive description of the P-3C *Orion* electronic equipment presented in chapter 2, a general analysis of the acoustic and nonacoustic sensor tactics can begin.

General Acoustic Sensor Tactics

The P-3C *Orion* uses its acoustic equipment or SASP in conjunction with aircraft deployed sonobuoys to prosecute diesel and nuclear submarines. Sonobuoys are most effective when deployed with some type of cueing data or positional data of the submarine. Cueing data can be obtained by another sensor found on the aircraft or from another naval platform. An organized deployment of sonobuoys in the vicinity of a probable submarine position would be identified as a sonobuoy pattern. The sonobuoy pattern has a specified geometry and spacing between buoys that will optimize the probability of detection of the submarine. Both items are critical because the submarine resonates a finite amount of sound into the water. This finite level of sound produced by the submarine translates into a detection range that is measured sometimes in only hundreds of yards. Therefore, the initial deployment of sonobuoys is critical in the ability of the crew to detect a submarine.

Once the submarine has been detected, the operators must be able to classify it. The P-3C *Orion* acoustic operators are trained to analyze the acoustic information of the submarine to determine its identity. The SASP can also assist the crew in determining the identity of the submarine. Once the submarine has been classified, it is the goal of the crew to maintain "contact" with the submarine. The crew will determine the submarine's course and speed and deploy sonobuoys in positions to help maintain contact with the submarine. The goal of the crew is to track the submarine as it changes course and speed.

The P-3C *Orion* crew uses its passive sonobuoys to detect two types of sound emitted by a submarine. The first type of sound is the broadband noise. The broadband sound produced by a submarine "creates acoustic energy over a wide range of frequencies" (Pike 1998b). There are three major types of broadband noise: propeller-shaft, flow noise, and cavitation. The submarine propeller and shaft rotation create "generally low frequency, meaning less than 1000 Hz" that is detectable by an acoustic operator (Pike 1998b). A submarine maneuvering through the water creates flow noise. Flow noise or hydrodynamic noise "results from the flow of water over the hull and accentuated by protrusions and orifices" located on the skin of the submarine (Miller 1984, 11-12). The second type of broadband noise is cavitation. Cavitation noise is the formation and collapse of bubbles along the face of the submarine propeller blade caused by turning of the propeller (Daniel 1986, 29). Submarine blade cavitation produces a "popping" sound that an acoustic operator can detect. Both types of broadband noise occur over a wide range of frequencies (Hill 1989, 41).

In addition to broadband noise, a submarine also produces a second type of sound called narrowband noise. Narrowband noise is produced internally by the submarine "by propulsion and auxiliary equipment, such as turbines, motors, gears, steam engines, electrical generators, compressors, blowers, pumps, and hydraulic systems (Daniel 1986, 29). Narrowband noise is predominantly cyclic or rhythmic in form and allows the operator to match the acoustic signature to a specified class of submarine (Daniel 1986, 29-30).

General Nonacoustic Sensor Tactics

Similar to the acoustic tactics, the goal of nonacoustic tactics is to detect, localize and track a submarine. The crew has several nonacoustic sensors found on board the P-3C *Orion*: Radar, magnetic anomaly detection or MAD, infrared detecting system or IRDS, AIMS and the ESM equipment or ALR-66. Each sensor is used to augment visual detection in order to detect a submarine. The goal is to use each of the sensors to exploit a weakness of a submarine that allows the crew to locate the submarine.

Radar. The radar of the P-3C *Orion* is used to search the water's surface for contacts of interest. The radar found on board the P-3C *Orion*, the APS-115, or the APS-137 is designed to detect surfaced submarines as well as exposed snorkels or periscopes. The submarine risks being detected when exposing any part of its mast. However, a submarine can use its own ESM equipment to detect the radar of the P-3C *Orion* and thus avoid detection. Either radar is capable of detecting a surfaced or partially exposed submarine and is capable of detecting an attack periscope "at distances well over 10 miles" (Hill 1989, 43). However, neither of the radar is capable of classifying a submarine by radar return alone. Thus, the *Orion* aircrew will need to corroborate the radar return with another sensor.

IRDS. The infrared equipment on the P-3C *Orion* is capable of detecting temperature differences beyond the visible light spectrum. The P-3C *Orion* will use the IRDS primarily as a corroborative sensor to augment its prescribed search tactics. The Orion aircrew can use the IRDS to locate the heat caused by a submarine on the surface. The IRDS will be an adequate sensor to locate the heat differential caused by a diesel submarine recharging its batteries on the surface.

MAD. The P-3C *Orion* is capable of using its magnetic anomaly detection gear to locate a submarine. The P-3C's MAD equipment is sensitive to the disturbances in the earth's magnetic field caused by the presence of a submarine. Mad sensors have a slant detection range "on the order of 500 meters from the sensor" (Weapons and Systems Engineering Department, USNA n.d.). Slant range is the lateral distance between the sensor and the magnetic source. A significant item to note is that the altitude of the aircraft and the depth of the submarine both are part of the slant range value. In addition, the greater the lateral separation between aircraft and submarine, the less reliable the MAD sensor will be. Conversely, the aircraft flying directly over the submarine will give the MAD equipment the greatest opportunity to get a "MAD hit."

The MAD is primarily a corroborative sensor. This means that the MAD will be used to help verify the presence of a submarine that has been detected by another sensor. The P-3C's MAD will establish that something is causing a magnetic disturbance. However, the MAD will not classify the "object" that is causing the magnetic disturbance. In shallow water or littoral environments, the MAD is vulnerable to detecting false returns caused by pinnacles, sea mounts, sea wrecks of debris scattered on the ocean floor (Edmonds 2000). The MAD can be operated continuously by the aircrew onstation with the hopes of getting a "random MAD" or chance detection during routine search and surveillance. A "random MAD" should never be discounted while onstation but should not be relied on as the primary means of detection.

AIMS. The AIMS electro-optical sensor will allow the P-3C *Orion* to search for a submarine from a greater distance. It will be primarily used as a corroborative sensor to verify contact by another aircraft sensor. It is also important to note that the AIMS will assist a competent, nonacoustic operator in his ability to classify a submarine if located on the surface.

ALR-66. The ALR-66 is used by the P-3C *Orion* aircrew to warn of any electronic emissions made by a submarine. The two types of typical, electronic emissions made by a submarine are radio communications and radar. The parametric data of the electronic emissions is used to identify the type of radar being used. This information can be used to help identify the source of the electronic radiation. The *Orion*'s ESM equipment is able to establish a bearing of the electronic emission and will need another of the aircraft sensors to corroborate the sensor. Otherwise, the *Orion* aircrew will hope that the submarine radiates its radar long enough for the aircraft to position itself to get another ESM bearing to give an area of probability or cross-fix to the crew.

The Total Package

For the P-3C *Orion* to detect, localize, and track a submarine, it must use both its acoustic and nonacoustic sensors together. The submarine commanding officer is aware of the general airborne tactics that will be utilized against his vessel and he will ensure that he minimizes the opportunity for detection of his submarine by the *Orion*. It is therefore imperative that the P-3C *Orion* aircrew work together as a team to ensure maximize opportunities for determining the position and identity of its submerged adversary.

Capabilities Versus Requirements: The Final Analysis

The thesis evaluation will be completed by completing a detailed analysis of the US Navy's long-range, airborne ASW capabilities represented by the P-3C *Orion*. The analysis will take place using portions of two specific areas of the JWCA. The first area of the JWCA to investigate will be the littoral portion of land and littoral warfare section. Upon completion of the littoral analysis, an examination will take place using the sea portion of the sea, air, and space superiority JWCA area. By comparing the capabilities of the P-3C *Orion* applied tactically in a littoral region as well as in the open ocean, a qualitative analysis will be completed that will answer the thesis topic.

Littoral Warfare and the P-3C *Orion*

Littoral warfare is conducted in regions at or near the coastline. It is a region of great concern as forces afloat as well as forces ashore are vulnerable in littoral regions. Whether US Marines are conducting an amphibious landing ashore or US Army maneuver units' equipment is being offloaded in a nonpermissive environment, there are many threats to US, allied, and coalition military forces. Submarines pose a tremendous threat to maritime forces during naval and amphibious operations. A submarine conducting antishipping or antisurface warfare can wreak havoc against surface forces. The P-3C *Orion* remains the sole aircraft in the USN inventory capable of conducting long-range, ASW against enemy submarines. Without the versatile *Orion's* ability to search, detect, localize, track, and if necessary, attack, US military forces will be vulnerable to attack by enemy submarines.

Both diesel and nuclear submarines are able to operate in littoral regions. The nuclear submarine will be more limited in maneuverability because of its greater overall size compared to a diesel submarine. However, a nuclear submarine could be operated in a littoral region if its naval command orders it too. Regardless of the submerged threat, the P-3C *Orion* aircrew will use its aircraft sensors in an attempt to exploit the weaknesses of the submarine and enable safe passage of joint forces afloat.

Sea Superiority and the P-3C *Orion*

In the open ocean, the nuclear submarine will remain the primary threat. It is possible for diesel submarines to operate in the open ocean, but it is traditionally more advantageous for a diesel submarine to operate in littoral regions closer to a home port. Nuclear submarines will remain the primary focus for open-ocean ASW. Nuclear submarines rely on stealth to complete their missions. In addition, a nuclear submarine does not have to make itself vulnerable to maintain power systems on board their submarine because it is nuclear powered. A nuclear powered submarine will continue to be an extremely challenging target for the P-3C *Orion* crew to prosecute.

Acoustic Sensors

Acoustic detection in both the littoral or open-ocean environments present a rather formidable task for the aircrew on board the P-3C *Orion*.

Littoral ASW. Regardless of the type of submarine used by an adversary, the littoral environment has several variables that make it difficult for the P-3C *Orion*. First, it is particularly important to note that submarines operating in the littoral will attempt to "blend in with local shipping traffic making it difficult to differentiate their acoustic signatures from local noise" (Mitchell 2000). Second, it is a common tactic for "diesel/electric submarines" to "'bottom out' or rest on the ocean floor" (Mitchell 2000). Once the submarine is at rest on the ocean bottom, the submarine literally fades into the ocean floor. Finally, a diesel submarine will use the sea bottom contour or underwater geography to mask its presence by coming to rest near a pinnacle or a seamount. The seamount, acting as an artificial submarine, will appear as if it has stopped maneuvering while the "real" submarine fades away. Any submarine operating in the littoral "will be able to take advantage of geography, topography, oceanography, environmental factors, and heavy shipping volume, which combine to pose a significant technical and tactical ASW problem" (Lodmell 1996, 31).

Open-Ocean ASW. Due to the relative size of the ocean, ASW rely on cueing data to initiate an acoustic search. Once the area has been determined, the P-3C *Orion* will deploy its sonobuoys in a "cold pattern" in order to locate the opponent's submarine. The purpose of the sonobuoy pattern is to detect a submarine operating near the area of probability. The problem with this tactic is that acoustic signatures of enemy submarines continue to decrease due to improvements in quieting technology for submarines. This improvement in quieting technology limits overall sound produced by the submarine resulting in limited detection ranges for the *Orion*'s deployed sonobuoys. Any improvement in favor of the submarine surreptitiousness will make ASW operations more difficult in the future.

Nonacoustic Sensors

The majority of the nonacoustic sensors on board the P-3C *Orion* attempt to exploit the diesel submarine's need to recharge its batteries. With the advent of AIP, the diesel submarine will not have to recharge its batteries as frequently. This will effectively limit the opportunities for the *Orion* to detect enemy submarines in a littoral region. The addition of AIP has effectively made diesel submarines similar in use to nuclear submarines, making them extremely challenging to detect in order to prosecute. Instead of having multiple opportunities to locate a submarine daily, current submarines will need to recharge just once every five days (Mitchell 2000). In addition, the addition of an AIP will extend that recharging requirement time line even further. The *Orion* nonacoustic sensor suite is designed to maximize its opportunities to detect an enemy submarine when it does reveal itself.

Despite the advent of AIP, radar will remain an important ASW sensor for the P-3C *Orion* now and in the future. The P-3C's older APS-115 search radar and more technologically advanced APS-137 ISAR/SAR radar still are more than capable of detecting snorkeling submarines (use of submarine radar and communication equipment to be covered further on). The APS-137 radar has an added capability over the APS-115 radar by having a periscope mode that allows the radar to detect a periscope within thirty-two miles of the aircraft (CNO 1999, 10-354). If a submarine decides to extend its periscope or snorkel, there is a good probability that an *Orion* within range of the target can detect it. The challenge for the *Orion* will be to be in the position to detect an AIP capable, diesel submarine or its nuclear counterpart. The *Orion* will remain an adequate platform against the older, non-AIP capable submarines.

Another significant capability of the APS-137 radar is the SAR mode. With SAR, the aircraft can develop a ground-mapping image. The added SAR capability of the APS-137 allows the P-3C *Orion* to locate a submarine while it is still in port at standoff range. The ability of the *Orion* to locate an AIP-capable diesel submarine or a nuclear submarine in port before they can become a credible threat to maritime forces is and will remain critical for naval forces operating in the littoral.

Similar to P-3C *Orion* radar, the IRDS will operate looking to exploit the presence of a submarine on the surface of the water. Anytime a submarine is surfaced, its presence provides the *Orion* aircrew an opportunity to detect the submarine due to the temperature differential between the submarine's hull and the surrounding water. In addition, a diesel submarine on the surface recharging its batteries is vulnerable to IRDS detection because of the heat produced by the diesel engines. Heat and humidity will provide environmental challenges that will degrade the overall effectiveness of the *Orion*'s IRDS in a littoral environment. Also, the density of commercial shipping, fishing boats, and pleasure craft add an additional distraction for the *Orion* aircrew. Nonetheless, the IRDS will remain an adequate sensor for detecting a surfaced submarine.

The AIMS electro-optic sensor provides a significant capability for ASuW that can be applied in the ASW realm by the *Orion* aircrew. The AIMS may be used in a reconnaissance role to locate submarines that are located pier-side in port at standoff ranges. This allows the P-3C *Orion* another way to locate a submarine before it becomes an immediate threat to naval forces in a maritime environment. Obviously, the *Orion* may still operate its AIMS electro-optic sensors to concentrate on an ASW area of interest.

Similar to the radar, the MAD will be affected by the addition of the AIP to diesel submarines in an indirect way. The MAD is primarily used as a secondary sensor that corroborates the detection of a submarine by alternate aircraft sensors. By limiting the number of times that the submarine exposes itself, it is effectively limiting the frequency that MAD will be used as a corroborating sensor. The aircrew will continue to operate MAD while onstation with the prospect of gaining a "random MAD" in a littoral environment as well in the open ocean when at the proper altitude.

The sensor used by the P-3C *Orion* crew to evaluate ESM emissions in the littoral region is the ALR-66. The P-3C *Orion* will continue to be able to use the ESM equipment against the submarine commanders regardless of whether the submarine is AIP capable or not. Traditional command and control operations for foreign militaries dictate some method of communication be maintained between the higher command and the submarine. This will continue to be a handicap the *Orion* can exploit (with ESM as well as radar, IRDS, or visually). However, the widespread proliferation of diesel submarines increases the chance of an unstable government adding a submarine to its inventory. Once this happens, the opportunity for a scenario from Tom Clancy's book, *The Hunt for the Red October,* increases. Another danger from the proliferation of diesel submarines is the opportunity of a terrorist organization to acquire a submarine. A submarine with a minimum amount of training in the hands of someone that has no concern for Western ideals and is dedicated to an extremist cause could be extremely perilous for allied militaries as well as innocents. A terrorist group in possession of a submarine with technologically advanced weapons could target cities, merchant shipping or military targets to further its terrorist agenda. Conventional weapons such as mines, cruise missiles, or torpedoes could be used with devastating results against a variety of targets in a littoral environment. Furthermore, the availability of biological, chemical or nuclear weapons and their employment in cruise missile warheads could give a terrorist the ability to use WMD against civilian targets on the coast as well as inland.

Besides intercepting communications, the *Orion*'s ESM equipment can be used to detect radar emissions from a submarine. As long as a submarine uses its radar for navigation, surface search, or targeting, the *Orion* ESM equipment will have the prospect of identifying the emission. The ability of the *Orion* crew to react to the sudden radiation of a submarine's radar will increase their chances of localizing their ESM contact.

Final P-3C *Orion* Sensor Analysis

Advances in technology and the challenges of the littoral environment prove to be the greatest two greatest challenges facing the P-3C *Orion* in its ASW role in the future. Progressive quieting techniques added to submarines make it much more difficult to detect both nuclear as well as new generation diesel submarines. Nonacoustic detection techniques remain a viable method to locate both nuclear and diesel submarines. However, the requirement for both nuclear and AIP capable diesel submarines to expose themselves and risk detection by P-3C *Orion* and other ASW forces has been greatly diminished. The P-3C *Orion* is now and will continue to face significant challenges in the ASW warfare area.

This chapter examined the primary, secondary, and tertiary thesis questions. By addressing the relevancy of ASW, the threat posed by submarines and the ASW capabilities of the P-3C *Orion*, the parameters have been established for the for the primary thesis question to be answered in chapter 5.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Introduction

ASW was a critical core competency of the US Navy throughout the Cold War. The P-3C *Orion* was a primary component of the Navy's ASW force during the Cold War; however, the world has changed. The primary mission areas for the P-3C *Orion* have changed in response to the shift in the global political and military environment. No longer facing the threat of Soviet submarines, the *Orion* aircrews became proficient in additional missions, still training in ASW but concentrating on missions in ASuW, strike warfare as well as ISR. This natural progression of post-Cold War mission emphasis is the foundation from which this thesis was developed.

Thesis Question

This thesis endeavored to confirm whether the US Navy possessed the airborne, ASW capability to defend itself from current as well as projected submarine threats. In order to answer the primary thesis question, several secondary and tertiary questions were addressed. The first topic explored was the end of the Cold War and its effect on the USN. The thesis then addressed the threat posed by submarines by examining the nations who possess either or both diesel and nuclear submarines. In addition, the submarine threat also focused on why a submarine is dangerous to military and nonmilitary parties and how it can be employed by America's enemies to interfere with the achievement of US or allied objectives. After analyzing the threat posed by a submarine, the thesis focused on why proliferation of submarines is dangerous to the US. In addition to analyzing submarine proliferation, the thesis considered the validity of ASW operations in the modern age as well in the future. After determining the relevancy of ASW, the thesis investigated the effect of technology on diesel and nuclear submarines and how these technological advances pose a serious threat to the security of the US and its allies. Finally, the thesis addressed the airborne, ASW capability of the US Navy, represented by the P-3C *Orion*, when measured against the hazards created by diesel and/or nuclear submarines. By examining the capabilities of the P-3C *Orion* against the current and future submarine threat, the thesis question was qualitatively answered.

Conclusions

Chapters 1 through 4 examined the primary, secondary, and tertiary thesis questions. By addressing the relevancy of ASW, the threat posed by submarines and the ASW capabilities of the P-3C *Orion*, the primary thesis question has been answered.

First, ASW is a vital component of the US national strategy. The four strategic concepts delineated in the most recent *NMS*, strategic agility, overseas presence, power projection, and decisive force, are not realistic without the ability for the US to counter the global submarine threat through its ASW forces. In addition, the fatal circumstances of 11 September have changed the US's view of the world. However, the *QDR* produced by the SECDEF still describes submarines as a tremendous threat to the US global interests and security. Thus, the danger facing the security of the US has increased since 11 September diminished. ASW remains a critical skill that American naval forces must possess. The US Navy must have the capability to deter adversary submarines and ensure the safety of American citizens and the security of American interests globally.

ASW is therefore an inherent part of American national security and more relevant than ever.

Next, the thesis reviewed the perils that exist due to the presence of submarines. A submarine is capable of "shaping" the naval battlefield by employing its torpedoes, mines, and antiship missiles against commercial shipping, naval warships as well as land targets. These weapons allow a submarine to threaten US political, economic, and military interests in the open ocean, littorals, or choke points. In addition, a submarine is capable of using cruise missiles to attack land targets that can affect land warfare as well as naval warfare. Finally, submarines are developing defensive measures to protect themselves from airborne, ASW units. The proliferation of submarine-launched SAMs and the optically guided Polyphem missile could cause a major disruption for naval expeditionary forces operating in littoral regions. The P-3C *Orion* will be severely limited in its activities with little or no defenses against modern fighter aircraft, land-based SAMs, and now submarine-launched SAMs. Therefore, the ability of the P-3C Orion to operate autonomously forward of naval forces will be limited when operating in non-permissive, hostile locations. Consequently, submarines operated by an opponent of the US or its allies can have a devastating effect on military operations and prove perilous for the sailors, soldiers, and Marines of the US military.

Finally, the last element of the thesis detailed in chapter 4 was the actual capabilities of the *Orion* aircraft against contemporary as well as future submarines. The advances in technology for submarines are proving to be quite challenging for the P-3C *Orion*. The P-3C *Orion* will need advances in technology and training to counter the acoustic advantages gained by both diesel and nuclear submarines with regards to acoustic quieting. Submarines are becoming increasingly challenging for aircrews to detect, localize, and track. The submarine quieting phenomena can be expected to continue to improve for the submarine making the task of ASW forces even more challenging.

Besides acoustic quieting techniques, the addition of air independent propulsion (AIP) on diesel submarines will render P-3C *Orion* sensor tactics virtually obsolete by limiting the requirement to recharge the diesel submarine's batteries. With the Antisurface Warfare Improvement Program sensor suite, the aircrew will be able to detect and localize the submarine when the submarine commanding officer decides to recharge the ship or boat's batteries. However, reliance upon this event to take place on a daily basis is no longer guaranteed due to the advent of AIP. Therefore, the opportunity for detection will rely upon radio and radar emissions, random magnetic anomaly detection (MAD), visual, and advanced imaging multispectral (AIMS)/infrared detecting set (IRDS) detection.

The two most alarming situations observed were a diesel submarine with an AIP capability in a littoral environment and nuclear submarine in the open ocean. Both submarines will offer little opportunity for detection and operate in an environment that they can exploit to their advantage. Detection will again be limited to radio and radar emissions, random MAD, visual, and AIMS/IRDS detection.

Overall, the P-3C *Orion* will remain an excellent platform for overland surveillance, reconnaissance, and strike warfare missions, but will be less than adequate for the ASW mission. The P-3C *Orion* will remain successful against aging nuclear and diesel submarines, with the technologically advanced Antisurface Warfare Improvement

Program aircraft having the advantage over the baseline Update III aircraft, but will have limited success in prosecuting newer technology in place on new submarines due to the lack of detection opportunities. The *Orion* capabilities are summarized in table 8.

Table 8. P-3C *Orion* Sensor Capability Assessment Against Diesel, Diesel with AIP, and Nuclear Submarines

Sensor (Environment)	Diesel Submarine	Diesel Submarine with AIP	Nuclear Submarine
SASP (Littoral)	Potential Problems	Significant Challenge	Potential Problems
SASP (Open ocean)	Potential Problems	Potential Problems	Significant Challenge
APS-115 Radar	Adequate	Potential Problems	Potential Problems
APS-137 ISAR	Adequate	Potential Problems	Potential Problems
AA-36 IRDS	Adequate	Potential Problems	Potential Problems
ASQ-81 MAD	Adequate	Adequate	Adequate
AIMS	Adequate	Adequate	Adequate
ALR-66	Adequate	Adequate	Adequate
Visual	Adequate	Adequate	Adequate

Adequate (green)   Potential Problems (yellow)   Significant Challenge (red)

Recommendations for Follow-On Research

The focus of this thesis was the long-range, airborne, ASW capability of the US Navy's naval expeditionary forces, which is represented by the P-3C *Orion*. This research has highlighted several issues. First, the thesis was centrally focused upon the airborne, ASW platform of the US Navy. While the thesis was confined the P-3C Orion, the US Navy's inventory consists of submarines, ships, and other aircraft. The research was based upon the premise that airborne, ASW is a necessary competency for the US Navy to possess. Additional research could be completed to determine an alternative or nontraditional platform that could conduct the ASW mission. Furthermore, the optimal platform to perform the ASW mission could be a part of another service in the Department of Defense. Therefore, it would be relevant to investigate alternative ASW platforms, such as satellites, unmanned underwater vehicles (UUVs), or unmanned airborne vehicles (UAVs).

Another potential area of follow-on research involves a replacement aircraft for the P-3C *Orion*. Should the replacement aircraft be a remanufactured P-3C *Orion*, an aircraft similar to the UK's *Nimrod*, or a new commercial derivative of a multimission aircraft (MMA)? Follow-on research could also focus on capabilities required for a replacement aircraft for a variety of missions or threats.

Finally, the lack of detection opportunities for AIP capable as well as nuclear submarines does create a need to look at ASW from a different perspective. Due to the increasing challenges regarding submarine detection, alternative methods for ASW should be investigated. Instead of locating submarines after they have sortied to sea, potential solutions should be addressed by defeating the submarine while in port. While this poses several possible escalation issues, the idea of defeating a submarine in port should be investigated. The mission could be performed by the P-3C Orion with its ISR sensors and strike capability in order to prevent an adversary's submarines from departing port.

Final Thoughts

The P-3C *Orion* is an extremely capable aircraft that is able to accomplish a variety of missions in support of the *NMS*. While *Orion*'s AIP capabilities make it an incredibly effective aircraft to support an expanded role in ASuW, the Orion's ASW skills must be closely monitored. As potential adversaries of the US are able to acquire advanced submarines and their complementary weaponry, the importance of having a highly capable ASW aircraft to counter the threat from proliferated submarines dramatically increases. In order to meet the tactical, operational, and strategic tasks required to support the *NMS* and ensure America's vital interests, ASW must remain a priority. While the *Orion* and its aircrews are able to meet the challenges posed by the today's submarine threat, the proliferation of new, quieter submarines armed with a deadly arsenal of weapons could pose the greatest challenge to the US Navy in the future. To counter the future submarine threat, the USN must continue to explore methods as well as technology to employ the *Orion* against advanced submarines. In addition, the Orion aircrews must look at further methods to employ the new AIP sensors in an ASW role. By addressing ASW tactics, crew training, and technological advances in ASW, the P-3C *Orion* and its crews will continue to perform a vital role for the US military and help the preserve the American way of life.

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