HOMELAND SECURITY AND THE COAST GUARD:
Postured for Technology Improvements

by
Arthur C. Walsh, Commander, USCG

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Author

CDR Artie Walsh was raised in New England and graduated from the U.S. Coast Guard Academy in 1982 with a degree in Mathematical and Computer Science. From 1982 to 1984, he performed law enforcement boardings in the Caribbean while stationed onboard the Coast Guard Cutter Acushnet, homeported in Gulfport, Mississippi. His primary duties included deck watch officer, lead boarding party officer, and supply/budget officer. In 1984, CDR Walsh was accepted to Navy flight training in Pensacola, Florida. In 1985 he received a degree as Flight Safety Officer from the Naval Postgraduate School in Monterey, California, and upon graduation, he was stationed in Brooklyn, New York, as the flight safety officer where his primary flying duties included search and rescue. In 1989, he assumed duties as Branch Chief and HH65 helicopter senior instructor pilot at Aviation Training Center Mobile. He was instrumental in converting the Coast Guard's flight training program to computer-based learning. In 1994, CDR Walsh received a master's degree in Operations Analysis with a specialty in Mathematical/Computer Discrete Simulation. He fully utilized his degree in his follow-on tour in the office of Human Resources, Personnel Forecasting and Analysis at Coast Guard Headquarters, Washington, D.C. His major accomplishments included modeling the active duty officer, active duty enlisted and civilian workforces, along with devising a plan for the Coast Guard downsizing and use of incentive tools. CDR Walsh returned to aviation in 2000, assuming executive officer duties at Coast Guard Air Station Detroit, Selfridge Air National Guard Base, Michigan. While there he successfully planned and completed the stand-up of Air Facility Muskegon, including an 80 percent increase in personnel, and 6.6 million dollars in construction and upgrades. CDR Walsh is a graduate of the Air War College.

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Abstract

The Coast Guard was effectively positioned to accomplish its missions and functions before the September 2001 terrorist attacks. The terrorist attacks reshaped the United States national security strategy, and this caused the Coast Guard to reprioritize its mission requirements elevating Homeland Security to be on par with the Coast Guard's number one priority, search and rescue operations.

To effectively carry out the Homeland Security mission, the Coast Guard must leverage existing and developing technologies. These technologies will improve efficiency across the full spectrum of Coast Guard missions. While these technologies are not cheap; costs for research, development, and application can be greatly reduced by partnering with other agencies. To leverage these technologies to improve Homeland Security effectiveness, a process for evaluating and infusing emerging technology within the Coast Guard must be developed. This process must then be institutionalized within the Coast Guard's corporate structure.

I. Introduction

The Coast Guard is a multi-mission military member of the armed forces, whose major mission areas include search and rescue, maritime safety, maritime security, protection of national resources, maritime mobility, and national defense. The terrorist attacks of September 2001 have reshaped the national security agenda, putting renewed emphasis on the Coast Guard and the its national defense mission of providing maritime homeland security.

The impact of these terrorist attacks has significantly changed the way the Coast Guard must carry out its missions. It gives new importance to a deficiency in the Coast Guard's ability to preemptively stop all potential terrorists from infiltrating the United States via the maritime environment. The pressing nature of this deficiency creates an unprecedented opportunity for the Coast Guard to improve and invest in its future through technology. There is fertile ground in exploring satellite surveillance, directed-energy weapons, and a host of other small-scale technologies. Yet, the Coast Guard has no institutionalized process to review, explore, or select emerging technologies for investment. The Coast Guard must create an institutionalized system for infusing advanced technology into its programs within the acquisition and budget processes. This is the focus of this paper, and its importance is echoed in the 2002 National Security Strategy of the United States:

> Defending our Nation against its enemies is the first and fundamental commitment of the Federal Government…. To defeat this threat we must make use of every tool in our arsenal—military power, better homeland defenses, law enforcement, intelligence…. History will judge harshly those who saw this coming danger, but failed to act. In this new world we have entered, the only path to peace and security is the path of action…. Our response must take full advantage of strengthened alliances, the establishment of new partnerships with former adversaries, innovation in the military forces, modern technologies…and increased emphasis on intelligence collection and analysis.[1]

Thus, the first goal of this paper is to show that there is a gap between Coast Guard roles and missions and the most effective way to accomplish those roles and missions. This is caused, at least in part, by the lack of a Coast Guard process to locate developing and existing technologies, analyze their potential applications into Coast Guard roles and missions, and incorporate valuable technologies to create a 21st century Coast Guard capable of meeting the National Security Strategy of the United States. This paper will make recommendations for how the Coast Guard can implement such a system to provide the level of homeland security the United States deserves.

This paper will begin by framing the issue of how well technology is being incorporated within the Coast Guard, particularly in light of the Coast Guard's rapidly expanding maritime homeland security mission. It will then explore a variety of technologies that could greatly enhance the Coast Guard's effectiveness in conducting its mission of maritime homeland security, but have not been pursued by the Coast Guard's corporate process. The paper will briefly discuss how the Coast Guard integrates technology and compare this to the more successful DoD processes. Lastly, this paper will recommend fundamental changes to how the Coast Guard views technology and how it interacts with other federal agencies who share the Coast Guard's needs to field a modern, highly-capable force.

II. Background and Framing the Issue

Although the Coast Guard is fully utilizing all of its resources for homeland security and intelligence purposes, these efforts are simply not enough to defend the nation from terrorists at an acceptable, much less desirable level. The Coast Guard does not have enough ships, aircraft, or personnel, to blanket the territorial waters of the United States. Further, it would be prohibitively expensive to own and operate such an organization. Technology can help fill this gap, and better use of other agencies' efforts to more effectively develop and employ existing technologies will allow the Coast Guard to be better positioned to successfully carry out its maritime homeland security mission in the 21st century. The potential uses for existing and developing technologies in Coast Guard missions are wide-ranging.

The Coast Guard has only been directly involved in small-scale technology development efforts mostly dealing with component upgrades like computer and software upgrades for the HH65 helicopter, shipboard computer connectivity upgrades, and secure communications systems. On larger scale efforts like the national distress and response system, vessel replacements, and the integrated deepwater system program, technology improvements have typically come from industry via acquisition contracts. These contracts were based on industry proposals, and new technology was acquired only to the extent it was included in the acquisition contract. This is certainly understandable. Because the Coast Guard is too small to conduct theoretical research and develop systems and programs on its own, it has relied on contractors and civilian industry to provide the Coast Guard with technology options. As a result, of the downsizing of the 1990's, there was minimal emphasis on major contracting initiatives with few exceptions.[2] As a result, the Coast Guard entered 2001 having pursued few new technology initiatives in the preceding ten years.

Pre 9/11

The Coast Guard has always been a diverse, mission-oriented organization. Its tasks are both wide ranging in scope yet intermeshed due to limited funding and multi-mission capabilities of existing resources. This pays dividends in stretching a limited budget to accomplish the most possible. It should also allow technology improvements to have a wide-ranging impact on multiple Coast Guard goals.

The roles and missions of the Coast Guard were developed over the last 200 years to meet changing National Security Strategy requirements. It is difficult to rank-order the numerous diversified missions as all missions are important. Historically, search and rescue has been the most urgent mission due to the risk to life in these cases. This mission has its roots to the early years of the Coast Guard's Life Saving Service. Every operational unit has a responsibility to respond to search and rescue cases, although some resources are not specifically designed for this mission. Other Coast Guard mission areas include Maritime Safety (maritime worker safety, passenger vessel safety, recreational boating safety, international ice patrol), Maritime Security (drug interdiction, migrant interdiction, foreign fishing vessel incursions, domestic fisheries enforcement, exclusive economic zone, general maritime law enforcement), Protection of National Resources (oil spill, marine debris, marine environmental protection, living marine resources and protected species), Maritime Mobility (navigation aids, vessel traffic, domestic icebreaking, polar operations and icebreaking, bridge administration), and National Defense (general defense operations, maritime interception operations, military environmental response operations, port operations/security and defense, coastal sea control operations, peacetime military engagement, maritime homeland security).[3]

Prior to the terrorist attacks of 11 September 2001, the Coast Guard had not undergone any significant changes to its method of conducting operations for decades. There was no need for significant change for several reasons. First, the old way of doing business was considered successful and continued to be successful. The Coast Guard was performing its law enforcement mission with effective results against drug trafficking and illegal immigration, and in protecting the fisheries.[4] Since it was not necessary to stop everything, searching the seas with ships and aviation, supplemented with intelligence and other agency support, allowed the Coast Guard to claim effective law enforcement involvement. Improved effectiveness and success was measured by many different performance benchmarks including the increased value of lives and property saved, vessels boarded, and illegal contraband interdicted. Secondly, there was limited funding to change the way the Coast Guard was operating, so it continued to function as effectively as possible with older ships known to be manpower intensive and technology poor. Coupled with increased missions and the emphasis on "doing more with less," this trend was exacerbated even further by the downsizing and

budget drawdowns of the late 1990's. As a consequence, Coast Guard people were working harder and harder to do their jobs well, and the Coast Guard became a technological laggard.

Post 9/11

The significance of the 9/11 terrorist attacks cannot be overstated. These were devastating events for the country. For law enforcement, government agencies and DOD, the terrorist attacks were a significant awakening to a new and imminent threat. It immediately constituted the 'new normalcy,' which was being defined on the fly as America stumbled along in the wake of 9/11.

Security, and homeland security in particular, took an immediate and pivotal shift in importance. It was more than civilian and political interest that shifted the importance of this mission for the Coast Guard. It was more than a stake in the federal budget. The terrorist threat involved the potential loss of human life, possibly in unimaginable numbers, and this significantly raised the urgency of maritime security to the top of the Coast Guard list of roles and missions. This importance was echoed in the new National Security Strategy of the United States. Under the reorganized set of Coast Guard missions, maritime homeland security will represent approximately 27 percent of the Coast Guard annual budget.[5] Additionally, the majority of the Coast Guard FY 2002 Report is centered on the importance of homeland security. Post 9/11, homeland security joined search and rescue as the two major Coast Guard missions directly contributing to the saving of lives.[6] The Coast Guard FY 2002 report put it this way:

> Today, we operate with the constant threat of terrorism. The enemy, unlike any other in our history, has turned the tools of our own prosperity into weapons against us. As a nation that depends heavily on oceans and sea-lanes as avenues of prosperity, we know whatever action we take against further acts of terrorism must include protection of our ports and waterways and the ships and people that use them…. This budget [FY2003] moves Maritime Homeland Security alongside SAR [search and rescue] as our primary mission focus.[7]

Before September 11, 2001, the Coast Guard had already realized a transformation was necessary to achieve success. "Several years ago, a rigorous analysis of the future operating environment and our current status revealed a real and growing gap between the Coast Guard's capabilities and the expectations of the American people."[8] Now, the Coast Guard can no longer afford to continue performing its missions the old-fashioned way. This is particularly true with respect to maritime security. In the past, the Coast Guard could accept some drug trafficking, illegal fishing, and illegal immigrants not being caught, but this is not the case for terrorist activities. As the Coast Guard has sailed into the new century, the emphasis on stopping terrorists and restoring readiness through people and assets has been a key issue. To address this, the Coast Guard has received large budget increases to improve its effectiveness.[9]

Homeland Security Mission

To understand the gap in technology required to execute the Coast Guard's homeland security mission, an overview of this mission area is necessary. There are five principal elements to homeland security: building maritime domain awareness; ensuring controlled movement of high interest vessels; enhancing presence and response capabilities; protecting critical infrastructure and enhancing force protection; and increasing domestic and international outreach.[10]

Maritime awareness centers on intelligence and communications to stay abreast of maritime activity. This requires information on the vessels, passengers, crews, and ships' cargo both in port and underway on the high seas. Communications and connectivity are important aspects of awareness due to the nature of the secure intelligence information and the need to disseminate the information in a timely manner. This also incorporates personnel, operations, and maintenance resources to use these systems. The key to success in maintaining awareness on vessel activities is surveillance. This is the only way to stay aware of who is going where and with what, and to isolate deviations when they occur.

The second aspect of homeland security involves the intervention and controlled movement of high-interest vessels. There are many different reasons a vessel could be classified as high interest, ranging from dangerous cargo, to vessels having past violations, to vessels deviating from their float plans, to having an origination port of interest (Panama). Once a vessel is identified as high interest, it is extremely important to

monitor its progress and ensure safety concerns are covered, either in port or underway or both. This is accomplished by the use of Sea Marshals, increased Coast Guard safety patrols in strategic ports, and conducting escort duties. Additionally, vessels in excess of 300 gross tons must provide 96-hour advance notification prior to arrival in port.

The mission area of "enhancing presence and response capabilities" equates to interdiction. This includes creating maritime safety and security teams to assist with harbor patrols, establishing security zones, interdicting or stopping vessels, and responding to other maritime incidents. The fourth element of maritime homeland security is protecting critical infrastructure and enhancing force protection as it relates to commercially owned infrastructures or maritime vessels. The Coast Guard assists and provides guidance in these areas to the civilian sector. This area is being expanded to encompass chemical, biological and radiological countermeasures, and computer virus and hacker attacks against critical infrastructure assets affecting the maritime environment.

The final element of maritime homeland security is increasing domestic and international outreach. Only through the cooperation of local and international agencies can the waterfront areas, vessels, and commercial interests be safeguarded.

Although the Coast Guard is making progress in its fight against terrorism with its developing maritime security mission, it is not being truly visionary when it comes to utilizing existing and developing technologies to improve capabilities. For example, the Coast Guard presently does not have a centralized infrastructure to collect, analyze, and disseminate intelligence and vessel information to enhance maritime awareness. It lacks the surveillance capability to monitor all vessels within U.S. waters, and many new technologies to interdict or stop vessels remains untested. With increased emphasis on antiterrorist activities, the current trend for increasing the Coast Guard budget makes today an excellent time to create a framework for homeland security that will additionally pay dividends across the mission areas of the Coast Guard.

Framing the Issue

The Coast Guard is not ready to protect the United States from terrorist attacks from our territorial waters. To begin, the Coast Guard is not able to stop and board 100 percent of inbound vessels—in great part

because it lacks the technological ability to locate and monitor all inbound vessels. Once inside United States waters, it is not difficult for vessels loaded with explosives to get near critical facilities such as nuclear power plants, oil offloading areas, or major commercial piers. The results of a major explosion near any such facility would be devastating to both people and the environment. A plausible future CNN headline may read, "The life saving Coast Guard fails the public as thousands die in preventable terrorist attack." In short, the Coast Guard's current capabilities fail the "CNN Test."[11]

Such a disaster is possible because the Coast Guard is not using all available technologies to provide the most effective maritime domain awareness, thereby increasing risk to the United States. Further, even if terrorist vessels could be identified within the coastal environment, controlling the movement, intercepting and then stopping these vessels is difficult with existing capabilities. Yet, currently available technologies could fix these shortfalls. While some are expensive and possibly beyond the ability of the Coast Guard to fund, the Coast Guard has neither researched nor requested budgeting for the available existing technologies to properly position itself to provide the best security to the nation. Leveraging emerging technologies is crucial if the Coast Guard is going to be effective in all of its missions in the 21st century, including Maritime Homeland Security.

The New Standard of Performance

It is worth comparing the current Coast Guard situation to the force protection and security measures associated with the terrorist attack on Khobar Towers. There are six issues involved. First, Khobar Towers was a terrorist attack in which there was loss of life. Second, the area commander took extraordinary measures, well beyond the actions of any other equivalent area commander, to provide for the security of the American troops residing there. Third, the areas assessed as being below standards from a security standpoint all involved high-value, costly repairs. Fourth, these improvements would have only slightly increased the overall safety posture, and fifth, they would have had no impact on loss of life in this particular terrorist situation. Finally, getting Khobar Towers to meet all security and safety requirements was beyond the ability of the area commander.[12]

The Khobar Towers situation is very similar to the current readiness of the Coast Guard against a maritime terrorist attack. First, such an attack would undoubtedly incur substantial loss of life and property. Second, like the security forces at Khobar Towers, the Coast Guard is working very hard to protect the United States and has maintained a very high operational tempo since 9/11. The Coast Guard has been going to extraordinary efforts to perform its security mission as efficiently and effectively as possible. Third, as in the Khobar Towers case, the technology to provide adequate security is very expensive. As in the sixth point in the Khobar Towers example, the majority of the needed technology is beyond the ability of the Coast Guard to fund, and consequently, the Coast Guard has decided it is not worth pursuing. In contrast to the fourth and fifth points in the Khobar Towers example, the Coast Guard could greatly benefit from an increased security net utilizing better surveillance and interdiction technologies. Such technologies would have a huge impact on homeland security and possibly avoid all loss of life from an attack. Based on the similarities and differences between these two cases, some conclusions can be drawn. In spite of all of the things that were done correctly at Khobar Towers, the area commander, Brigadier General Schwalier, was determined to be at fault and was held personally accountable. It was determined that General Schwalier should have gone to higher authority on issues beyond his control, even though it would have had negligible impact on the outcome of the terrorist attack itself. The nation's civilian leadership determined General Schwalier took an at-risk decision he was not in a position to make.[13] If a successful attack occurred against U.S. territory, the Coast Guard would likely be judged far more harshly. The Khobar Towers attack established a new standard…one all government departments are expected to achieve. The failure to rise to that standard, especially after 9-11, would result in a "guilty" verdict in the court of American public opinion.

Why is the Coast Guard in this predicament? Simply, the Coast Guard has not fully evaluated the range of available technologies to provide the best homeland security net for protecting the United States. The reason this hasn't been done is because the Coast Guard has no organization or structural element responsible for surveying the range of available technologies and recommending which should be pursued. Further, the Coast Guard has not requested increased budget approval for those items deemed too expensive for the Coast Guard to fund out of its

current budget. As a result of its lack of action, the Coast Guard has decided, by default, the level of safety the American people deserve, and the resultant level of protection is not as high as it could be.

Coast Guard Commandant Admiral Collins assessed the situation in August 2002 when he stated, "the Coast Guard command, control, communications, computers, intelligence, surveillance, and reconnaissance (C^4ISR) infrastructure is increasingly incapable of meeting the full-range of Maritime Domain Awareness needs in critical operating areas."[14] Admiral Collins' statement points out the harsh reality that without new and more advanced infrastructure, the Coast Guard will not be fully relevant or be able to rise to the new standard.[15]

The need to improve performance has already been noticed by a media that is showing little sympathy for failure. This was evident with the CNN coverage of the more than 200 Haitian refugees jumping ship in Florida on 31 November 2002. The press asked pointed questions regarding how such a vessel could reach U.S. territorial waters undetected. The media is aware that maritime terrorist activities, drug running operations, illegal fishing activities and rampant illegal immigration are all related, since all such vessels are used to gain access to the United States. After the press pointedly stated the Coast Guard was unable to keep immigrants and drugs from entering the country, they then questioned how the Coast Guard expected to play a vital role in Homeland Security terrorist activities with any degree of success.[16] Although the Coast Guard successfully skirted the issue at the time, it must begin to realize there is a problem, and it must begin to explore new solutions to avoid failing the CNN/60 minutes test. This is the key to avoid the Khobar Towers trap; it is the missing piece to homeland security.

The Coast Guard issued the contract on the Integrated Deepwater System 25 June 2002, but it does not go far enough in providing the technology needed to meet mission requirements.[17] This multi-billion dollar program, which is a step in the right direction, looks at an integrated deepwater asset replacement plan including unmanned aerial vehicles (UAV) and shipboard vertical unmanned aerial vehicles (VUAV). However, the Deepwater System Program does not integrate the existing or emerging technologies needed to create a new Coast Guard-wide C^4ISR system. As such, it does not achieve a "transformation through modernization of our assets, our workforce, and our thinking.[18]

In this program, the Coast Guard has relied on contractors to bring technology into its daily business. Yet, to be successful, the Coast Guard

senior leadership must have a clear vision of the future that involves technology, and drive its procurement toward that vision. Here, both the program and vision were provided by a contractor.

To plan for the future, an organization must do more than contract out its future technology planning. "The principal reason for continuously learning about technologies is that you can no longer be confident about analyzing future threats and opportunities without such knowledge."[19] This is an essential element to thinking outside the proverbial box. It is fundamental to leadership. It cannot be contracted out.

III. Technology and Maritime Homeland Security

In light of the discussion above, it is important to address the progress made to date and justify the position that the Coast Guard could be doing more with technology. There are three areas in which technology could directly affect Homeland Security. These areas include intelligence and surveillance, interdiction and deterrence, and small-scale technologies.

Intelligence and surveillance

Aerial surveillance providing intelligence information is critical to maritime security, and in the last year there have been great strides made toward this end. Since the 9/11 terrorist attacks, there has been some progress in analyzing and acquiring technologies such as UAVs. The Coast Guard is going to enter the arena of unmanned vehicles with two systems: Global Hawk and a vertical takeoff and landing unmanned aerial vehicle called Eagle Eye. The major driver behind this is the Integrated Deepwater System project. Possessing UAVs for land-based and shipboard use will add great flexibility and increase the scope of operations. The Coast Guard is eventually planning on two Eagle Eye UAVs per cutter starting in 2006 and Global Hawks after 2010. Unfortunately, in taking this step toward unmanned aerial surveillance technology, the Coast Guard has dismissed looking at satellites, primarily due to cost.[20]

This dismissal of satellites and what they can bring to the role of Maritime Homeland Security is premature. While many factors are used to determine cost and utility of satellite constellations, satellite-based synthetic aperture radar with ground moving target indication (GMTI) is best suited for large area continuous monitoring of the maritime environment.[21] With specialized software, synthetic aperture radar can locate moving targets and still get exceptional resolution by measuring the phase history of the returns. A moving target will be indicated by a changing phase between the pulses and the difference in these phases can be used to calculate the targets radial velocity.

Synthetic aperture radar with GMTI can provide a comprehensive surveillance package as in the Discoverer II program.[22] In this program, the satellite could locate small objects traveling at speeds between 1.3 and

58 knots in an area 1000km by 2000km—an area roughly equivalent to the entire East Coast of the United States out to a distance of 620 miles. Table 1 shows the four modes of Discover II and the resolution of its systems. The advancements made will be carried into a new generation of space-based radar (SBR) satellites.

Table 1. Space-Based Radar Capabilities[23]

Type of SBR	Mode	Resolution	Collection Rate (per hour)	Purpose
Aperture Radar	Strip mode	3m	700,000 km^2	Detection
	Scanning mode	1m	100,000 km^2	Classification
	Spot mode	0.3m	160 images of 4x4 km areas	Identification
Moving Target	Grazing mode	3m	2,000,000 km^2	Location

The SBR satellite is well suited for Coast Guard searching for various size vessels by providing both large and small area coverage. These satellites, when augmented with optical satellites and the Coast Guard's future Integrated Deepwater System, would provide a complete surveillance package. Such a surveillance system could be controlled by sophisticated software packages and require little or no human intervention. The ground based architecture, both hardware and software, and the onboard satellite software are improving using multi intelligent computerized systems. Software upgrades to the SBR system are achieving larger and more detailed collection areas with automated recognition.[24] It is also achieving extremely high probabilities of detection—from 77 to 97 percent depending on sea state and radar incident angle to target.[25] This system uses little manpower, is extremely accurate, has a rapid response time, provides accurate information, and uses less bandwidth. The system would enable automated, effortless search of large areas of ocean. Targets of interest could be identified and tracked in greater detail or pictures could be made with 0.3m resolution.

Testing of the next generation mid-orbit Discoverer II with combined synthetic aperture radar and moving target capabilities took

place in 2000 with favorable results. The Air Force expects to have this SBR technology with worldwide coverage and approximately 24 satellites up and running between 2007 and 2010.[26] The Navy has determined 10 of these satellites could provide surveillance of all the world's waters and is progressing with their own plans to leverage this technology for both the Navy and Marine Corps.[27] This effort provides the Coast Guard an ideal opportunity to partner with the other military services to improve its own capabilities without incurring the research and development cost of the system.

Investment in SBR satellites is not unique to the United States; there may be potential for international partnerships as well. French SBR satellites will be deployed in the 300 to 400 km orbit. Estimated 2003 cost based on an existing French proposal is $50 million per satellite, roughly one-half of the1998 cost projection of $100 per satellite.[28] It is estimated this eventual system of 24 low altitude satellites orbiting the earth in eight planes of three satellites could provide worldwide coverage with a fifteen-minute revisit time.[29] By increasing the orbit to 770 km, the altitude of the Discoverer II system, Lockheed Martin and TRW are indicating they could provide increased worldwide coverage of any location for six out of every eight minutes.[30] This higher altitude works well, and others have reached the same conclusion. For example, Canada's RadarSat Company currently has one SBR satellite in a 798 km orbit with an additional satellite planned for future launch.[31] In the final analysis, the expense of owning a complete satellite surveillance program is probably too costly for the Coast Guard. However, less expensive partnership opportunities abound.

Satellite systems would be valuable for maritime homeland security. Coast Guard Commandant Admiral Collins' main goal of maritime domain awareness is to "design and implement a maritime domain awareness capability that provides integrated afloat, ashore, and airborne C^4ISR focused on meeting both the informational needs of decision makers and the tactical needs of operational commanders."[32] The Coast Guard works with foreign governments at foreign ports to get some information. Arrival notification of 96 hours prior to reaching a U.S. port assists in vessel monitoring. Additional intelligence and surveillance will be provided by the maritime automatic identification system similar to the one presently utilized within the St. Lawrence Seaway. The Integrated Deepwater System Project will add some increased shipboard capabilities. The most noteworthy development to date will be the use of UAVs for

surveillance and detection in addition to the more traditional helicopter and fixed wing support. Yet, even with all these, the Coast Guard will still be unable to continuously monitor all vessels within the U.S. territorial waters and the deep oceans. But, if the Coast Guard were investing in new technologies like space-based radar satellites, this capability would be possible.

Satellite radar also provides increased surveillance capabilities in other mission areas, too. The type of activity a vessel is involved with does not matter to the satellite system. SBRs can track vessels whether they are involved with drugs, illegal fishing, or terrorist activities. Further, SBR is a proven technology for obtaining oil spill imagery. While factors such as sea state and wind affect radar sensing, oil slicks under lighter wind speeds have a unique, detectable radar signature.[33] While satellites currently have difficulty detecting slicks in high sea states and determining oil thickness, the classification performance algorithms used in accurately defining the size of the oil spill are continually improving. The identification process is presently semi-automatic, and fully automatic computer detection should be possible within the next couple of years.[34] Early detection of these slicks will very help in mitigating their effects on the environment and our coastal economy.

Both Great Lakes and Polar Ice operations are another mission area to benefit from SBR technology. The Arctic ice cap has been mapped in size and thickness using SBR in a joint venture between Canada and NASA.[35] Not only is the thickness being monitored over time, developing and spreading cracks are also evident. This could prove valuable in deploying the Coast Guard icebreaker fleet and in conducting Great Lakes winter operations.

The evidence outlined above demonstrates the need for the Coast Guard to have a plan to address the future of satellite technology as it pertains to Coast Guard future roles and missions. The Coast Guard does not have to venture down this road by itself, as the other services are all working the same issues the Coast Guard faces. The 2002 Report of the Secretary of the Army stated, "Army Transformation will pursue advanced technologies that will lead to unprecedented intelligence, surveillance, and reconnaissance capabilities coupled with ground, air, and space sensors networked into a common integrated operational picture."[36] General Jumper, the Air Force Chief of Staff, is stressing the importance for all new programs to focus on "the integration of manned, unmanned, and space platforms."[37] The Navy has identified "maritime continuous global

awareness" and "feature-aided recognition of high-interest contacts" as areas to improve with space-based radar.[38] Partnering with the Navy in the planning phases is important to ensure Coast Guard needs are met with relation to vessel size and resolution issues.

Satellite technology can presently produce object and detail results down to the limits indicated in bold in the following chart. Numbers in parenthesis indicate the future requirements that engineers are working to fulfill, steadily increasing the effectiveness of the SBRs. Most of the other services are largely concerned with improving resolution vice increasing area of coverage. Technology will soon have resolution down to under 50cm by 2004.[39] In contrast, the Coast Guard needs to be able to search large areas for large vessels while trying to maximize large areas of coverage searching for smaller vessels in closer to shore and through the Caribbean.[40]

Table 2. Required satellite imagery resolution to detect various maritime objects.

	Detect	Identify	Precise Identification	Description	Technical Analysis
Surface Vessel	**7.5m**	**4.5m**	**(60cm)**	**(30cm)**	**(4.5cm)**
Surfaced Submarines	**7.5m**	**4.5m**	**1.5m**	**1m**	**(3cm)**
Bridges	**6m**	**4.5m**	**1.5m**	**1m**	**(30cm)**
Coasts & Beaches	**15m**	**4.5m**	**3m**	**1.5m**	**(15cm)**
Ports	**30m**	**15m**	**6m**	**3m**	**(30cm)**

To reduce the costs associated with developing and employing space-based systems, the Coast Guard should convince the Homeland Security Department's "Science and Technology Development" office to team with other government and civilian agencies. This aligns well with the policy statement of the Science and Technology Development Office which states, "The department would press this advantage with a national research and development enterprise for homeland security…driven by a constant evaluation of the nation's vulnerabilities, constant testing of our security systems, and constant evaluation of the threat and its

weaknesses…that would result in large-scale loss of life and major economic impact."[41] Just as the other nations pool their resources to afford satellites, the agencies of our government must pool resources to afford it.[42] The Coast Guard is no different.

Interdiction and Deterrence

The Coast Guard has not advanced very far in this area over the last 50 years, yet revolutionary jumps in this area are being made with directed energy technology. Using lasers or microwaves as a weapon could be as few as three years away. Operational high-energy laser systems will be fielded by the Air Force in 2007.[43] Area denial microwave system prototypes will soon be in use.[44] This is important because it shows the steps and progress being made in directed energy system development. Further, the DOD POM is already incorporating budgetary dollars for directed energy development out beyond 2007.

Now is the time to be planning for the next evolution in weaponry. If the next generation of weapons can disable a vessel with a single accurate shot, then it is something to seriously consider. Laser weapons, microwave technologies, and small-to-intermediate caliber laser-sighted weapons all meet these criteria. The purpose of this section is not to show one of these technologies as being superior to the other but to show there is a need to have information on all of these technologies to determine the future direction of the Coast Guard. A succinct description of laser theory and types of lasers is presented in another Air University Center for Strategy and Technology Occasional Paper written by Capt McCarthy and is available at http://www.au.af.mil/au/awc/awcgate/cst/csat10.pdf.[45]

The Coast Guard's perceptions and organizational inertia should not stand in the way of technology and facts. A laser weapon, although years down the road for actual use for Coast Guard applications, is one of the next revolutions in weaponry and is not as much science fiction as is believed. "Something of this nature, this big of a change, will face scientific and political hurdles…. [The Coast Guard is presently in the same situation the Army was several years back with respect to lasers.] The Army needed to open its collective mind to the potential of laser weapons."[46] The Army has embraced this technology and is now discussing and formulating future systems that may have battlefield viability. Major breakthroughs and politically driven investments have resulted in rapid progress in laser technology and application.

While the Navy initially had rejected the use of lasers as weapons, recent developments are forcing them to reconsider. The Navy's initial decision was based on their need for long-range attack weapons and shipboard missile defense capabilities.[47] The maritime environment significantly reduces the effectiveness of laser weapons at long ranges.[48] Advances in adaptive optics are now overcoming even these issues. Furthermore, the Navy's requirements are more stressing than those of the Coast Guard. For example, wavelength restrictions and range to the target issues are easier to solve for the Coast Guard than the problems faced by the Navy. Therefore, while large chemical lasers are not ideal for Coast Guard missions, electric (free-electron-photon) lasers, fiber optic lasers, and solid-state lasers may be a perfect fit.

Directed-energy weapons can address the Coast Guard functional area of interdiction and force protection, which applies to all law enforcement mission areas and homeland security. As shown above, laser weapon concepts are being developed for both surface and airborne assets. Airborne assets can interdict fast moving vessels in the Caribbean. Laser weapons can be sighted to the engine compartment, and disabling fire can be made without endangering human life.[49] A similar scenario can be envisioned for a terrorist fishing vessel in coastal waters. While present assets could interdict such vessels, stopping power is a problem for smaller Coast Guard vessels. A laser-sighted, infrared, mounted machinegun planned for the future would certainly work. However, using the same computer programmed laser sights with a laser with power adjusted for range, atmospheric conditions, and vessel/engine composition, and the vessel could be stopped without loss of human life or stray shots.

Once again the Coast Guard does not have to do it alone. The Air Force, the Army, and the Marines are all working on battlefield laser devices.[50] Joint development of all laser systems is underway with the sharing of information and advances at numerous locations including the Army's High Energy Laser Systems Test Facility.[51] This includes partnerships with civilian industry as well. Lockheed Martin and Raytheon are focusing future efforts toward solid-state laser systems for the F-35 Joint Strike Fighter, C-130, and UAVs.[52] The Coast Guard is already behind in determining if laser weapons fit into its future, when to partner, to what degree, and what level of request for budgetary dollars if needed.

The Coast Guard is unprepared to take advantage of these advances because it has not been involved in the R&D cycle leading to full development. This problem exists because there is no single office responsible nor a process in place to act as a think-tank for future and developing technologies and to evaluate their applicability to the future of the Coast Guard. Thus, no one has asked the question as to whether the Coast Guard should look at this or any other technology at all. If lasers weapons were to prove valuable to the mission of intervention and stopping of dangerous personnel and cargos, there is no one in the Coast Guard ready to take the lead in ensuring Coast Guard requirements for such a system are defined or met.

Coastguard Successes

Despite the lack of a lead agent or agency within the Coast Guard to spearhead the development and application of new technologies, the Coast Guard is making headway to improve its shortcomings in some technological areas. The progress on the electro-optical infrared gyro stab mounted machinegun is a prime example. This technology will allow a more precise aiming point for disabling a vessel, further reducing the risk of sinking the vessel (or at least putting so many holes in the vessel before disabling it that long hours will have to be spent on damage control). Although this device will be a great addition to increase present capabilities, it is based on old technology. In fact, DOD has been employing this technology from land, sea, and air for decades, though the system has become more accurate and more precise with upgrades. The Coast Guard device will incorporate these updates along with computerization, making this the next step in the evolution of small caliber weapon systems. While it is a needed interim step for the Coast Guard to progress, it should not be the Coast Guard's stopping point.

Additionally, the Coast Guard needs to be given some credit for advances and initiating partnerships in non-lethal technologies. The Coast Guard is a relatively recent member of both the Joint Non-lethal Weapons Directorate and Joint Small Arms program. The Coast Guard is partnering through these teams and the Coast Guard Research and Development Center on electronic corruption technology and anti-personnel microwave programs, among others. This example shows the Coast Guard is capable of going in the right direction in some areas, but this forward progress does not span the full range of potentially useful technologies.

Small-scale technology

Small-scale technology is the final area to be addressed in this section of the paper. Admittedly, while satellite systems and directed energy weapons are big items with associated high dollar costs, the Coast Guard could also be leveraging a wide range of less costly technologies for future applications.

A new generation of night vision technology will soon be fielded by the Air Force. This technology has developed quickly from the previous night vision goggle upgrades, and combines binocular vision with a much wider field of view. The wide-angle goggles provide additional peripheral vision. Additionally, by having independent left and right eye receptacles with a combined third center receptacle, depth perception is also increased.[53] This not only increases search effectiveness, but also dramatically increases safety, which is paramount for low-level helicopter water operations where the additional visual cues would better aide in situational awareness. Since the Coast Guard makes use of night vision goggles on all nighttime activities, this relatively low-cost, crosscutting technology improvement will enhance mission effectiveness across the missions of law enforcement, counter-drugs, immigration, homeland security and rescue operations.

Another new cockpit technology under development is a display system which generates an integrated and combined cockpit heads-up display (HUD)/infrared/radar image. The system uses all available information to provide the pilot with a three-dimensional representation of what the outside world looks like, even when flying in instrument conditions. For example, if a pilot were shooting an approach in low visibility, the HUD would display the aircraft approach track in three-dimensional space. The imaginary glideslope would track down to the airfield, which by merging IR, radar, and other computerized inputs, would also be displayed on the HUD. The pilot would know his position with reference to runways, airfield boundaries, and buildings before breaking out of the cloud layer. There would be no last minute decisions to be made as the sight picture has been there all along. A similar sight picture could also be displayed for helicopter approaches to a hover over the water. This technology directly enhances safety.[54]

Another technology issue being addressed by DOD is airspace requirements for unmanned aerial vehicles. UAVs perform many government missions for which airspace requirements are an issue, and

this problem is being addressed by a DOD joint workgroup at Kirtland AFB.[55] Being engaged in these discussions would ensure Coast Guard requirements are met.

Advances in technology are also assisting well established programs achieve significant improvements essential for extending asset life cycles. DOD is currently utilizing Integrated High Performance Turbine Engine Technology and Versatile-Affordable-Advanced-Turbine-Engines to gain propulsion advances by increasing power and reliability while reducing cycle fatigue and costs. These programs are providing an additional dividend for the Air Force with increased electrical power output for future laser and microwave weapons technologies. Engine reliability, cycle fatigue, and costs are not new issues for the Coast Guard, and the research pertaining to increased power output might be useful to the Coast Guard should directed-energy technologies be pursued.

This list could go on almost indefinitely with theoretical basic research, applied research, and advanced prototype development programs. Research efforts such as nanotechnology, improvement in intelligence and surveillance, bio-organic thermal sensing for container ship inspection, collision avoidance, intelligent systems integrated into fully automated UAVs and aircraft, active denial high power microwave systems for deterring personnel, collectively intelligent systems networking to communicate and act as an integrated system, amorphous diamond materials performing marine safety spectrum analysis, and microsystems integration for secure communications may all have promise for improving Coast Guard capabilities. It would be hard to dispute that the technologies mentioned above would not be of benefit to maritime homeland security. Yet, in all these cases, from satellites, to directed energy, to night vision devices, to cockpit displays…in all these areas, the Coast Guard is not engaged. This is because the only mechanism the Coast Guard has to integrate technology is its acquisition contracts. As will be shown below, such contracts have limited scope, and only bring to the forefront those technologies a contractor is interested in selling at the time.

IV. Integration of Technology

Integration of new technology within the Coast Guard is presently being accomplished within the acquisition process through programs such as the Integrated Deepwater System and National Distress and Response System. Officially, the Coast Guard believes that "Recapitalization and modernization through the performance-based acquisition of the Integrated Deepwater System and overhaul of the National Distress and Response System will provide the Coast Guard with the tools necessary to do the Nation's work both offshore and in our coastal environment."[56] These projects are large-scale integrated technology efforts being undertaken by the Coast Guard in coordination with contract services and guidance. Through this process, the Coast Guard obtains future technology options from the contractor. The Coast Guard also receives technology information from its membership on panels such as the Joint Non-lethal Warfare Directorate and Joint Small Arms program. These are examples where the Coast Guard is going in the right direction.

There are several drawbacks to this Spartan approach. The Coast Guard is getting filtered information generally limited to a subset of programs DOD already wants to pursue or those programs contractors are trying to sell. Another drawback is the potential of a non-integrated approach to technology development, particularly in the area of connectivity to all Coast Guard systems. Finally, there is no one office responsible for oversight. This causes the Coast Guard to miss many potential technology opportunities while not ensuring DOD interoperability. It is vital for the long-term health of the Coast Guard to make every attempt to make its systems common with those of the other services. This will simplify the influx of new technology from DOD research. To understand how to achieve this commonality, a brief description of DOD research and development may be useful. The Department of Defense is involved in a robust research and development program utilizing approximately three percent of its budget in getting technology from the "6.1 level" to the "6.3 level" (see Table 3 below).

This three percent does not include additional technologies garnered and money saved by DOD from partnerships with other laboratories and civilian contractors who are taking at-risk positions.[57] The 6.1 level of theoretical work takes a high-risk position on a variety of projects and typically yields a small return from those projects for further

development. Those programs showing a promise of success and a potential role in future mission areas are then allowed to go to the 6.2 level. A posture of reduced budgetary risk while increasing the potential return is necessary to allow the continued cost associated with applied research, which sometimes involves the building of technology demonstrators or small-scale prototypes. The project is moved to the 6.3 research level if the applied research is successful and it is believed that the technology will play a role in future warfighter missions. The 6.3 and 6.4 levels bridge the gap from research and development to production. Few projects are allowed to the 6.3 level without eventually progressing into full-scale production.[58] If a technology reaches the 6.3 research level, it has been proven successful. When the technology is ready for full demonstration and validation, then major command agencies budget for the funds to transition the technology out of the laboratory and into a "run-up" to production. This process shows a concerted effort to plan, develop, and infuse technology in a timely manner.

Table 3. Research Funding Categories[59]

Category	Description	Type	Risk	Return on Investment
6.1	Basic Research	Theoretical	High (approx 80%)	Low
6.2	Applied Research	Small Scale Prototype	Medium	Medium
6.3	Advanced Technology Development	Full Scale Prototype	Low	High
6.4	Demonstration/ Validation	Constitutes Full Production and Funding	None	High
6.5	Engineering Manufacturing & Development			
6.6	RDT&E Management Support			

Two points need to be made in regard to the Coast Guard achieving commonality with DOD via research and development. The Coast Guard's Research and Development Center in Groton, CT, has only a $30 million annual budget. This is far too small to support the full range of research and development starting at the 6.1 and 6.2 levels. These levels of research require a considerable capability to conduct in-house theoretical and experimental work as well as partnering with industry to defer costs. The Coast Guard is unable to attract the necessary civilian workforce to conduct such research based on limited project size and minimal return on investment. However, this might not be the case if the research and development were to be accomplished at the Homeland Security Department level coordinated through a single support research and development center. Secondly, the programs with which the Coast Guard is currently involved all tend to be at the 6.3 level.[60] The active denial microwave program is a prime example. The Coast Guard does not track nor plan on 6.1 and 6.2 programs.

The few 6.3 full-scale prototype technologies that progress into full-scale production tend to reach the Coast Guard through the acquisition process as in the Integrated Deepwater System project. This means that there are a lot of technologies the Coast Guard will never see. The National Labs and service research labs tend not to think in terms of Coast Guard needs, and their technologies are typically not tailored for Coast Guard use. This leads to two conclusions. First, the Coast Guard must better plan for and infuse technology into accomplishing its core missions if it is to remain competitive in the future. This can only occur by increasing the Coast Guard's awareness of technology programs at the 6.1 and 6.2 research levels. Secondly, there must be a focal point within the organization to monitor and incorporate developing technologies. Without both of these issues being addressed, segmentation and stovepipes will lead the Coast Guard along too many non-coordinated future paths as each program team works on its own ideas, and the Coast Guard will continue to benefit only from a small subset of the available technologies.

V. Conclusion

The purpose of this paper is to show that there is an unacceptable delta between Coast Guard roles and missions and the most effective way to accomplish those roles and missions. This delta is caused in large part by the lack of a Coast Guard process to locate developing and existing technologies, analyze their potential applications for Coast Guard roles and missions, and incorporate those approved technologies to create a 21st century Coast Guard capable of meeting the National Security Strategy of the United States.

This delta is not caused by a lack of qualified personnel. The Coast Guard is an extraordinarily professional force comprised of hard-working men and women who seek to defend their country, protect its environment, and rescue those in need. These dedicated people are among this nation's most precious treasure. Yet, in spite of their efforts, this delta persists. Its cause is inherent in the Coast Guard organization, and until it is fixed, the heroic efforts of its people will not be able to fully overcome the difficulties of bringing new technology into the institution.

Yet, the technology available to assist these men and women is truly astounding. Integrated systems of systems combining kinetic and directed energy weapons are under development in the Air Force and Army. Satellite systems that will offer near continuous surveillance of the whole Earth are on the drawing table now. New technologies to protect the force are in the laboratories. The Coast Guard needs to leverage these and other research efforts to improve its mission capability.

To do this, the Coast Guard must have both an in-house focal point to oversee the technology development process, and a specific office within the Coast Guard that is chartered to continually monitor and evaluate the progress of existing and developing technologies. These technologies must then be brought together under the rubric of a substantive and detailed leadership-driven future vision, which then drives the acquisition process. This will solve the coordination problem within the Coast Guard.

To physically get the technology is a different issue. This can only be accomplished by partnering with agencies, industry, other research labs and foreign sources. Partnering will not only allow the Coast Guard to obtain the technology and ensure dissemination within the Coast Guard, but it will also allow for a continually updated roadmap of what is

exploitable. Better liaisons will help; however, it must be more than occasional verbal communication to be successful at gaining access to the 6.1 and 6.2 level technologies. This will require continuous face-to-face, onsite coordination by people who have maintaining U.S. government-wide technological awareness as their primary job description. With minimal cost, this type of close relationship will allow the Coast Guard to better plan and transition what it finds, influence technologies in the early stages of research, and develop what it needs. For minimal risk, the Coast Guard gets access to research it could never afford, is able to construct partnerships with those who have the deep pockets and who will continue to develop technology, and this gives the Coast Guard earlier opportunities to exploit the best technologies and equipment to most effectively perform its many missions.

By partnering with the other DOD and national laboratories, the Coast Guard can leverage others' research for its needs. The result will be a more technologically advanced Coast Guard fleet with the tools needed to perform its missions. An added result will be improved interoperability throughout DOD and the United States Government, as many technologies and systems will be developed and bought in conjunction with the other services. Given the right modern and advanced tools, the professional and dedicated men and women of this nation's smallest military service will be able to ensure our territorial waters are well defended, and will be ready to meet any challenge that rises in this new century.

[1] The National Security Strategy of the United States of America, September 2002.

Notes

[2] The Integrated Deepwater System, discussed later in this paper, is one notable exception.

[3] "U.S. Coast Guard Overview Briefing, June 2002," United States Coast Guard Governmental and Public Affairs Directorate, CD-ROM, 2002.

[4] The Coast Guard's unit of measure has been in amounts of cargo seized. Thus, if the amount of cocaine seized this year is an increase over last, then this represents success, even if the amount of cocaine actually reaching the U.S. through the territorial waters increased.

[5] Admiral Thomas H. Collins, "Constancy Amid Great Change," *Proceedings* (August 2002): 33.

[6] This is the first time in the Coast Guard's history that another mission has been considered on par with search and rescue. As such, this represents a major paradigm change for the Coast Guard.

[7] United States Coast Guard, *U.S. Coast Guard FY2002 Report*, p. 1.

[8] Ibid.

[9] The Coast Guard budget increased 11 percent in FY02 to a total of over $5 billion. See: C.W. Bill Young, R-FL, "House Approves FY02 Transportation Spending Bill: Improving Infrastructure and Safety," June 26, 2001, available online at http://www.house.gov/appropriations/news/107_1/02transpofloor.htm, April 22, 2003.

[10] Collins, p. 34.

[11] The CNN Test is a commonly referred to litmus test in the military, and refers to how the news media and general public would likely respond to a particular event. Both the news media and the American public would likely judge the Coast Guard very harshly if they failed to protect the United States from a terrorist attack that passed through our territorial waters.

[12] Matt LaBash, "The Scapegoat: How the Secretary of Defense Ended the Career of an Exemplary Air Force General," *The Weekly Standard*, Vol. 3, No. 12 (24 November 1997): 20-29.

[13] Ibid., 23-28.

[14] Collins, p. 33.

[15] The importance of technology and the capabilities it provides cannot be overemphasized. General Shinseki's view of the future Army

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was to "wean the Army from the tanks and armored fighting vehicles it loves, and replace them with systems so advanced that they couldn't be detected by the enemy, using technology not yet invented." See Peter J. Boyer, "Is the Army becoming irrelevant? A different War (Shinseki's Legacy)," *New Yorker,* 1 July 2002, on-line, www.freerepublic.com, 28 June 2002.

[16] CNN, interview with Coast Guard reference Haitian immigrants in Florida, 31 Oct 02.

[17] Collins.

[18] *U.S. Coast Guard FY2002 Report*.

[19] Michael Earl and David Feeny, "How to Be a CEO for the Information Age," *Sloan's Management Review* in *Leadership and Ethics*, Book 2, (Maxwell AFB, Al.: Air University Press, 2003), 190.

[20] Numerous interviews conducted by author with Coast Guard offices of Deepwater, OAV, MDA, and R&D Center, on various dates between 9 September 2002 and 27 September 2002.

[21] Satellite theory, movement of satellite planes, satellite types and capabilities, satellite orbital distances, and costs associated with weight and size limitations are all interrelated factors in determining a specific satellite package for maritime surveillance. Space-based radar satellites, such as Discoverer II, discussed later in the text, cover wider areas with more adequate resolution than do optical, multi-spectral, hyperspectral, or infrared sensing platforms.

[22] The Discoverer II program is a joint DARPA–U.S. Air Force program to put a synthetic aperture radar system into space in a low earth orbit (circa 770 km). If successful, a full constellation of 24 satellites will be launched beginning in fiscal year 2007. See: "Fact Sheet, Discoverer II Joint Program," available at: http://www.losangeles.af.mil/SMC/PA/Fact_Sheet/discoverer2.pdf as of March 31, 2003

[23] Mark Hewish, "Cost Cut for Eyes in Space," *Jane's International Space Review,* Vol. 33, No.12 (Dec 2000): 36.

[24] Hewish.

[25] Michael D. Henschel, "Vessel Detection with Wide Area Remote Sensing," August, on-line, Internet, 20 September 2002, available from http://www.satlantic.com.

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[26] "Fact Sheet, Discover II Joint Program" and John A. Tirpak, "The Space Based Laser Plan," *Air Force Magazine*, Vol. 85, No. 8 (Aug 2002):65.

[27] Tirpak.

[28] Nicholas Fiorenza, "Joint Eyes in the Sky," *Armed Forces Journal International*, Vol 138, Issue 1 (Aug 2000): Academic Search Primer, 3.

[29] Bernard Fitzsimons, "Synthetic Aperture Radar: Pictures from Radio Waves," *Armada International*, Vol. 22, No. 4 (Aug-Sep 1998): 38.

[30] Hewish.

[31] "Research and Support Programs," and "RADARSAT-2," Web sites maintained by the Canadian Space Agency. Available on-line at http://www.space.gc.ca/csa_sectors/earth_environment/radarsat/research/default.asp and http://www.space.gc.ca/asc/eng/csa_sectors/earth/radarsat2/rad_inf.asp, 27 February 2003.

[32] Collins, p. 36.

[33] Light winds are optimum for detection of lightweight oils. For heavy oil slicks, winds of 5-6 meters per second are ideal. For specifics, see: B. Jones, "A Comparison of Visual Observations of Surface Oil with Synthetic Aperture Radar Imagery of the Sea Empress Oil Spill," *International Journal of Remote Sensing*, Vol. 22, Issue 9, Abstract (6/15/2001): Academic Search Primer.

[34] Fabio Del Frate and Andrea Petrocchi, "Neural Networks for Oil Spill Detection," *IEEE Transactions on Geoscience & Remote Sensing*, Part 1, Vol. 38, Issue 5 (Sep 2000): 2282-2287.

[35] "Scientists Cut through the Clouds to the Shifting Arctic Ice," *Bulletin of the American Meteorological Society*, Vol. 81, Issue 11 (Nov 2000): 2702,2703.

[36] Department of the Army, *ADR 2002 Report of the Secretary of the Army*, (2002), Defense Link, 1.

[37] Tirpak.

[38] Gordon Roesler and Allan Steinhardt, "Space-based Radar lets the Navy see it all," *U.S. Naval Institute Proceedings,* Vol. 128, No. 9 (Sep 2002):56.

[39] Maryann Lawlor, "Satellite images capture picture perfect future," *Signal,* Vol. 55, No. 7 (Mar 2001): 17.

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[40] Laurence Nardon, "The Dilemma of Satellite Imagery Control," *Military Technology*, Vol. 26, No. 7 (2002): 39.

[41] The President of the United States, "The Department of Homeland Security," June 2002, on-line, Internet, 13 December 2002, available online at http://www.whitehouse.gov/deptofhomeland/book.pdf.

[42] Nicholas Fiorenza, "Joint Eyes in the Sky," *Armed Forces Journal International*, Vol 138, Issue 1 (Aug 2000): Academic Search Primer, 1.

[43] Jennifer Palmer, "Airborne Laser Slated for 2003 Shoot-down Test," *Air Force Times,* Vol. 61, No. 17 (20 Nov 2000): 12.

[44] Laboratory work on "Active Denial" technology, which uses microwave energy to penetrate the upper 1/64-inch of the skin to induce pain, continues. Public release of this program's existence suggests weaponization of this system will occur in the relatively near future. See: "High Power Microwaves—United States Air Force Fact Sheet," Air Force Research Laboratory Office of Public Affairs, Kirtland AFB, NM, September 2002, available at: http://www.de.afrl.af.mil/Factsheets/HPM.html.

[45] See also, Geis, John P. II, *Directed Energy Weapons: A New Vision for 2025*, Center for Strategy and Technology Occasional Paper Number 32, Maxwell AFB, AL, April 2003

[46] Sean D. Naylor, "Laser-weapons Program Faces Uncertain Future," *Army Times,* Vol. 61, No.1 (31 Jul 2000): 20.

[47] Robert Wall, "Interest in Laser Weapons Grows Among All Services," *Aviation Week & Space Technology,* Vol. 156, Issue 2 ((14 Jan 2002): Academic Search Primer, 1.

[48] Maj Franz J. Gayl, "High-energy Laser Weapons," *Marine Corps Gazette,* Vol. 86, No. 1 (Jan 2002): 39.

[49] There is an assumption here that the engagement will likely come from behind…which is the normal way of intercepting another vessel. In this case, there is a risk of some reflected laser energy coming off the engine casing. As such, crewmembers of the Coast Guard vessel involved in the engagement would need laser eye protection.

[50] Catherine MacRae, "The Promise and Problem of Laser Weapons," *Air Force Magazine,* Vol 84, No. 12 (Dec 2001): 73.

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[51] Robert Wall, "Interest in Laser Weapons Grows Among All Services," *Aviation Week & Space Technology,* Vol. 156, Issue 2 (14 Jan 2002): Academic Search Primer, 1.

[52] David A. Fulghum, "Lasers Being Developed for F-35 and AC-130," *Aviation Week & Space Technology,*Vol. 157, Issue 2 (8 Jul 2002): Academic Search Primer, 1.

[53] Kristen Ligget, "Controlled Flight Simulation," Tour of Wright-Patterson AFB, OH, 17 Sep 02.

[54] Ligget.

[55] David M. Lanman, "UCAV Program," Tour of Wright-Patterson AFB, OH, 17 Sep 02.

[56] United States Coast Guard, *U.S. Coast Guard FY2002 Report*. P. 1.

[57] Dr. Bill Borger, "AFRL Overview," Tour of Wright-Patterson AFB, OH, 17 Sep 02.

[58] Borger.

[59] Borger.

[60] Capt Dan Deputy, Coast Guard HQ (OCU, non-lethal force), telephone interview, 26 September 02; and Mike Perdall, Coast Guard HQ (OCU, non-lethal force), telephone interview, 27 September 2002.

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Acronyms

C^4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance
GMTI	Ground Moving Target Indication
HEL	High Energy Laser
HUD	Heads-up Display
SBR	Satellite Based Radar
UAV	Unmanned Aerial Vehicle
VUAV	Vertical Unmanned Aerial Vehicle