Assuring Access and Projecting Power

The Navy in the New Security Environment

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This report is part of an ongoing M.I.T. Security Studies Program (SSP) research project on the nature of the new security environment, and on the demands it will create on U.S. military strategy and doctrine. A prior draft of this report was reviewed on January 16, 2001 at a conference in Washington D.C., and the author would like to thank the following for their feedback: Vice Admiral Lyle Bien, USN (Ret), Barry Blechman, Rear Admiral Daniel R. Bowler, USN, Michael E. Brown, Rear Admiral Phil Coady, USN (Ret), Gregory Duckworth, Rear Admiral Bruce Engelhardt, USN, Michele Flournoy, Vice Admiral Edmund P. Giambastiani, USN, Rear Admiral W.J. Holland, Jr. USN (Ret), Andrew Krepinevich, Eric Labs, Leo Mackay, Rear Admiral Michael J. McCabe, USN, Rear Admiral John G. Morgan, Jr., USN, Lieutenant Commander Paul Nagy, USN, Rick Newman, Michael O'Hanlon, Ronald O'Rourke, Arnold L. Punaro, Cindy Williams, and Dov Zakheim.

The author would also like to thank Harlene Miller and Kristen Cashin for their help in preparing this report, and Brandi Sladek for designing and producing it.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
APR 2002		**00-04-2002 to 00-04-2002**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Assuring Access and Projecting Power. The Navy in the New Security Environment	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Massachusetts Institute of Technology,Security Studies Program,BG E38, 6th Floor,Cambridge,MA,02139**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**83**	

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The report is also available online at http://web.mit.edu/ssp/.


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During the Cold War, U.S. military forces enjoyed assured access to many tens of bases from which they could project power within Western Europe and the Far East, the two main theaters of military engagement. In the new security environment, U.S. forces have assured access to only two bases within 3000 miles of its most likely theater of future military engagement, the Mediterranean-Indo-Pacific littoral.

Executive Summary

In the new security environment, the U.S. military's deployments and operations will reflect a greater strategic concern with the balance of power along the long arc of the Mediterranean-Indo-Pacific littoral than on the balance between the major continental powers on the Eurasian land mass. The balance of power on the Eurasian land mass will remain important, but it will also remain stable without significant U.S. military support or intervention because Russia, China, India, and Germany are all likely to remain secure from major attack by their landward neighbors. Russia, China, and India are all

nuclear powers and likely to remain so, and therefore enjoy the ultimate security from invasion and occupation that nuclear forces provide. On the other hand, though a unified Germany no longer requires U.S. military support to defend its borders from conventional attack, it remains a non-nuclear power. Here, its membership in NATO compensates by substituting collective for national security, both protecting Germany from nuclear attack and reducing the instabilities that might result from a more independent exercise of its conventional military power.

A greater strategic and military focus on the balance of power along the littoral between Gibralter and the Sea of Japan will confront the United States with near term challenges that can already be identified with some precision, and though there is much about the distant term that is more uncertain, at least one of these near term challenges will likely remain a major strategic and military constraint. The constant theme in both the near and distant security environment is the challenge of rapidly deploying and sustaining decisive military power over intercontinental distances without assured access to bases ashore in the region of concern.

In the near term, access constraints to bases ashore will have largely political sources. The formal alliance relationships most relevant to U.S. military planning in the new security environment will be more like the U.S.-Saudi relationship than, say, the U.S.-German relationship during the Cold War. They will result in less predictable access to bases ashore than during the Cold War because the collective interests of the United States and its allies will likely diverge as often as they converge, and there will therefore be many circumstances in which access comes late or not at all. In addition, many conflicts in the new security environment will be impossible to predict in advance, bringing the United States into temporary alliances with local states with which it had no prior military relationship. Under these circumstances, even if U.S. military forces gain rapid access to bases ashore, they will be operating in a purely expeditionary environment, without any host nation support or pre-positioned stockpiles of fuel, ammunition, food, and water. Finally, because of the unique political geography of the Mediterranean-Indo-Pacific littoral, there will be important circumstances in the new security environment in which local bases simply will not exist, or in which the United States will not want access to local bases even if they are made available.

Another near term political constraint on access is more subtle. The United States greatly exceeds all of its potential opponents in military power and is separated from them by wide oceans which it controls. Thus, when it becomes engaged in military conflicts, it is by definition fighting over far less than its national survival or sovereignty. On the other hand, its opponents often are fighting over exactly such vital interests. Thus, alongside the asymmetry in

military power favoring the United States is an asymmetry in the interests at stake that will often favor its opponents.

Two consequences flow from these asymmetries: U.S. political and military leaders will be much more averse to losses than their opponents; and those opponents will be forced to focus their limited military capabilities on the less ambitious mission of causing losses to U.S. military forces, rather than actually defeating them on the battlefield. Because the stakes are so relatively high for them, potential opponents will likely be ruthless in choosing how to attack U.S. military vulnerabilities, ceding large areas of uncontested battlespace to U.S. forces in order to focus their limited military resources on achieving maximum political effect at the chosen point or points of leverage. By contrast, because the political stakes are so relatively low for the United States, and the potential threats its faces so diffuse, the danger is that it will be less ruthless in identifying the points of leverage where its forces are most vulnerable, and in making the choices necessary to eliminate those vulnerabilities.

In short, the danger is that likely opponents of the U.S. military will be guided by a clear strategy as they prepare for future battlefields and that the U.S. military will not. Today, the main points of leverage for likely opponents to exploit are the overseas bases that traditional means of long range power projection by U.S. forces depend on. If the U.S. military does not reduce its dependence on assured access to such bases, and increase its dependence on forces that project power by other means, then it will face significant and growing constraints on its ability to credibly threaten the use of force.

In the near term, these constraints will be political at their root because they will be a reflection of the casualty aversion of U.S. political and military leaders in conflicts over less than vital interests, rather than of the ability of a weaker power to actually defeat the U.S. military. Over the longer term, if the U.S. military does not reduce its dependence on overseas bases, and assuming the inevitable decline in its relative superiority in relation to future regional great powers, the constraints on U.S. power projection capabilities will become more severe, because they will be the result of more powerful opponent’s who have designed their forces to defeat U.S. military forces that must use fixed bases.

In this way, the need to avoid or reduce dependence on assured access to bases ashore is the one common link between the near and more distant security environments that can be seen clearly today, and it is therefore the dominant measure of effectiveness that U.S. political and military leaders should use in fashioning their military forces to meet the demands of the new security environment. In responding to this imperative, they will need to find ways of making land-based forces

less dependent on fixed bases, and of assuring that naval forces can simultaneously maintain access to the sea and project more power from it.

Because of these demands, this paper argues that the new security environment will place a larger relative burden on the U.S. Navy than on the other services. Even in the near term, the Air Force and the Army face the need for significant transformations in their capabilities in order to counter the largely political constraints on access to overseas bases that they are already experiencing. In the more distant term, if they do not transform, major ground formations and air expeditionary forces will face serious military constraints on their ability to deploy to major contingencies because the ports and airfields that they now depend on will simply not be viable.

By contrast, the Navy faces far fewer constraints on its access to its sea base in the near term. Of course, over the longer term, opponents will also attempt to deny naval forces access to the Mediterranean-Indo-Pacific littoral, but they will face more serious challenges in this endeavor than they will in denying land forces access to fixed bases ashore along that littoral. The challenge for the Navy in this environment will be to preserve its relatively unhindered access to the sea while at the same time increasing its ability to project power ashore from that secure sea base.

In the very near term, a Navy of about today's size will barely be able to meet the demands of the new security environment through aggressive innovation in the way its existing platforms use weapons, sensors, and data networks. This paper identifies several specific opportunities for such innovation in each of the Navy's major warfare areas. But a Navy of today's size and comprised of existing platforms will not be able to make up for the gap in U.S. power projection capabilities that will soon emerge if the other services do not radically reduce their current dependence on overseas bases. In that scenario, the Navy will need both to grow and to modernize more aggressively than its current budget will allow.

In short, the Navy may be able to meet the demands of the near term security by itself, but it will need help to meet the demands that will likely emerge in the future. That help can come either in the form of real transformation efforts by the other services, or by increased budget share for the Navy. The best way for U.S. political leaders to maximize the probability of either one of those outcomes is to formulate a military strategy that defense spending priorities will reflect whose primary measure of effectiveness for future military forces is assured access in an environment where access to bases ashore will be inherently limited. Such a strategy would either catalyze the transformation efforts that are necessary, particularly in the Army and the Air Force, or lead to the reallocation of resources that will be necessary if the Navy is to fill the void.

This report argues that new weapons, sensors, and networks can dramatically improve the capabilities of the Navy's existing and planned platforms, such as the USS Churchill, the first in a series of improved Arleigh Burke Class destroyers, but it also assumes that those platforms will be procured in numbers sufficient to sustain a Navy of at least 300 ships.

The New, Access-Constrained Security Environment

Geopolitical and technical trends in both the near and the far term will make it harder for U.S. military forces to rapidly project power. The dominant geopolitical change in the new security environment has been the virtual elimination from a purely military perspective of the need for a continental commitment to the security of Western Europe by the United States. The dominant technical change in the new security environment has been the continued and even accelerating growth in the performance of sensors, weapons, and communication links, all broadly driven by the exponential advance in the speed and processing power of

microelectronic information processors. These changes in the external security environment will have two consequences for U.S. military planners, one of which the United States is already experiencing today, and one that it is likely to face in the coming decades.

The near-term consequence is that the U.S. military will generally find itself fighting in conflicts where the political stakes for the United States are dramatically lower than those of its adversaries, and where pre-existing military alliances are either absent or not directly relevant. In these conflicts, opponents will be unable to contest U.S. military superiority in direct, force-on-force engagements, but will seek instead to attack the political will of U.S. leaders by deploying their more limited military capabilities against specific points of U.S. military weakness in ways that maximize the threat of U.S. military casualties.

In general, these points of vulnerability will vary according to the degree to which U.S. military forces present opponents with large, fixed, surface targets such as air bases or ports close to the theater of battle; the degree to which U.S. forces must penetrate ground, sea, and air battlefields protected by modern defensive weapons with non-stealthy, manned platforms; and the degree to which opponents are able to focus their more limited exploitation of modern military technology at those points of maximum U.S. weakness or exposure. Under no circumstances will the resulting U.S. vulnerabilities be decisive in a traditional military sense: the goal for an opponent will be to use these vulnerabilities to drive up the political costs of an engagement, ideally in such a fashion as to deter the engagement altogether.

In the more distant term, the battlefields for which the U.S. military needs to prepare are, of course, less well defined, but a longer-term perspective does force consideration of the potential reemergence of one or even several regional “peer competitors” to upset what some are already calling today’s unipolar moment.[1] Should such a power or powers emerge, the issue of preserving a Eurasian balance of power might return as the main focus of U.S. military planning, and the chief means of balancing such a power will likely be sea power rather than land power. This is because the collapse of the former Soviet Union and the reunification of Germany have fundamentally altered the balance of power along Eurasia’s major land boundaries, making it unlikely in the extreme that a renewed continental commitment of U.S. ground and air forces on the scale which obtained during the Cold War will be necessary.[2]

Instead, strategically significant changes in the Eurasian balance of power are most likely should China continue to grow in power and ambition, intensifying the existing competition for security and prestige between China, Japan, and India, and threatening the many wealthy medium powers in the long littoral extending between Korea and the Persian Gulf. In this scenario, the United States might once again

need to commit a major element of its military forces to restore the balance. That commitment would be conditioned by two factors: the borders in need of protection will bisect seas rather than industrial heartlands like the North German plain, and the opponent will be sufficiently advanced to exploit modern military technology much more widely and deeply than today's opponents. This will result in a return to more traditional military planning, in which both sides have the highest national interests at stake and are willing to suffer substantial military losses in their pursuit, and in which victory will be determined by the result of relatively unlimited force-on-force struggles for control of the sea and the land alongside it, between opponents with more equal capabilities.

Strategy and the Near-Term Security Environment

In the near term, U.S. military strategy needs to account for the political and military asymmetries between the United States and its potential opponents, and the changed nature of U.S. alliance relationships. Taking these factors into account will make clear the importance of minimizing casualties, help identify the points of U.S. military weakness where casualties are most likely to be incurred, and demonstrate why allies will be likely to withhold or limit access to local bases on their territory in many crises.

Political leaders of strong powers fighting weak powers over less than vital interests will constrain their military forces in order to avoid casualties.

America's aversion to casualties in post Cold War conflicts has been much discussed. Fear of casualties measured in the thousands or even tens of thousands dominated the debate over whether to launch a ground war in Desert Storm, a conflict in which U.S. stakes were as high as they are likely to be in any future conflict. In the event, casualties during Desert Storm were orders of magnitude lower than expected, leaving the question of America's tolerance for casualties open for debate.[3] Then the events in Mogadishu, Somalia in October 1993 seemed to resolve the debate.[4] The death of a small number of Rangers and Delta Force troopers led the United States to abandon that operation abruptly. A growing consensus developed that the United States could be stopped in its tracks by the deaths of a few of its soldiers, leading some to question the viability of its enormous but seemingly unusable military power.

The recent experience in Kosovo certainly provides evidence that U. S. political and military leaders are casualty-averse. NATO air crews were ordered to remain above 15,000–20,000 feet throughout the entire conflict because it was only at that altitude that they remained immune from Serbian air defenses, while of course, ground forces were foresworn from the outset. This reduced nearly to nil NATO's ability to

stop or limit the ethnic cleansing being conducted by Serbian army and police units in Kosovo, and drove NATO political and military leaders to adopt a gradual strategic bombing campaign designed to coerce Serbian compliance which took months to succeed.

The evidence supporting the proposition that the U.S. political and military leadership has become casualty-averse is overwhelming, but the explanation for this aversion has more to do with the strength of the U.S. position in the world, rather than the weakness of its leaders or its people. As Stephen Walt has argued, the United States is the most secure country the world has ever seen:

> [which] leads to something of a paradox: Although solving many global problems requires active U.S. involvement, Americans do not see them as vital to their own interests and they are unwilling to expend much effort addressing them…. Americans would like to coerce others to do what they want, but they aren't willing to risk much blood or treasure to make sure they do.[5]

In this view, America's aversion to casualties, and the degree to which U.S. leaders will constrain how the U.S. military fights in order to reduce their exposure, will depend on the stakes the United States has in the conflict. Because of the great superiority of U.S. power in today's security environment, and because of the United States' basic security, few if any conflicts are likely to engage its vital interests, and many conflicts, like Kosovo, will be fought over much lesser interests.

This structural paradox sets the bar very high for the U.S. military, because it must win while keeping its exposure to losses extremely low by historical standards. Certainly, the degree of acceptable exposure will vary, depending on whether a conflict is a major contingency on the Korean peninsula or in the Persian Gulf, as opposed to a humanitarian intervention in Latin America or Central Africa. Yet because there is little prospect of war with a great power, there is little prospect that the U.S. military will be ordered to fight without restraint, as great powers have traditionally fought their wars in the twentieth century.

The main military consequence of this new strategic reality will be a growing demand for weapons that can stand off at a distance from enemy defenses and avoid direct fire engagements with their targets at short ranges. In many cases, such as attacks from the air against high-profile, fixed targets on the ground, long range, precision weapons such as Tomahawk already address this problem for a large subset of the fixed target set. In other cases, such as in attacks from the air against mobile or hidden targets, the problem of combining effectiveness with protection from opposing defenses is far from solved, but it is at least imaginable how to get there. However, there are still other contingencies, such as urban counter-insurgency

operations by a regular army against local guerillas, where it is difficult even to imagine a low-casualty, standoff solution when the opponent is highly motivated and the United States is not.

The push to provide standoff solutions to battlefield problems will not address all military problems, but it will be ubiquitous as long as asymmetric advantages in new military technology give U.S. forces the ability to stand off, and as long as asymmetric political stakes favor weaker powers in a contest of wills. Both the asymmetry in political stakes favoring the United States' likely opponents in future conflicts, and the asymmetry in the ability to exploit modern military technology favoring the United States are likely to endure for some time.

Compared to the United States, lesser powers must focus their investments in modern military technology in only a few mission areas. Because they spend so little on defense compared to the United States, lesser powers must focus their military investments more narrowly, and the U.S. military must not let its pursuit of a much broader set of capabilities blind it to the threats it will face where opponents focus their military investments.

Desert Storm was a major contingency in which important U.S. interests were clearly at stake. On its eve, the U.S. Senate voted narrowly to support a ground invasion to liberate Kuwait in which thousands of U.S. casualties were expected. Yet the opponent in this case — Iraq — had a defense budget that was less than 5 percent the size of the U.S. defense budget. In the near term, it is difficult to imagine the United States getting into a conflict with a state whose military capability would even match Iraq's 1991 capabilities.

A defense budget of $10–15 billion a year, which is as much as any so-called "rogue state" spends on defense, can by definition buy only a small portion of the capabilities provided by a budget of some $300 billion a year. Public descriptions of the threat posed by these rogue states often mask this reality. This is especially apparent when one looks at the air forces and navies of these states, which cede enormous sanctuaries of control to their opponents compared to the efforts, say, of the former Soviet Union. Thus, the U.S. Navy faces almost no threat to its deep-water operations, because smaller states cannot even begin to afford long-range sea-denial assets such as nuclear attack submarines. Likewise, the U.S. Air Force is able to gain total control of the airspace over friendly forces quickly, and to penetrate hostile airspace, because very few states can afford even to attempt to defend their own airspace fully. Such a defense would not only require a modern tactical air force but equally important and even more expensive, supporting assets such as sophisticated Airborne Warning and Control System (AWACS) aircraft.

Only when a country can afford such assets in their requisite numbers, and when it has the skill to operate them effectively, can it aspire to secure its own airspace and launch offensive operations from within it using traditional methods. Instead, future opponents will likely focus their investments on tactical ballistic missiles (TBMs) for offensive attacks against airfields and ports of debarkation used by U.S. forces, and on shorter range, defensive weapons such as anti-ship cruise missiles (ASCMs) and surface-to-air missiles (SAMs).

This more limited, asymmetrical approach to future battlefields will present serious challenges. TBMs with INS/GPS guidance and sub-munition payloads will be lethal in attacks against local airfields and ports.[6] In some cases, TBMs with nuclear, chemical, or biological payloads will also threaten potential regional allies of the United States with attacks by weapons of mass destruction (WMD), possibly deterring them from even allowing U.S. forces access to local bases.

Complementing these offensive weapons will be defensive weapons. Within their engagement envelopes, modern ASCMs and SAMs have formidable capabilities and the capabilities of the U.S. forces that must operate directly in the face of these threats in the air and on the surface will be stressed. It is within the engagement envelopes of such weapons that the most expensive U.S. instruments of rapid power projection, such as manned bombers and aircraft carriers, face their most serious threats.

For example, take the case of penetrating ground-based air defense networks based on mobile SAM systems. In reference to the experience in Kosovo, where Serbian air defenses were based on mobile SAMs dating from the early 1970s, the U.S. Air Force has acknowledged that it "needs to find and kill non-cooperative defensive systems much more effectively than it can today."[7] In describing a scenario in which more modern mobile SAMs had been introduced into the conflict, General John Jumper, then Commander of Allied Air Forces in Europe, has acknowledged that the U.S. Air Force "would have had to fight [its] way in with brute force because we don't have the techniques to adequately defend ourselves against SAM-10s and 12s."[8]

The first quotation is an acknowledgment that while current defense suppression techniques are designed to destroy a "cooperative" target, they can only hope to suppress a target that is "non-cooperative." A cooperative target is one that seeks to complete a SAM engagement against a package of strike aircraft, and in doing so creates a continuous radar signal that defense suppression escorts can locate within hundreds or thousands of feet; the escorts can then jam the signal to reduce its range and attack it with a short-range, high-speed antiradiation missile (HARM). If the SAM operator stays on the air in an effort to complete the engagement, the HARM has a good chance of destroying the engagement radar before the engagement is completed and the SAM missile will lose its guidance, or in the military vernacular,

“go silly.” If, on the other hand, the SAM operator shuts down - i.e., if it is non-cooperative - both the SAM missile and the HARM go silly, and both the SAM radar and the aircraft it is shooting at survive. In the first case, the defense system is destroyed; in the second it is only temporarily suppressed.

Iraqi SAM operators during the early days of Desert Storm were, by and large, cooperative, meaning that early in the war their engagement radars were essentially destroyed, and after that allied air operated freely at medium altitude without need for close SAM-suppression escorts. In contrast, during Allied Force, Serbian SAM operators were non-cooperative, meaning that every Allied strike package needed the full panoply of SAM-suppression escorts. Because those escorts are scarce, or so-called high demand/low density (HD/LD) assets, this put an upper bound on the rate at which the campaign could be prosecuted.

The Serb air defense system was based on the SAM-6, the first Soviet mobile radar-guided SAM, which first saw action in the 1973 Yom Kippur war. The quotation from General Jumper, above, indicates that the more modern mobile SAM-10s and SAM-12s first deployed in the 1980s, which the United States has yet to encounter, can defeat current U.S. defense suppression assets. This is because their phased-array engagement radar and 80–100 mile range missiles (as opposed to 25 miles for the SAM-6) can complete an engagement well before HARM-carrying aircraft would come into range to launch their missiles.

Alternative approaches to the defense suppression mission that would be effective against non-cooperative opponents will depend on networks of standoff sensors that can instantaneously locate a SAM radar with precision sufficient to target it with a GPS-guided standoff weapon. Such an approach separates the sensor that finds the target from the shooter that launches a weapon against it, and therefore eliminates the need for these two functions to be combined in a manned combat aircraft such as the F-22.[9]

Therefore, future opponents are likely to focus their efforts on the development or purchase of much more accurate TBMs, with and without WMD payloads, and on weapons such as the Russian SAM-10 air defense system or submarine-launched, anti-ship cruise missiles.[10] Higher profile but inherently more expensive purchases, such as a squadron or wing of modern tactical fighters or several major naval surface combatants, buy only a “shopfront” capability that can be quickly destroyed or rendered irrelevant at the outset of a conflict, as was, for example, the Serbian Air Force in Allied Force.

The U.S. military strategy must adapt itself to this new strategic reality. Many of the most important tactical and operational challenges that dominated Cold War military planning and procurement will not exist on future battlefields, while others will remain, in some cases in more advanced form. A continued focus on the former, especially in a time of reduced defense spending, will come at the expense of the

latter. This would be dangerous because future U.S. opponents will find these points of weakness and exploit them.

U.S. alliance relationships and access to overseas bases will be less formal and more unpredictable than those that obtained during the Cold War.

The main Cold War alliance relationships between the United States and NATO and Japan benefited from a basic agreement among the parties to each alliance on the threats that justified it, the tools needed to oppose those threats, and the essential equality of national interests and thermonuclear risks at stake for all its members. Although the United States dominated each alliance, it also committed itself to the most binding of security guarantees: the promise to use U.S. nuclear weapons, if necessary, to defend allied territory from attack, whether conventional or nuclear. In return for this commitment, U.S. allies granted unprecedented access to bases within their territory and allowed the United States to station hundreds of thousands of troops. The rights of access and operational activity granted by each host nation were codified in formal status-of-forces agreements and were therefore predictable and reliable enough to be assumed as a given in Cold War military planning.

Both alliances were a response to the Soviet threat, and both continue after its demise, but neither, with the important exceptions of Japan in a Korean war and Turkey in Iraq, provides the United States access to local bases near or along the long littoral from the Mediterranean to the Sea of Japan. There, a better model for the alliance relationships that will provide such access, when it is granted, is the U.S.-Saudi relationship.

Originally formed early in the Cold War, the relationship grew in importance to both the United States and Saudi Arabia after the fall of the Shah appeared to eliminate Iran as a buffer between the Soviet Union and Persian Gulf oil. Yet the United States gained only limited access to Saudi bases in support of its Rapid Deployment Force (RDF), mostly in the form of port visits and pre-positioning of ammunition and other supplies. Iraq’s invasion of Kuwait resulted in a decision by the Saudi monarchy to allow U.S. forces unlimited access, but that decision was not made until four days after the invasion began, when Iraqi forces were already poised on the Saudi border.[11] After the war, the Saudis allowed U.S. combat aircraft to remain deployed, but refused U.S. requests to pre-position a brigade set of heavy armor.[12] Those deployed air forces are not always available for use in a crisis, as during Operation Desert Fox in December 1998, when the Saudis refused permission for strike aircraft to fly from their bases.[13]

Many factors explain this Saudi reluctance. The Saudi regime is a Sunni feudal monarchy that sits across a narrow sea from Iran, a Shia fundamentalist theocracy; it is an Arab state that enjoys good

relations with Israel's largest supporter; it is a wealthy state with a small population that abuts several poorer states with large and growing populations. The United States can solve only some of the Saudis' security problems, and in fact creates or exacerbates others. For example, there is no question that the Saudi regime's greatest domestic threat comes from fundamentalist Islamists, and the U.S. military presence serves as a lightning rod for their claims that the current regime has failed to protect the holy cities of Mecca and Medinah from the infidel.

Both the 1997 Report of the National Defense Panel and the more recent Hart-Rudman Commission report New World Coming have discussed other reasons why access to local bases in future conflicts will remain uncertain. For example, the latter noted that:

> In dealing with security crises, the 21st century will be characterized more by episodic "posses of the willing" than the traditional World War II–style alliance systems. The United States will increasingly find itself wishing to form coalitions but increasingly unable to find partners willing and able to carry out combined military operations.[14]

When the alliances that produce base access are episodic and temporary, the access they produce will be as well.

Finally and perhaps most importantly, those like the Saudis who today grant access to U.S. forces do so without the security guarantees that the United States gave its important Cold War allies. This makes it harder for them to determine whether giving U.S. forces access will increase or decrease their long-term security. For example, as the National Defense Panel argued, this might lead to limits on access for U.S. forces when potential allies face regional rivals armed with weapons of mass destruction.[15] During the Cold War, the United States made commitments to its major allies that use of such weapons against their territory would be met by retaliation in kind by the United States, but such guarantees are absent in alliance relationships with countries such as Saudi Arabia.

This is not to argue that U.S. forces will gain no access to bases abroad. When faced with clear threats to their sovereignty, many states will ask for help, and when it is in the interests of the United States to respond, its forces will be given access. But this access will often come late, after a conflict has already begun; it will often be austere, in that few preparations will have been made in advance; and it will often be withdrawn or sharply limited after the particular conflict that generated it is resolved.

Strategy and the Longer-term Security Environment

The longer-term security environment is inherently less predictable than the near term, and it is therefore more difficult to make specific assumptions about its likely characteristics. But two assumptions seem credible: first, it is unlikely that the United States will have to make a major continental commitment in order to preserve a balance of power in Eurasia; and second, the battlefields on the Indo-Pacific littoral where the United States might need to make military commitments will be much more lethal than they are today, because likely opponents will be able to exploit the most modern military technology. One specific distinction between these future battlefields and today's will be that opponents in the more distant term will be space-capable; they will have the ability to deploy and operate sensors in space.

Major continental commitments on the Eurasian land mass will not be necessary.

The unification of Germany and the collapse of the Soviet Union made Germany and Russia much more equal in basic power potential, and also established a number of medium-size buffer states between them. Today, Germany's non-nuclear status is compensated by continuing NATO nuclear guarantees, and NATO and the EU also serve to enmesh Germany in a series of multilateral relationships that limit the potential for insecurity among other European powers like France and Poland. All of these functions can endure without a major U.S. commitment of ground forces.[16]

The land border separating Russia and China has also acquired buffer states such as Kazakhstan and Mongolia, so that the two larger countries abut only in China's upper Xinjiang province and more extensively along the border between Manchuria and the Russian maritime provinces. Both of these borders could become future sources of instability, but these instabilities should be constrained both by the fact that China and Russia are likely to remain major nuclear powers, and by the fact that the vulnerabilities along their land borders should tend to cancel each other out. That is, China is vulnerable to separatism in Xinjiang province, which is near the base of Russian land power, and Russia is vulnerable to separatism in its maritime provinces, which are near the base of Chinese land power.

Finally, India is likely to become and remain at least a medium nuclear power, and its geography gives it a powerful buffer against invasion along the entire Indo-Chinese land border. Central Asia and the Indian subcontinent are likely to be enormous sources of instability, but geography and nuclear weapons make it unlikely that that instability will provoke a major ground war between India and China.

The most likely venue of great power competition and even war will, instead, have a more maritime focus. China and Japan is one obvious

potential conflict dyad, and China and India is another. A triangular competition among all three powers over control of the energy flows from the Middle East and Central Asia is also possible. The medium powers that sit astride the key sea routes, such as Singapore, Malaysia, Indonesia, the Philippines, Korea, and of course, Taiwan, will all have stakes in the outcome of such a competition, and will all face competing pressures to balance or bandwagon against different perceived threats to their own interests.

The United States will be the balancer of last resort in these competitions, and the power that will determine the balance in these competitions will be seaborne.[17] This will put a premium on forces that can independently survive in and gain control over contested sea and littoral battle spaces against all comers, and when necessary, can project power rapidly ashore. The requirements for power projection ashore will stop short of an independent ability to wrest control of significant land areas from another great power, and will be focused instead on two capabilities: the ability to deploy long-range fires rapidly as an equalizer in land conflicts between medium powers and larger powers, and the ability to deploy both long-range fires and ground forces rapidly to a weak power threatened by a medium power in those rare instances when the former's survival and autonomy are an important U.S. interest.

The latter type of conflict has been relatively ubiquitous in the immediate post–Cold War era, and were today's "unipolar" moment to last forever, it would probably be the only type of conflict for which the U.S. military needed to prepare. But the unipolar moment is likely to be replaced by a more multipolar world in which the United States will face the prospect of conflict with great powers that spend $150 billion rather than $15 billion on defense.

Thus, the United States should plan on dominating other great powers at sea without allied assistance, but it should only plan on fighting other great powers on land with the assistance of another medium power. In both cases, the battlefields of the longer-term security environment will be much more lethal because the asymmetry in wealth and technological prowess that favors the United States today will be gone or significantly reduced.

Battles between great powers for control of the sea and land will be decided in prior battles for control of the undersea and space.

Technology has already made fixed land targets essentially indefensible from conventional attack by U.S. forces, and both the fiscal and human costs of mounting such attacks should drop even further should U.S. forces fully embrace standoff weapons with guidance that integrates signals from Global Positioning System (GPS) satellites and miniaturized inertial navigation systems (INS).[18] Technology will also soon greatly increase, from today's low level, the ability of U.S.

forces to attack a variety of moving or mobile targets such as SAM radars, tactical ballistic missiles (TBMs), and armored vehicles, using long-range fires.[19] These long-range fires will be cued by wide-area sensors which will initially be air-based, but which may also eventually migrate to space-based platforms in low earth orbit for some applications. This growing arsenal of capability to use long-range fires to attack fixed and mobile land targets takes advantage of the enormous asymmetries in technological prowess that now favor the United States over its likely opponents.

Capabilities analogous to this were developed by the U.S. Navy in its Cold War struggle with the Soviet Navy, and particularly with the Soviet submarine force. The latter posed the greatest conventional threat to allied sea lines of communication, and as early as the late 1950s, the Navy was using undersea-based acoustic sensors to detect and track Soviet submarines on an ocean-wide basis, and to cue long-range anti-submarine warfare (ASW) platforms to prosecute them. This capability was also based on an asymmetry in technological prowess, in this case the ability to understand the significance of and exploit narrow-band low-frequency acoustic signal processing, but that asymmetry was eventually reduced by the Soviet Union, albeit too late to influence the course of the Cold War.

Major asymmetries in technological prowess are rare in major power conflicts, and usually evanescent when they do occur. The dominant technological characteristic of the longer-term security environment is that America’s current advantage over the rest of the world would be greatly reduced if one or several new regional powers arise in Eurasia. In prospective battles with such a power, the United States will once again have to assume the golden rule of war between more equal powers: that which it can do unto others, they are likely to be able to do unto it.

U.S. military planners faced with an increasingly lethal environment on or near the surface along the Eurasian littoral will still need to operate so as to gain information and project power. But in a competition with a major regional power, no operating medium will remain a sanctuary for long, and battles for control of those mediums will be much more intense than they would be in today’s security environment.

Fixed targets on the surface will be indefensible if within range of an opponent’s arsenal of precision TBMs and cruise missiles, for as long as the supply of those weapons lasts. Even mobile targets on the surface will be at greater risk if the opponent retains access to wide-area battlefield surveillance assets. The anti-access capabilities of future opponents will depend most specifically on their ability to detect, locate, and target U.S. power projection assets, and their ability to use space-based sensor networks will be a key determinant of these capabilities.

For example, the United States will likely face space-based sensor networks that can support time urgent strikes against fixed targets before it will face networks that can detect, identify, and track mobile targets on the surface. Also, of the uncontested sanctuaries in space and under the seas which U.S. forces now enjoy, satellites in low earth orbit are likely to become vulnerable to future opponents before quiet nuclear submarines.

This will put a premium on systems able to spoof these surveillance networks, and on attacks against the network's space-borne sensors, or on the ground-based command, control, and processing infrastructure that such space-based networks always depend upon.

One main conclusion that should inform current defense planning therefore concerns the issue of access to overseas bases. Where such access is uncertain and episodic in the near-term security environment for essentially political reasons, it is likely to remain problematic in the longer term for both political and military reasons. Potential allies will have to decide whether to join forces with the United States to oppose regional aggressors that will often be armed with WMD. Even in cases where potential allies decide to join forces with the United States to oppose such a regional aggressor, significant conventional military access constraints will remain. Local bases are likely to be indefensible as long as the opponent has a supply of standoff weapons with sufficient range to attack them.

Forces that nevertheless must operate on land and close with the enemy will be able to do so only if they operate in such a way as not to present large, predictable, fixed targets to that opponent. This will be very difficult, because many measures taken to avoid military constraints on access will exacerbate political constraints. For example, instead of operating from a single base, air expeditionary forces might attempt to create uncertainty for the opponent as to their position by shifting their operations on a daily basis among several local bases. This tactic might succeed in a military sense, especially against an opponent lacking access to rapid readout overhead imagery. On the other hand, such a concept also assumes unlimited political access to several rather than one airbase for each wing-sized unit deployed, doubling or tripling the amount of access needed compared to traditional concepts of operations. Such a concept also assumes several times the amount of pre-postioned fuel, ammunition, and spare parts or, in the likely absence of such pre-postioning, enough airlift to compensate.

As modern mobile SAM systems and precision tactical ballistic missiles proliferate, military constraints on access to bases ashore and on traditional methods of projecting power from those bases will be added to the political constraints which already exist

Demands on Today’s Navy in the New Security Environment

Because the other services are likely to face political constraints on their access ashore early in future conflicts, the Navy will face greater demands on its power projection capabilities. But the Navy will also remain solely responsible for countering opposing access

denial efforts at sea, both to ensure the security of its own base of operations, and to enable the safe entry and secure operation of joint, follow-on forces. One key to meeting this challenge will be improved sensors and weapons for existing and planned naval platforms, as well as better data networks linking those platforms together.

This section will be organized around discussions of strike warfare, undersea warfare, and anti-air warfare. The evolution of the demands in each warfare area since the Cold War will be described, and projections will be made of how those demands are likely to change further in the transition from the near to the more distant term security environment. The section ends with shorter discussions of the evolving role of space and of new challenges in countering weapons of mass destruction (WMD).

This discussion will lay the groundwork for the next section, which will look at opportunities within those warfare areas for new sensors, weapons, and networks on or supporting the Navy's main platform communities – aviation, submarine, and surface. The specific systems discussed will be those which best help the Navy to meet its near term demands, while at the same time preparing it for a more distant security environment where access constraints of all types will be more serious.

Undersea Warfare

Undersea warfare can be divided for our purposes into antisubmarine warfare and counter-mine warfare. Both warfare areas have experienced dramatic change since the end of the Cold War, but both remain important sources of sea denial leverage for future opponents. That is because modern, non-nuclear submarines and mines remain in some ways the ultimate conventional, asymmetric threats. They can do damage to major, high value naval platforms, yet they can only be countered by an effort whose cost greatly exceeds that necessary to generate the initial threat. Thus, they pose unique challenges in today's security environment because they remain one of the best ways to cause politically significant losses to American or allied ships despite the dramatic diminution in the overall level of the ASW and mine threat compared to the Cold War. This often makes the case for better ASW and mine warfare capabilities both important and difficult to make in today's budgetary environment.

ASW During the Cold War

The U.S. Navy emerged from World War II victorious in two ASW campaigns. In the Battle of the Atlantic, U.S. and allied antisubmarine forces beat back the challenge posed to their sea lines of communication by Doenitz's U-boats, while in the Pacific, a prosubmarine campaign was waged by American submarines that cut the sea lines of communication within Japan's Greater East Asia Co-Prosperity

Sphere. In the years immediately after the war, the U.S. Navy confronted a major challenge to its undersea warfare dominance. German submarine development, driven by the rigors of waging the Battle of the Atlantic against the Allies' increasingly potent ASW forces, had leapt forward during the course of WWII. By the end of the war, using snorkels, greater battery capacity, and better hull forms, the Kriegsmarine had deployed Type XXI submarines with vastly improved offensive performance while submerged. These developments came too late to influence the outcome of the war, but they were a harbinger of things to come, since their designs also fell into the hands of the Soviet Union.

Soviet submarines based on these German designs threatened to render obsolete much of the U.S. Navy's ASW posture, which had been focused on dealing with submarines that lost a substantial portion of their offensive capabilities when forced to submerge. At the same time, the Soviet Union, being a continental power, threatened to make the U.S. Navy's victorious submarine force irrelevant, since submarines were primarily useful as an anti-surface weapon against merchant shipping, and the Soviet Union could easily survive without merchant shipping. Out of this challenge grew two initially separate innovations which, when brought together, formed one of the cornerstones of the U.S. Navy's Cold War ASW posture.

The first innovation involved the exploitation of passive acoustics to detect and track submerged submarines, using the sounds they generated as a signature. Passive sonars significantly increased the range at which submerged submarines could be detected compared to active sonar, allowing for very wide area searches by ocean-wide sound surveillance systems, which in turn could be used to accurately cue ASW platforms to localize and prosecute the submarine contact. The second innovation began with the embrace by the U.S. Navy's submarine community of ASW as its primary Cold War mission. Although this focus on ASW predated the introduction of nuclear power, its full potential was realized in the early 1960s when quiet nuclear submarines were developed that could hear their louder Soviet counterparts at much greater ranges than they themselves could be heard. This acoustic superiority lasted almost through to the end of the Cold War.

Submarines were certainly never the only ASW instrument during the Cold War. Maritime patrol aircraft also played a key role as undersea surveillance systems became fully operational in the early 1960s. Patrol aircraft offered speed that submarines lacked, making them particularly useful in the initial localization of a contact which could then be handed off to a platform with more endurance, such as a nuclear submarine. The surface warfare community remained dependent on active sonar and short range ASW weapons until the late 1970s. Then, in response to the deployment of more capable Soviet submarine-launched

antiship missiles, surface combatants also embraced passive acoustics and long range, shipborne ASW helicopters.

By the early 1980s, all of the Navy's platform communities were being used successfully in ASW operations against Soviet submarines, and increasingly these operations demanded a high degree of coordination as Soviet submarines became quieter. Earlier in the Cold War, when U.S. acoustic superiority was still unchallenged, each platform community's ASW operations had been relatively independent of each other. This independence reflected a natural division of labor based on the strengths and weaknesses of each ASW platform. Thus, submarines went forward into contested waters where other ASW platforms could not operate, maritime patrol aircraft used their speed to prosecute long range contacts generated by underwater surveillance systems, and surface combatants utilized their endurance to provide a local screen for battle groups and convoys.

The key to success in these relatively uncoordinated operations was maintaining a high degree of acoustic superiority over Soviet submarines. Ironically, that superiority began waning in the 1980s, just as the Cold War was ending, in an echo of the end of World War II. This ending to what was the third battle of the Atlantic was fortunate, but current trends in America's external security environment may confront the U.S. Navy with new ASW challenges not unlike those it avoided when the Soviet Union collapsed, albeit on a smaller scale.

ASW After the Cold War

The threat to American acoustic superiority resulting from the first Soviet deployments of the Akula in the mid 1980s may recur in today's security environment with the increasingly wide proliferation of modern non-nuclear submarines. Deployed relatively close to their homes, in or near littoral waters through which the United States may need to project power from the sea, and where it is easier for a weaker Navy to obtain cueing information against U.S. ships, these submarines pose a potentially formidable threat. With a competent crew and the kind of advanced weapons that are now widely available in global arms markets, a modern non-nuclear submarine deployed in its own backyard might become a poor man's Akula. Of even more concern is the fact that modern weapons, such as wake homing torpedoes for example, tend to reduce the demands on submarine crews, making even less competent crews too dangerous to ignore.

Modern non-nuclear submarines are both better than those deployed by the Soviet Union during the Cold War, and more widely available as defense industries that served their home markets during the Cold War now use exports to stay alive. One reason that the submarines are better is because many decades of continual investment by countries like Germany and Sweden have finally paid off in the form of non-

nuclear submarines with air independent propulsion (AIP) systems that make them more like true submarines rather than mere submersibles.

These submarines still do not provide anything like the mobility and endurance of a nuclear submarine, but they reduce the indiscretion rate of a traditional diesel-electric submarine when on a slow speed patrol. Such a submarine, patrolling in a limited area in or near its home waters, would need to expose its snorkeling mast much less frequently than do current diesels like the Russian Kilo.

Such submarines will also be armed with better weapons and fire control systems. One particularly alarming development is the marriage made possible by the end of the Cold War of the air independent, non-nuclear submarine with the submarine-launched antiship missile. Armed with Harpoons or Exocets available from several western suppliers, or Russian missiles like the Novator 3M-54E, these platforms can launch fire and forget missiles from over the radar horizon without the need for the noisy and battery-draining approach run necessary for a traditional, torpedo-armed, diesel-electric boat.[20] Absent high quality over-the-horizon cueing, these attacks will be prone to homing on the wrong target in a cluttered environment, but will be very hard to defend against in those cases where the weapon homes on the right target. This threat circumvents the traditional ASW approach to dealing with very quiet diesel-electrics, i.e. to flood the ocean surface with radar and use speed to force the submarine to either run down its battery and expose itself in an attack run or stay quiet and defensive.

There is also a political challenge associated with conflicts in which the United States is fighting over less than all out stakes. In such conflicts, there will be a very low tolerance for shipping losses, but the presence of an opposing submarine force will put great pressure on the Navy if it must rapidly project power and protect against those submarines at the same time.

Regarding casualties, even in a major regional contingency, the stakes for the United States are limited while those of its opponents are very high indeed. The opponent may be willing to run great risks and sustain high losses, while the U.S. is less willing to do so. Faced with the possibility or the reality of losses at sea, the Navy will need to mount a major effort to eliminate the threat of further losses. In order to be able to do this while still projecting its own power, the Navy will need to make ASW a less asset-intensive and protracted exercise.

A good analogy is to the great Scud hunt of Desert Storm. Thousands of sorties were diverted over several weeks from the air war during Desert Storm to hunt for SCUDs to little or no effect. From an ASW perspective, this experience is illuminating for both operational and political reasons.

Operationally, Scud hunting was like ASW using traditional methods against a very quiet target. A large area needed to be searched for objects that easily blended into the background and only intermittently exposed themselves. Thus radar was used to flood SCUD operating areas, unattended ground sensors were also deployed, and aircraft were used to pounce on potential contacts. This was a protracted, extremely asset intensive endeavor, characterized by false alarms, high weapon expenditures, and low success rates. In short, a SCUD launcher was most likely to reveal itself by successfully launching its weapon, just as sinking ships are often the only reliable indication that there is a submarine in the neighborhood.

The political lessons of the SCUD hunt also apply to ASW. Before the war, the SCUD had rightly been dismissed as a serious military threat, but once they began landing in Israel, the political imperative to allocate scarce resources to at least appear to counter this threat rapidly overwhelmed these narrow military calculations. The same political pressures would be brought to bear on ASW forces facing active enemy submarines, but unlike the Iraqi Scuds, which were terror weapons without much military utility, submarines are a serious military threat as well a political one. Therefore, it will be important to avoid delays in containing the ASW threat, and an ensuing delay in the closure of Marine amphibians or Army sealift ships.

A delay of several weeks during the halting phase of a major contingency might not be a war stopper all by itself, but it is important to understand the consequences for current time phased force deployment list (TPFDL) timelines, which assume closure of millions of square feet of pre-positioned sealift within the first two weeks of the start of an MRC. This would transform a rapid deployment into a slow one, throw the deployment timelines of all the services askew, and open a window of indeterminate size at the outset of a conflict in which the enemy can operate unmolested except by those opposing forces already in theater, assuming they do not need an open sea line of communication to sustain themselves.

There is also a doctrinal challenge the Navy faces as it attempts to increase its ability to project power from the sea. The Navy faces a new operating environment in which it is increasingly relevant and therefore in demand. Unlike in the post WWII era when the Navy was searching for a mission, it has been inundated with new missions in the post Cold War era, and these new missions compete with ASW for resources.

This has serious consequences for ASW because, as noted above, ASW is a multi-platform mission area performed by multi-mission platforms. As the Navy’s strike warfare, anti-air warfare, missile defense, and amphibious warfare capabilities have grown in importance in the nation’s military strategy, the Navy has shifted its focus away from an emphasis on blue water sea control toward power projection and land

control in the littorals. Yet these missions must be performed by the same platforms that will perform ASW in the littorals - the air, surface, and submarine communities, all supported by the ocean surveillance community.

This “multi-mission pull” increasingly makes ASW compete with strike warfare and theater air and missile defense for the same resources and training opportunities. This shift in orientation is occurring at a time when technology increasingly demands that ASW be a coordinated, “combined arms” exercise if it is to succeed. All elements of the Navy’s ASW posture must be maintained to succeed in the fight against quiet submarines, but all three of the Navy’s major platform communities also face pressures to improve the capabilities of their multimission platforms in other mission areas.

Mine Warfare During and After the Cold War

Counter-mine warfare in today’s security environment shares much in common with ASW, but is also unique in several respects. Like modern non-nuclear submarines operating on battery, mines can not be detected at operationally significant ranges using passive sonar, and they “operate” in a shallow, cluttered environment in which their small size and ability to remain still while retaining operational effectiveness all conspire to make detection and classification with active sonar extremely difficult. Likewise, in their effects, they also pose the same kind of asymmetric threat in operations where the U.S. Navy and its allies must limit ship losses to very low levels.

Like submarine-launched torpedoes, mines attack ships under their waterline which makes them extremely lethal, but unlike submarines, mines lack mobility. Thus even more then submarines, mines are only effective when used in confined waters or chokepoints, and most mines also require relatively shallow water. Thus, mines have always had particular utility when used to limit passage to and from ports, to limit the operation of ships in shallow coastal waters or straits, and to frustrate or delay amphibious assaults.

All of these potential uses for mines have been of historic concern for the U.S. Navy, but during the Cold War its counter mine posture was determined largely by a small subset of this threat. First, traditional amphibious assaults were not considered likely in a major war with the Soviet Union, and though the Navy and the Marine Corps retained capabilities to clear mines in the approaches to a landing beach, the requirements in this mission area were set at the relatively low level expected in lesser contingencies. Second, the U.S. Navy’s main operational focus during the Cold War lay in countering the Soviet Navy’s expected attempts to contest control of the Atlantic and Pacific sea lines of communications (SLOCs). In this blue water environment, mines were a minor factor. Certainly there were ports at both ends of these SLOCs, and there were also shallow, enclosed seas like Baltic and

the Yellow Sea which would have been contested, but here Allied navies bore the brunt of the counter-mine burden. The main exception to this division of labor lay in the need for the U.S. Navy to assure access to ports in the United States. For this purpose, the Navy developed and maintained a dedicated, U.S.-based Mine Countermeasure (MCM) force.

Desert Shield illustrated two weaknesses in this posture. First, early arriving naval forces lacked the organic MCM capabilities needed in the event of an aggressive Iraqi mine laying effort in the shallow waters of the Persian Gulf. In the event, a relatively small and incompetent Iraqi mine laying effort led to two major ship casualties. Second, even after dedicated MCM forces arrived in the Gulf after several months, these forces could not clear the extensive mine defenses the Iraqis had prepared along the Kuwaiti coastline with sufficient confidence to enable an amphibious assault.

This experience highlighted the new MCM challenges presented by the new security environment. First, CONUS-based, dedicated MCM forces can not deploy fast enough to support a forward deployed Navy that must confidently operate in littoral waters early in a conflict, so those forward deployed forces must have organic MCM capabilities that at least allow them to find, identify, and evade mines that would otherwise limit its access. Second, a serious mining effort by a competent adversary using modern mines will demand MCM capabilities based on new technology not resident in existing MCM forces.

This challenge will be most serious in two specific scenarios where mines can extract the greatest leverage; in deterring amphibious assaults against prepared coastal defenses, and in delaying or interdicting the deployment and sustainment of land-based forces by mining the ports of debarkation to which their sealift must have timely and unimpeded access. In the second of these scenarios, the ASW and MCM challenges merge, as the submarine is the only mining platform available to a weaker power seeking to operate in an opponent’s home waters. In both cases, the U.S. Navy’s challenge is to enable power projection and sustainment of joint forces.

Antiair Warfare

As with undersea warfare, elements of the U.S. Navy’s current antiair warfare (AAW) posture can be traced back to its experience in World War II. But the Navy’s AAW forces also face the brand new challenges of countering both conventional and WMD-armed, land attack ballistic missiles and projecting defense ashore against them. Today’s antiship cruise missile threat is the descendant of the Kamikaze threat and represents the primary above-the-waterline access constraint on naval surface combatants. Ballistic missiles do not pose such a threat to ships at sea, but the threat they pose to targets ashore may only be countered in an access-constrained environment from the sea. Thus, the

Navy will need to defend itself at sea, and project a defense for joint forces ashore from the sea.

Antiship Missile Defense During the Cold War

The integrated air defenses contained within Carrier Task Forces became quite effective against Japanese dive bombers and torpedo bombers for two reasons. First, they projected the defense outward such that many Japanese aircraft never delivered their weapons, and second, their inner or terminal defenses greatly reduced the effectiveness of weapons that were delivered by deterring most Japanese pilots from flying the delivery profiles necessary to give the short-range and unguided antiship weapons of the day the accuracy needed to strike a maneuvering ship with reasonable probability.

During the last year of the war, two new AAW challenges presented themselves. First, the Navy's Carrier Task Forces switched from pursuing the by then defeated Japanese fleet to supporting amphibious assaults beyond the range of land-based, tactical aircraft. This fixed carrier operations in space and time, making their movements more confined and predictable, therefore making them easier for opposing, land-based air forces to find. Furthermore, this limitation on the carriers' ability to use movement and deception to frustrate Japanese air attacks lasted for the weeks or months that it took to build up land-based aviation ashore.

Second, it was also at this point that the Japanese introduced the Kamikaze tactic. The challenge posed by Kamikaze aircraft was that their pilots were no longer deterred by a Task Force's terminal defenses, making the platforms they were piloting into very intelligent missiles that were guided all the way to their targets. These aircraft had no better luck than their non-Kamikaze counterparts penetrating a task force's outer defenses, but those that did penetrate were much more lethal. Thus, Carrier Task Forces became easier to find because they were tethered to the shore for an extended period, and their terminal defenses were less effective against guided weapons that could not be deterred from pressing home their attacks.

During the Cold War, the evolution of the antiship missile threat went through three phases corresponding to the years when the Carrier Battle Group was expected to be a primary nuclear delivery platform against the Soviet Union (roughly 1948-1960), the years when Battle Groups were focused on projecting power in limited conflicts in the third world (roughly 1960-1975), and the years when Battle Groups refocused on operations against the Soviet Union, albeit in a primarily conventional rather than a nuclear role (roughly 1975-1990).

During the first phase, the Soviet Navy deployed radar-guided missiles in both air and submarine-launched versions that were designed to defend Soviet territory from carrier-based nuclear strikes. Launched from faster, higher flying, radar equipped jet aircraft like

the Badger, these air-launched missiles posed a day or night, all weather threat to the carriers which could not be countered by traditional air defense systems. Attacking jet aircraft approached the carrier too high and fast for reactive, deck-launched intercepts to be effective, while the tactic of having a continuous combat air patrol in the air above the carrier was infeasible using the Navy's early jet interceptors, which had low endurance and were not yet truly night/all weather platforms. Furthermore, antiaircraft guns were almost completely ineffective against antiship missiles with jet and later rocket motors.

Out of this threat grew several major innovations which have become keystones of any modern integrated air defense system. Carrier-based airborne warning and control aircraft with powerful radars were developed and deployed which greatly extended the outer ring of a Battle Group's defenses by providing much more warning of attack. Radar-guided surface-to-air missiles (SAMs) were developed and deployed. SAMs greatly increased the reach and effectiveness of an individual ship's defenses. Ships so equipped provided true night/all weather air defense capability, and with a family of missiles of varying size and range – the so-called 3-Ts: Terrier, Tartar, and Talos, these ships also contributed to both the outer and inner defenses of a Battle Group.

A less visible but equally important innovation of this period was the development and deployment of the Naval Tactical Data System (NTDS). NTDS was the first widely-used digital data link and it grew out of the need to integrate the Battle Group's integrated air defense systems in a period when the speed and complexity of AAW operations had exceeded the capacity of voice radio links and yeomen with grease pencils writing backwards on glass tracking boards.

Thus began a classic measure/countermeasure race between Navy fleet air defense systems and Soviet antiship systems. Soviet antiship missiles (ASMs) grew faster and developed longer legs, forcing the Navy to further extend the outer rings of its Battle Groups' air defenses, and to improve its SAM-based inner rings. It was at this point that E-2 warning aircraft and F-4 interceptors armed with radar guided air-to-air missiles became the mainstay of the Battle Group's outer ring of air defenses. The need to stand off from greater distances forced the Soviet Navy to improve its ocean surveillance and over-the-horizon targeting capabilities, which in turn led the Navy to place increasing emphasis on evading, spoofing, or destroying those systems.

This race abated somewhat during the Vietnam years when the Navy's Battle Groups were focused on power projection operations in Southeast Asia, but renewed with a vengeance during the third phase of Cold War AAW operations. The Navy emerged from the Vietnam years facing a Soviet Navy armed with a space-based ocean surveillance system that used radar and ELINT satellites to find and identify U.S. ships, and

provide over-the-horizon targeting information to long range Soviet Naval Aviation (SNA) and nuclear powered cruise missile submarines (SSGNs). Launch platforms like the Backfire and the Oscar were armed with supersonic antiship missiles of 100-300 mile range. From this distance, SNA bombers and SSGNs sought to launch missiles from outside a Battle Group's outer defenses, thus saturating its inner defenses with multiple incoming missiles.

Out of this challenge grew the AAW posture designed to enable the forward Battle Group operations envisaged by the Maritime Strategy of the 1980s. E-2s and F-14s armed with long range Phoenix AAMs extended the Battle Group's outer ring. As important, aggressive efforts were mounted to provide strategic as well as tactical warning to the Battle Group of an impending SNA attack. Out of this particular initiative grew some of the first and most successful tactical exploitations of national capabilities (TENCAP), including a program which used missile early warning systems to detect and track the exhaust plumes of Soviet naval aviation aircraft in flight. Linked together by real time data links, these assets collectively extended the outer air battle hundreds of miles from the Battle Group, reestablishing a robust barrier that SNA needed to penetrate before it could launch its missiles.

At the same time, the Aegis weapon system was deployed during this period. Aegis vastly expanded the capabilities of the Navy's air defense cruisers to deal with antiship missiles that leaked through a Battle Group's outer ring. Its phased array radar could track hundreds rather than tens of targets simultaneously, and its target illuminators could guide up to 16 SAMs simultaneously, rather than one or two. Furthermore, because Soviet antiship missiles flew high altitude, arcing profiles in order to extend their range, Aegis could see them at great distances, and because of the speed with which Aegis could prosecute individual engagements, it could get off multiple shots against the same missile raid.

In addition to Aegis and the Outer Air Battle, the Navy aggressively pursued measures to counter Soviet ocean surveillance systems at the front end of the engagement cycle, as well as a panoply of close in systems designed to give each Battle Group combatant the ability to defend against antiship missiles in their terminal phase.

Soviet ocean surveillance systems, which by the 1970s included a substantial space-based component, provide an example of the kind of space capabilities that future adversaries might deploy. Its photo satellites, ELINT satellites, and radar satellites used technology that was quite advanced for the time, including systems designed to geolocate electronic emissions from space, and to use synthetic aperture techniques to distinguish between specific ship types. And the U.S. Navy's response to this system is also instructive, including a reporting system that told ships when Soviet satellites were overhead, emission control tactics which denied ELINT satellites a

signal to exploit, or false emitter tactics which put an emitter normally associated with a specific platform on a decoy platform.

One indication of the success of these countermeasures is the fact that the Soviets were never able to reduce their reliance on maritime patrol aircraft such as the Bear, which of course were quite vulnerable to a carrier's outer air defenses. It is important to keep this experience in mind for the future, because it demonstrates that the mere demonstration of space capability by a future opponent, even a very ambitious one like the Soviets deployed during the Cold War, will not necessarily translate into an effective ocean surveillance system

The Navy was also aggressive in improving terminal defenses during this period. In this category were systems like the Close In Weapons System (CIWS), a self-contained, radar-cued gatling gun designed to detect and attack incoming missiles automatically as they approached individual ships. Also, because Soviet antiship missiles were guided by small aperture radars in their terminal phase, decoys and jammers were deployed to either fool or blind those radars when they went active. In this context, the Navy also began to reduce the radar cross section of its ships, not to defeat Soviet surveillance efforts, but to enhance the effectiveness of decoys and jammers used against missile homing radars.

Antiship Missile Defense After the Cold War

In the new security environment, the AAW threat has changed in four basic ways. First, the days of large, saturation missile attacks launched at long range by platforms with an ocean-wide reach are over. In that sense, the antiship threat has declined dramatically. Second, on the other hand, the U.S. Navy aspires to a much more aggressive power projection posture than it did during the Cold War. For example, in today's security environment, in an analogue to what happened in the Pacific during WWII after the Japanese fleet was defeated, Battle Groups are expected to conduct protracted, high volume strike operations within 200 miles of an enemy coast. In the not too distant future, surface combatants will be expected to provide naval surface fire support to engaged Marines ashore from just over the horizon of an enemy coastline. Third, for the foreseeable future, these operations will likely occur in crises or conflicts where there is a great asymmetry in the stakes in the outcome among the contestants favoring the United States' opponent. This will continue to make U.S. military and political leaders averse to human and material loss among its forces. And fourth, "export or die," post Cold War arms export markets will continue to provide potential U.S. opponents with modern sea skimming, antiship cruise missiles.

This environment has already caused a fundamental shift in the Navy's AAW posture, and this posture will need to continue evolving to stay abreast of this threat. The essence of this threat is the specter

of supersonic, sea skimming ASCM attack in the littoral from truck-mounted launchers ashore, fast boats, or non-nuclear submarines that are largely immune to, or which evade a Battle Group's traditional outer defenses, and give individual ship terminal defenses only minutes to detect and attack incoming missiles as they break the radar horizon at a distance of only 15-20 miles. This threat is already ubiquitous today in those operational scenarios where ships must approach line-of sight of a hostile coastline. Coming this close essentially solves the opponent's surveillance problem, and provides sufficient targeting information to launch truck-mounted, ASCMs down a bearing along which lies a U.S. surface combatant within 20-25 miles.

In order to extend this threat outward the 200-300 miles necessary to sharply limit Battle Group operations, the opponent will need to extend its view of the littoral battlespace by moving its surveillance assets upwards, and to extend the reach of its ASM platforms without thereby re-exposing them to a Battle Group's outer defenses. In assessing how potential opponents will grapple with this challenge, it is essential to be clear about the problems they will face.

The most important issue is the distinction between a wartime capability and one that functions effectively only in peacetime or a crisis. Wide area surveillance of the ocean surface requires putting sensors within relatively continuous line-of-sight of the area to be surveilled. In the case of any near term opponent, these sensors will need to be deployed in airspace that will be contested during a war. Certainly in the near term, the United States will win those contests when an opponent seeks to operate well outside its own airspace. Thus, it will be very difficult for some time for potential U.S. opponents to develop and deploy a robust, dedicated, ocean wide or even littoral wide surveillance system for use in wartime against U.S. naval forces.

Much more feasible is a system that seeks only to preserve the wartime reach of surveillance assets out to the "electronic horizon" of the littoral battlespace as viewed from the opponent's coastline. Depending on the range and elevation of the sensors used, the highly contested littoral battlespace in wartime would extend for at least 20-25 miles, and its outer limits would roughly correspond to the 200-300 mile radius limit for current, high volume carrier strike operations. Outside that radius, an opponent's view would be limited to peacetime or crisis operations in which vulnerable assets like long range patrol aircraft are able to operate because the rules of engagement do not allow U.S. attacks against them. This would enable an opponent to cue ASCM-equipped surface combatants with the speed and endurance to trail Battle Groups, providing a limited but potentially effective "first salvo" capability much like that pursued by otherwise vulnerable Soviet surface ships in the Mediterranean during the 1973 Yom Kippur War. But such a wide area system would not be effective against Battle Groups which survived or were not-exposed to the first salvo.

Inside a 200-300 mile radius, early in a conflict, Navy surface combatants will face the prospect of ASCM attacks launched from land, submarines, or small, fast boats, and cued by elevated, offboard sensors. The elevated offboard sensors, whether aircraft, UAVs, or aerostats, and their command, control, and processing facilities will be protected by modern, mobile SAMs able to reach some 50-100 miles outward from the opponent's coast, and at elevations of 50-60,000 feet, these sensors will have a horizon stretching some 200 miles. A further step upward in the opponent's anti-access capability will occur within 20-25 miles of its coast. Within this region of the littoral, an opponent's ASCM missiles will not need offboard cueing to be effective, and the opponent's ASCM launchers will be operating in a high clutter environment in which it will be much more difficult for the Battle Group to interdict or suppress these launchers before they launch their missiles. In this environment, extreme pressure will be placed on the intermediate and terminal ASCM defenses of the ships comprising a Battle Group.

Thus, the near to mid term antiship missile defense challenge will likely resolve itself into three elements corresponding to the survivability of the opponent's surveillance capabilities: the opponent's peacetime surveillance system that gives extended reach but is vulnerable; it's extended littoral system which reaches out 200-300 miles and whose airborne sensors can survive as long as the modern, mobile SAMs that protect it remain unsuppressed; and its core wartime system which is limited to the 20-25 mile horizon from the opponent's own coastline.

It is important to note again that the most serious access challenge faced by the Navy in this area comes when it is playing the role of an enabling force for the other services. Thus, for example, Battle Groups standing off more than 300 miles from an opponent's coast can still launch Tomahawk missiles and long range aircraft strikes essentially at will once an opponent's peacetime surveillance system has been destroyed, albeit at a lower sortie rate than when such operations are mounted over a shorter radius of operation. But naval combatants will have to close within 20-25 miles of a hostile shore to provide the naval fires that will enable ship to objective maneuver (STOM) by Marine Expeditionary Units (MEUs), and MEUs will often be the key to gaining access to the ports and airfields ashore that are necessary for reinforcing ground and air units.

Tactical Ballistic Missile Defense After the Cold War

Alongside ASCM defense lies the all new AAW challenge of tactical ballistic missile defense (TBMD). Tactical or theater ballistic missiles are attractive to lesser powers because they provide a method of launching long range fires against a major power such as the United States where the barriers to entry created by scale economies are much

lower than they are for combat aviation. This is because the first missile that a regional power deploys gives it an initial capability, whereas combat aviation requires a whole system of systems before it can provide a credible capability against a major power. Thus, a country such as Iraq could spend many billions on modern Soviet and French fighters and not have one of its aircraft penetrate Saudi airspace during Desert Storm, while the best evidence indicates that few if any Iraqi SCUD missiles were shot down after being launched, and few if any mobile SCUD launchers were destroyed in their launch areas.

TBMs can be used as indiscriminate terror weapons whether they are armed with weapons of mass destruction or with conventional high explosive warheads. More ambitiously, with the advent of satellite-based navigation systems like GLONASS and GPS, conventional TBMs can be used with relative precision against high value military targets if they are provided a maneuverable payload with INS/GPS guidance. These two potential TBM missions pose brand new access challenges to U.S. forces.

First, opposing TBMs, and especially TBMs armed with WMD, create a political problem if and when they cause potential allies of the United States to weigh the advantages and disadvantages of balancing regional threats with U.S.military support. In these cases, the potential ally will need to be convinced that military cooperation with the United States against a regional, missile-armed threat will enhance its security rather than decrease it by making it a potential target of missile attacks.

During the Cold War, the United States assured allies such as Germany and Japan of the value of their close ties to the United States by extending or projecting its nuclear deterrent forces to cover them, promising for example to use nuclear weapons first if such use was deemed necessary to turn back a conventional attack, and promising to treat a nuclear attack against an ally as if it were a nuclear attack against the United States. In return for these promises, and the repeated and very expensive efforts mounted to preserve their credibility, U.S. forces were granted extensive peacetime access to the bases needed to mount a credible defense of its allies' territory and prevent Soviet expansion.

The analogue to extending or projecting deterrence in today's security environment will depend largely on the U.S.'s ability to extend or project a credible defensive umbrella over allied territory. Such an umbrella need not be impermeable to have the desired political effect, which is to demonstrate U.S. resolve to protect its potential allies from threats against which they might otherwise be naked. Thus, TBMD will be an access enabler because it will reduce the likelihood that potential allies will be blackmailed into appeasing regional aggressors rather than balancing against them by allying with the United States.

Opposing TBMs will also pose direct military challenges to U.S. forces when they become capable of attacking specific military targets with high accuracy. This will enable conventional missile attacks against soft, fixed, aboveground targets. Unhardened air bases of the type that expeditionary air forces must often use will be vulnerable to such attacks, as will ports where military and commercial sealift must debark. The emergence of such a conventional missile threat will depend largely on whether potential opponents develop and deploy INS/GPS guidance for the already ubiquitous TBMs whose range and payload bump up against or exceed existing Missile Technology Control Regime (MTCR) limits of 300 kilometer range and 500 kilogram payload.

In both cases, the need to project TBMD ashore is a brand new, post Cold War challenge. Despite the fact that the Soviet Union deployed a large TBM force during the Cold War, defenses against that threat were never considered necessary for two reasons. First, because of the deep and prolonged cooperation between the U.S. and its main allies, elaborate and very expensive measures to harden overseas air bases against conventional, chemical, or even nuclear attack were possible and were implemented. At the same time, prior to GPS, conventional TBM guidance was limited to all-inertial systems which could not give the accuracy needed for precision attacks against such bases. Second, the geographic scale of the main fronts of the Cold War allowed the United States and its Allies to use strategic depth to protect the more vulnerable nodal points of its logistics infrastructure from conventional missile attack. Thus, for example, many (but not all) major NATO ports of debarkation lay outside the range of TBM systems such as the SS-21.

By contrast, even in Saudi Arabia during Desert Storm, which intentionally built a surplus of expensive hardened airbases during the Cold War, many allied air units were forced to operate from unhardened bases within range of Iraqi Scud missiles, and both main Saudi ports of debarkation were within range of Iraqi Scuds as well. Because Iraq only fired conventional Scuds, and because those missiles had primitive guidance, they could not be aimed accurately at such inviting targets. This threat will almost certainly continue to evolve in ways that greatly constrain the ability of land-based forces to operate without fear of attack at their operational and logistics bases unless those bases are provided a credible defense.

Strike Warfare

Over the course of the Cold War, and into today’s security environment, strike warfare operations mounted by aircraft have evolved into a mature system. In that system, individual platforms have become much more lethal because of precision weapons, but the cost of penetrating modern defenses with manned platforms has also risen sharply.

Alongside traditional combat aviation are newer standoff precision weapons such as Tomahawk cruise missiles, and TBMs such as Land Attack Standard Missile (LASM) or Army Tactical Missile System (ATACMS). These systems are substantially less mature in their development than combat aviation, but therefore also face increasing returns on investment. Thus, they will get both cheaper and more capable with time.

The new security environment will demand that strike warfare assets become both more lethal, particularly against moving or mobile targets in addition to fixed targets, and less vulnerable to opposing air defenses, particularly un-cooperative ones such as those encountered in Allied Force, which seek only to survive and remain a threat in being, diverting strike capabilities to the task of defense suppression. In cases where an opponent possesses WMD-armed ballistic missiles, there will also be a demand for platforms that can strike with surprise and en masse, in order to give political leaders the option to attack all of the opponent's WMD weapons and infrastructure at the outset of a conflict. This will be a particular challenge for the Navy, whose carriers will provide the best access for tactical aviation in both crises and early in regional conflicts, but whose deckspace is finite, amplifying the negative effects of any diversion of its air wings away from true strike operations.

In facing this unique challenge, naval aviation will also possess some unique advantages, the main one being the fact that the Navy's other major strike warfare assets in the surface and submarine communities are aggressively pursuing the increasing returns on investment available from further stand off precision weapon development. Together, the air, surface, and submarine communities face significant opportunities for combined arms solutions to problems like finding and attacking mobile targets, or quickly destroying rather than merely suppressing a non-cooperative air defense system.

Strike Warfare During the Cold War

Methods of performing the strike warfare mission during the Cold War varied largely according to changes in the offense-defense relationship between combat aircraft and air defenses, because during much of that period, aircraft were the dominant strike platform. Changes in this relationship affected both the Air Force and naval aviation.

In the beginning, aircraft were designed to simply fly over enemy defenses, using a combination of speed and altitude. This trend reached it's apotheosis with aircraft like the B-70, which was designed to exceed Mach 3 at 60-70,000 feet. In the Navy, the progression from Savage (AJ-1), to Skywarrior (A-3), to Vigilante (A-5) in heavy attack squadrons illustrates the same trend. This approach was rendered obsolete in the early 1960s by the SAM which, by using a rocket motor,

finally eliminated for good the high altitude sanctuary that aircraft designers had pursued since the dawn of the air age.

There were two main responses to the SAM. One led to the adoption of ballistic missiles, which restored to the offense the advantage in height and speed, albeit in a platform that was limited to delivering nuclear weapons because of its relative inaccuracy compared to aircraft. The second led to the adoption of low level penetration tactics by aircraft. These relied on the fact that terrain obstructions masked a low level penetrator from surface radars, and that background clutter masked it from airborne radars looking down at it. The classic example of an aircraft designed for this mission was the F-111, which sought survival in fast, terrain following flight. This is also the tactic that allowed B-52s and A-6s to remain effective as lone penetrators beyond the early 1960s. It was adopted for both nuclear and conventional air operations, and became threatened with obsolescence in those two mission areas for different reasons.

The air war in Vietnam, as well as the Israeli experience in the Yom Kippur war, demonstrated that low altitude attacks were not well suited to conventional operations. Aircraft flying low and fast could not find and bomb targets with great precision. Nuclear weapons could compensate for this imprecision, but in a conventional war, pilots were forced to climb to find the target and then dive to deliver weapons more precisely on it. Against unattrited terminal air defenses, which included both SAMs and dense antiaircraft artillery (AAA) barrages, these tactics led to significant losses and still did not provide the precision necessary to deliver unguided iron bombs accurately enough to destroy important targets like bridges or hardened bunkers.

This was less of a problem in nuclear operations, because nuclear weapons could destroy even the hardest targets within a lethal radius of hundreds of feet. On the other hand, nuclear operations against the Soviet Union required passing through an air defense system that included an enormous fleet of manned interceptors. Low flying bombers depended on terrain clutter to hide them from airborne radars, but by the early 1970s, the U.S. was using doppler signal processing to allow such radars to distinguish fixed from moving targets in the their field of view when looking downward. Look down/shoot down radars, once deployed by Soviet air defense forces, would eliminate the low altitude sanctuary.

The responses to these two separate challenges were quite different. For conventional operations, medium altitude tactics were adopted. These tactics depended on two innovations. The first was the creation of forces dedicated to suppressing enemy SAMs, while the second was the creation of precision guidance techniques that greatly increased the accuracy with which weapons could be delivered from medium altitude. SAM suppression tactics varied by service and country, but in all variations used some combination of radar homing weapons, jamming, and

deception to kill or confuse SAM radars, thus creating a medium altitude sanctuary against ground-based air defense systems. From medium altitude, strike aircraft could locate their targets and guide new precision weapons to them, either semi-actively using a laser beam to designate the target, an approach favored by the Air Force, or by command using a data link to steer the weapon based on the readout provided by a terminal seeker in its nose, the method initially preferred by naval aviation.

This defense suppression tactic was not available to the long range bombers of the Air Force's Strategic Air Command, since its aircraft could not operate as part of a massive strike package containing fighters, Wild Weasels firing antiradiation missiles, and various jamming and other electronic warfare aircraft.[21] One answer was the B-1, which essentially sought to preserve the low altitude tactic by combining speed with a very sophisticated electronic countermeasures (ECM) suite. Its cancellation in the late 1970s led to both standoff weapons and stealth aircraft. The standoff tactic kept the launching aircraft out of range of opposing air defenses, relying for penetration on long range cruise missiles. The small size and terrain-hugging flight of these missiles made them hard to detect and even harder to kill, and they could be launched in numbers sufficient to saturate opposing defenses. Perhaps most important, a new type of guidance system enabled these missiles to fly long distances at very low altitude with precision equal to manned bombers.

Stealth, on the other hand, sought to restore to the aircraft the ability to penetrate defenses by eluding them. Technologically, this means designing aircraft which either absorb radar energy or reflect it away from its transmitter, hence the unusual shapes of aircraft like the F-117 and the B-2. When first deployed, stealth allowed a lone aircraft to penetrate unattrited air defenses at medium altitude and subsonic speed as long as it avoided daylight operations when visual detections were possible.

Strike Warfare During Desert Storm

Systems representing every stage in this evolution participated in Desert Storm. Stealth aircraft carrying laser guided bombs (LGBs) and conventional cruise missiles with terminal seekers launched from Navy ships and submarines were the only weapons aimed at targets inside the ring of terminal defenses surrounding metropolitan Baghdad. American war planners sent only F-117s and Tomahawks against these targets both because they were the most heavily defended, and because they were in areas where collateral damage was least acceptable. Other well defended targets in Iraq were attacked by large, medium altitude strike packages in which escorts outnumbered bomb droppers by as much as 3 to 1. When able to use precision weapons, mostly LGBs, the strike packages were very effective, but there were relatively few LGB-capable

aircraft available. Strike packages using traditional iron bombs were much less effective. In neither case did aircraft in these packages suffer significant losses. The low altitude tactic remained the preferred penetration method of the Royal Air Force, which like other European members of NATO had never fully embraced the strike package method because of its great cost. As a result, its Tornados experienced higher, though still historically low, loss rates.

Very rapidly, these combined operations destroyed or suppressed the Iraqi air defense system to such a degree that a medium altitude sanctuary over Iraq for essentially any aircraft was created within days. This allowed B-52s and, on occasion, even AWACS and tanker aircraft to operate safely in opposing airspace with only limited fighter and defense suppression escorts.

Strike Warfare in Allied Force

The Desert Storm experience confirmed both the value of precision weapons and the increasing expense of delivering them against well defended targets using manned aircraft that must overfly the target. However, it only hinted at the promise of precision weapons, since percentage wise so few were actually used, and of those used, the overwhelming majority were laser guided gravity bombs delivered by aircraft. Thus, other than the Navy's Tomahawk cruise missile, which played a major role early in the conflict, other uses of ballistic missiles and cruise missiles, both surface and air-launched, were extremely limited. Also, Desert Storm demonstrated the limitations of any laser or IR-guided weapon when used through weather. Also, the various means of delivering precision weapons were tested along only one axis, that being their ability to penetrate defenses. Other potential challenges to precision weapon delivery were absent due to the immediate and wide availability of local bases ashore. Also, the Desert Storm defense suppression experience was with a cooperative opponent, i.e. one that sought at least initially to complete SAM engagements against Allied aircraft even if that made engagement radars and batteries more vulnerable to destruction by antiradiation missiles. Finally, the moving or mobile target problem in Desert Storm presented itself to the Allies in a relatively benign geographic and operational environment. Thus, the desert terrain was flat and relatively featureless, giving unrestricted, relatively clutter free views of the battlefield to allied sensors, while operationally, mobile targets appeared in "weapons free" environments where the opponent had to concentrate in order to be effective, and in which collateral damage was generally not a concern.

By contrast, the Allied Force experience produced a very different set of lessons. First, precision weapons, and specifically laser-guided bombs, were widely used. Because of their wide use, and because periods of cloud free weather were significantly rarer in the temperate

European climate, Allied air operations encountered many periods when LGBs could not be used effectively. On the other hand, Allied Force also saw the first, limited use of INS/GPS guided weapons immune to the effects of weather, but limited to attacks against fixed targets whose location is known. Second, unlike the Iraqis, the Serbs operated their air defense system in a way designed to preserve it as a threat in being. Thus, Allied air planners never faced the relatively benign "air supremacy" phase that they experienced in Desert Storm after largely destroying rather than merely suppressing Iraqi SAM batteries. And third, allied air planners in Allied Force faced a very different mobile target problem than they faced in Desert Storm, one in which geography limited the view of the battlefield for standoff sensors like JSTARS, in which mobile Serb ground units were intermingled with civilians, and in which those ground units were never really forced to concentrate and move en masse in order to attack or defend territory from opposing ground forces.

From LGBs to INS/GPS. First generation LGBs were day/clear weather systems, and were used only in the latter part of Vietnam after the Air Force and the Navy experienced repeated failure in attacking high value fixed targets around Hanoi.[22] Post-Vietnam development of forward looking infrared (FLIR) technology allowed night/clear weather LGB operations on aircraft which combined a laser designator and a FLIR. This second generation capability was not demonstrated on a large scale until Desert Storm, and even then, a relatively small percentage of the total force in that conflict was so equipped.[23] The wide deployment since Desert Storm of FLIR/laser illumination pods in both the Air Force and the Navy has greatly increased the percentage of the force with such night/clear weather precision strike capabilities against fixed targets, as demonstrated in more recent operations over Iraq, Bosnia, and more recently, Serbia and Kosovo.

LGBs allow clear weather, precision strikes from medium to high altitudes, but operations from those altitudes frequently encounter cloud cover. This constraint prevents all weather use of LGBs and therefore reduces LGB-based precision strike capabilities to the extent that cloud cover over the target is common. Even over the deserts of Iraq and Kuwait, this constraint proved troublesome, and it proved crippling at times in the more cloudy, climate typical of Serbia and Kosovo, a characteristic obtaining throughout the temperate zones of the world, including all of the Asian littoral.

The solution to this problem will be weapons that integrate GPS and inertial navigation systems (INS). Integrated GPS/INS provides an all weather, through the cloud, weapon guidance capability that is compact, relatively cheap, and which can be made robust against countermeasures. As with second generation LGBs during Desert Storm, weapons reliant only on INS/GPS were first introduced amidst great acclaim in Allied

Force, but only on a limited scale, mostly in the form of some 600 joint direct attack munitions (JDAMs) dropped over 78 days by 6 B-2s.[24]

INS/GPS guidance will revolutionize precision strike against fixed targets because, compared to laser guidance, it will make the accuracy of precision weapons completely independent of weather, range as well as altitude of delivery, and perhaps most important, a man in the loop to identify and lase the target. In principal, this should mean that all strikes against fixed targets will eventually be conducted with standoff weapons of sufficient range to put their launch platforms out of range of surviving enemy defenses.[25] This does not mean, however, that all precision strikes against fixed targets will be made with 700 mile range weapons like Tomahawk at $500,000 apiece. Non-stealthy aircraft dropping cheap gravity bombs like JDAM will still be needed to destroy a large percentage of the total target set, but will need better defense suppression support to fully exploit their unique advantages, and thereby avoid the need to expend at least two or three HARMS at $250,000 apiece on each strike package sortie.[26]

That INS/GPS will enable a more robust, standoff, precision strike capability against fixed targets is fortunate, because as we shall see in the next section, enemy defenses will likely become much more effective than they already are. But these defenses will also complicate any solution to the mobile target problem by making it difficult to deploy survivable sensor networks within line-of-sight of the mobile targets that need to be found and identified. In the traditional approach to attacking both fixed and mobile targets, a man in the loop within line-of-sight of both the target and its defenses combines the target location and weapon aiming/guiding functions. INS/GPS weapons can eliminate the need for a human to guide the weapon, allowing standoff operations, but a network of sensors within line-of-sight of the targets must be developed if the human is to be replaced in locating the target with GPS-quality precision. No such network exists today.

From the SAM-2 to the SAM-6 to the SAM 10. Smaller countries which anticipate conflict with the United States generally do not plan on mounting a preclusive defense of their own air space. Instead, they depend largely on radar-guided SAMs, man-portable IR SAMs, and antiaircraft artillery (AAA) and assign these systems the operational goal of imposing costs rather than providing a preclusive defense. These costs can be measured in three ways: directly, as a function of opposing aircraft shot down; or indirectly, either as a function of opposing strike assets diverted to defense suppression missions, or of strike missions flown at altitudes which limit their effectiveness. There is also an operational tradeoff between air defense tactics designed to maximize direct costs and those designed to maximize indirect costs, and this tradeoff is manifest in the different approaches taken by Iraq in Desert Storm and Serbia in Allied Force.

In pressing home their SAM engagements, Iraq only succeeded in shooting down one allied aircraft that enjoyed a direct Wild Weasel escort, but their SAM units suffered enormous attrition from HARM attacks.[27] Within a week, these losses caused Iraqi radar-guided SAM activity to drop off precipitously, and allied aircraft were able to operate freely without HARM escorts at medium altitudes throughout much of Iraqi air space. Thus, by initially seeking to maximize the number of allied aircraft shot down, the Iraqis also rapidly expended their radar-guided SAM force.

The Serbs, faced with a similar operational challenge, chose instead to maximize the indirect costs incurred by allied air operations. In more than two months of operations, they only shot down three allied aircraft, but their radar-guided SAMs also managed to survive the war in large numbers. In particular, 19 out of 22 of their most modern, mobile SAM-6 batteries survived, even though they were used throughout the war, having fired at least 266 missiles.[28] The Serb strategy appears to have been to preserve the threat of its most potent, ground based air defenses in order to force the allies to continue allocating the full panoply of defense suppression assets needed to suppress them on each strike mission. They did this by repeatedly refusing to press home SAM engagements, in many cases wasting their missiles, but making it quite clear that they were still extent and operational. They also repeatedly moved their SAM batteries after such engagements had revealed their position. Given the relatively low numbers and high value of allied defense suppression assets, and given the continuing demand for them, their availability put an upper bound on the rate at which the air war could be prosecuted, a ceiling which was much lower than would have been the case if Serb radar-guided SAMs had been destroyed at the outset. This was one of the big indirect costs incurred by the allies.

Thus, by husbanding their SAMs, the Serbs were able to limit the intensity of NATO air operations to that which could be supported by their limited defense suppression assets. Yet the Allies expended HARMs at roughly the same rate as they did in Desert Storm, but with much less effect.[29]

These problems will get much worse if and when Allied air forces encounter more modern, mobile SAM systems such as the Russian SAM-10. SAM-10 missiles provide the greater than 100 km range of strategic SAMs like the SAM-2, with the mobility of shorter range systems like the SAM-6. Furthermore, its phased array main engagement radar has both a much higher power-aperture product and a much more agile beam than its mechanically scanned predecessors. This gives the radar a much longer detection range against even low radar cross section targets such as the stealthy F-117 and the B-2, and allows it to more quickly acquire and track multiple targets.

Systems such as the SAM-10 will greatly increase the indirect costs of defense suppression if traditional methods are maintained. This is because the greater effective detection range of the system will prevent even stealthy aircraft from attacking it without a weapon with a significantly greater range than the HARM. In this scenario, Wild Weasel aircraft would have to become stealthy, and their antiradiation weapons would need greater range than today's HARM, and higher speeds, all in a package small enough to be carried internally by an F-22 or a JSF. This dramatic increase in the cost of individual Wild Weasel platforms would at best buy an equal capability against new systems such as the SAM-10 as its predecessors provided against systems like the SAM-6. Yet by refusing to press home its engagements, a modestly sized force of SAM-10s could still extract indirect costs, forcing U.S. forces to limit their operations to the level that could be supported by still scarce and now much more expensive Wild Weasel platforms.

The unattractiveness of this scenario has led to consideration of an alternative approach to defense suppression. In it, SAM engagement radar locations are instantaneously and more precisely determined using multiple rather than single platform geolocation techniques. These techniques allow detection of even the briefest signals with a precision sufficient to target the emitter with an INS/GPS-guided standoff weapon rather than an antiradiation missile. Such an approach is attractive both because it deals with the advancing threat of opposing air defense systems, and with the tactic of using them in ways that emphasize indirect rather than direct costs.

In the near term, this is one of the areas where programs like TENCAP can produce significant leverage by using national assets in space to help form networks of multiple sensors within line-of-sight of the relevant targets.

From Fixed to Mobile Targets. Fixed targets are often found and identified using traditional intelligence methods, often well in advance of a conflict. Even when the value of certain fixed targets, such as command posts and WMD storage sites, varies significantly over the course of a conflict, their positions are still usually known with precision in advance of the conflict, even if the time when it is optimal to strike them is not.

By contrast, though mobile targets can sometimes be preemptively struck at their bases using pre-conflict intelligence, usually they must be found and identified while in the field. Rather than traditional intelligence methods, this creates the demand for surveillance and reconnaissance capabilities with continuous, wide area coverage that can search for and detect potential targets, classify them as real targets, and locate them in both time and space with accuracies compatible with the accuracy, lethal radius, and time late of the weapons that will be used to attack them. As any practitioner of ASW will

understand immediately, it is the ability to find and identify these targets in a “noisy” environment with an acceptable false alarm rate that will be the most difficult challenge. In different ways, and under different circumstances, both the failure of the great SCUD hunt of Desert Storm, and the success of Serb ethnic cleansing activities in Kosovo during Allied Force, demonstrate that this challenge is a long way from being met.

Other examples from the recent past might seem to vitiate this point. For example, in two cases during the Gulf War, the Battle of Khafji and the later Iraqi retreat from Kuwait City toward Basra, allied air forces pummeled Iraqi ground forces from the air, in the former case stopping an attack, and in the latter case turning a retreat into a rout. The difference is that in both these cases the false target problem was moot. At Khafji, this was because the battle took place in a low or zero noise environment. In other words, detection equaled classification because the only vehicles in the area were Iraqi military vehicles. Later, at the so-called Highway of Death, where civilian and military targets were intermingled, the false target problem was initially ignored, although this did not last for more than 48 hours, when the decision was made to cease operations at least in part out of humanitarian concerns.[30]

The Desert Storm SCUD hunt and the effort to slow Serb ethnic cleansing operations in Kosovo during Allied Force were different because the false target problem was real. In the SCUD hunt, one of the main problems was that allied aircraft had difficulty distinguishing SCUD launchers from trucks and other vehicles. There were many more of the latter than the former, and both used the same road networks. Thus, many fuel trucks were attacked and destroyed, but few if any SCUD launchers. Another problem was that the best sensors were not always available for the SCUD hunt because it occurred relatively deep in Iraqi airspace. This often prevented assets like JSTARS and Rivet Joint from participating. In Kosovo, roughly the same problem of distinguishing military from civilian vehicles was exacerbated further by an extreme aversion to civilian casualties and collateral damage, political concerns that were entirely absent from the SCUD hunt, which was dominated by the overwhelming political imperative of keeping Israel out of the war by reducing, or of at least appearing to reduce, the SCUD threat. Also, there is considerable evidence that the Serbs were more aggressive than the Iraqis in their use of decoys, making an already noisy environment even noisier, and diverting Allied weapons from their real targets.

An obvious first step toward addressing these problems is to find ways of providing continuous, theater wide, synthetic aperture (SAR) and moving target indicator (MTI) radar surveillance coverage in support of future conflicts. Such a step would not by any means be

sufficient as a solution to the mobile target problem, but it is almost certainly a necessary step toward one.

SAR and MTI are two different radar techniques that can be combined in a single surveillance platform.[31] SAR uses the movement of the radar platform over time to create an artificially wide "aperture" or antenna that can be used to produce higher resolution images of a fixed target than could be produced using the natural aperture of the platform's radar antenna. With SAR, a radar gains an imaging capability with resolutions approaching those normally provided only at much higher optical wavelengths. By contrast, MTI exploits the relative movement of a moving target normal to the path of the radar platform. It does this by exploiting the fact that radar pulses reflected back from a target moving toward the radar have a higher, or doppler shifted, frequency than the pulses reflected from the stationary background around the target. With doppler signal processing, the radar can therefore be instructed to "see" only moving targets, and the background clutter can be filtered out.

When combined, a SAR/MTI radar can detect and track moving vehicles over a wide area using the MTI mode, or provide high resolution, precisely located images of a series of spots within that area. SAR/MTI radars can not yet interleave these two different modes rapidly enough such that a target detected using the MTI mode can be imaged and more precisely located using the SAR mode as soon as it stops moving, and then picked back up on MTI once it starts moving again. When and if this capability is developed, it will in theory allow continuous, all weather tracking of high value mobile targets within the coverage area of the radar. In practice, this capability will be dependent both on the density of SAR/MTI coverage over the battlefield, and on the skill of the network's human operators.

Two major technical challenges will dominate SAR/MTI sensor development. One concerns the precision with which it can locate targets, and the other concerns the degree to which it can identify and classify the targets it detects. Mobile targets pose particular challenges in both areas. Current MTI radars cannot by themselves provide targeting quality geolocation information for moving targets, and their classification capabilities are limited to relatively gross distinctions like that between tracked and wheeled vehicles. There will certainly be great technical progress in both these areas, and it is well beyond the scope of this report to speculate about the details of what will result, but it is possible now to outline how different outcomes in SAR/MTI sensor development might broadly effect other elements of the mobile target problem.

At one extreme, perhaps in the near term, one can imagine SAR/MTI radars providing a cueing function to other platforms which would classify and attack the target. The latter two functions might be combined on one platform, probably a combat aircraft, which would

result in the simplest, most evolutionary architecture, albeit one that would remain constrained by the future defense suppression challenge. At the opposite extreme, one could imagine SAR/MTI radars, probably linked with other sensors using different phenomenologies, in a global or theater-wide network which could find, classify, track, and target a variety of mobile targets of interest. This targeting information could be used to launch standoff weapons from platforms deployed outside the range of enemy defenses. The simplest and cheapest of these weapons might be capable only of quickly attacking a set of GPS coordinates provided by the network. This would be useful against a mobile target temporarily at rest, such as a SAM-10 radar. More complicated would be a weapon able to receive continuous GPS targeting updates from the network in flight, providing a closed loop between the sensor and the weapon, and making it possible to attack targets that had moved after the weapon was launched. Most complicated would be a fire and forget weapon with a terminal seeker able autonomously to reacquire and attack a moving target designated by the network using automatic target recognition (ATR) algorithms.

In all of these architectures a common theme is that targets are found, and in many cases identified and precisely located, by sensors separated from the weapon delivery platform. This separation implies an important additional characteristic about future strike operations against mobile targets. They will, in today's jargon, be net-centric, meaning that the strike platforms participating in such operations will be dependent on their connectivity to offboard sensors via a network for their effectiveness. In many cases, elements of these networks will need eventually to migrate into space.

The Navy and Space During and After the Cold War

During the Cold War, space was a sanctuary used for intelligence or military purposes by both superpowers, mostly for remote sensing, communication, and navigation. The main value of space to naval warfighters was and is that it provides an elevated perch from which to send and/or receive signals from earth. With some important exceptions, the Cold War saw space-based remote sensors focused on the intelligence and early warning function, rather than on supporting conventional military and naval operations. Space was also widely used for satellite communications by conventional military forces, and the Navy was the prime developer and by far the widest and deepest user at the operational and even tactical levels. The Navy also developed and was the prime user of Transit, a satellite navigation system designed in the late 1950s to support SSBN operations, which constituted the first purely military (as opposed to intelligence community) use of space.

Remote sensing, communications, navigation, and timing will remain the primary uses of space by the intelligence and military communities in the future security environment, but little else about space in the pre and post Cold War security environments will be the same. The two main changes will be the need for much greater military exploitation of space, particularly in remote sensing, and the possibility or even likelihood that space will not remain a sanctuary. There will therefore be increased technical and budgetary tradeoffs to be resolved between military and intelligence community requirements, and between steps taken to exploit access to space and steps taken to assure access to that medium and the assets deployed within it. The need to resolve these technical and budgetary tradeoffs will spur debates, some of which have already begun, over the organizational structures needed to make the necessary decisions.

The Navy and Space During the Cold War

The Navy was in many respects the dominant user of space during the Cold War.[32] As noted above, the first purely military use of space was the Transit navigation satellite system, which was used from the early 1960s onward as a means for nuclear submarines, particularly SSBNs, to provide periodic, precision updates to their ships inertial navigation systems while at sea. The Navy also developed the very precise clocks that have become the heart of the Global Positioning System.

The Navy was also the most aggressive service in its use of space-based sensors in direct support of its operations, developing and operating dedicated systems such as Classic Wizard, and gaining access to other national assets through its highly successful TENCAP program. Cold War Navy TENCAP programs exploited national assets to help detect, identify, locate, track, and target ships, and to detect and track aircraft in flight. And the Navy has been the most successful developer and aggressive user of satellite communication systems, particularly at UHF starting in the 1960s, and more recently at EHF.

Space-based sensors, satellite communications, shore and ship-based command centers, and deployed naval platforms formed some of the first U.S. sensor-to-shooter networks in the 1970s when the Navy began focusing on the over-the-horizon targeting requirements for Harpoon and, later, the anti-ship version of Tomahawk. Similar networks using different sensor phenomenologies were formed to support the outer air battle against Soviet Naval Aviation.

Neither the United States nor the Soviet Union chose to pursue anti-satellite (ASAT) technologies seriously during the Cold War, though both sides did develop and test limited systems capable of attacking satellites in low earth orbit. Thus, the Navy and the other services were largely free of the need to focus on assuring their access to space, or to denying their opponent access to space. Certainly, one of the reasons that space remained a sanctuary during the Cold War was

because space simply never became necessary on a wide enough scale to the operations of either side's general purpose forces. Yet it was nevertheless of great importance to identify and track the opponent's satellites even if that information was not to be used to support ASATs. In support of this surveillance requirement, the Navy also developed and continues to operate a major element of the United States' space tracking system, which was used through most of the Cold War both for intelligence purposes, and as a means of warning deployed forces of the imminent arrival overhead of a Soviet satellite.

The Navy and Space After the Cold War

The future security environment will likely force all three of the military services to exploit space more vigorously, and technology will both enable that evolution and threaten it. The drive to exploit space more intensively will come from the need to identify and precisely locate significant targets, to allow platforms to stand off from the defenses deployed by an opponent, and to permit operations in dispersed fashion so as not to present fixed or concentrated targets for that opponent to attack. The technology to exploit space, particularly in remote sensing, is growing rapidly, both in the military and the commercial sectors. For example, just as it was discovered during the Cold War that early warning satellites could detect and track aircraft, modern early warning satellite technology has already demonstrated an ability to detect the flash of a general purpose bomb exploding on the ground, potentially enabling real time assessment from space of the effects of conventional strikes on the ground. At the same time, the sensors, communication circuits, and navigation transmitters placed in space to enable this evolution will be subject to a variety of soft kill satellite countermeasures that the technology already exists to support, as well as the future threat of ASATs.[33]

Among the organizational and technical tradeoffs that will need resolution are the following questions. What will be the balance between continuing intelligence operations in space, where the protection of collection sources and methods will remain a paramount priority, and growing military operations in space, where the main priority is the timely delivery of the product in usable formats to the user in the field? What will be the balance between efforts devoted to exploiting space and efforts devoted to assuring access to it while denying access to others? Will the DOD continue to allow the individual military services to generate requirements for space systems? Will all military space systems be developed as joint, common user systems? What will be the balance between dedicated military satellite development by DOD and the use of growing commercial capabilities in space? Will DOD-commercial partnerships in space system development be possible, particularly for broadband communications systems? What will be the balance in low earth orbit

between large, multipurpose satellites launched by large boosters in small numbers providing intermittent coverage, and networks of many more small satellites launched by much smaller boosters providing continuous or near continuous coverage? What will be the balance between the data rate and jam resistance built into the RF circuits forming the uplinks, downlinks, and crosslinks of future space networks?

The range and depth of the uncertainties captured by these questions show how fluid and undefined the future of space is in the future security environment. This combination of great potential and organizational and technical uncertainty resembles in some ways the situation regarding aviation during the interwar period. This analogy has already been used by some who argue in favor of a new, independent space service which would presumably be a more fervent advocate for space, just as an independent Air Force was perceived by many to have been the key to a more aggressive development of air power. Such analogies can carry great weight in the political arena and it is important that they be fully explored before serving as a guide to the future. There are actually at least three models of air power development that are potentially appropriate to the future development of space.

The most commonly cited analogy is to the Army's view of air power in the 1930s. Here, ironically, space advocates argue that today's Air Force's view of space is like yesterday's Army's view of air power. In this view, neither service was or is willing to make major investments in the exploitation and control of a new medium of operation. This explains the advocacy for either a central military space advocate and manager, or should that step prove inadequate, the further step of creating an independent space service.

Supporters of an independent space service do not discuss a second possible analogy to air power development, that being the Air Force's view of its purpose once it became independent. That view focused on the control of the air as a means toward conducting independent, strategic air bombardment operations to the exclusion of operations supporting ground and naval forces. In this view, it may be correct to assume that an independent space service would invest more in space, but it may be incorrect to assume that those investments would be focused on the support of conventional ground, naval, and air operations. Rather, it is possible that an independent space service would focus more on space control than on space exploitation, and take the same attitude to systems designed to support the other services as the U.S. Air Force took to tactical air forces supporting the Army in the 1950s.

There is still a third analogy between aviation and space development that is almost never discussed, and that is the analogy between the development of naval aviation in the interwar period and

the Navy's approach to space during the Cold War. In this view, space is a medium that is no different from the air, surface, and undersea mediums. As the Navy pursues its responsibilities, it needs access to any medium that might support its ultimate objectives. Thus, unlike the Army of the 1930s, the Navy was more willing to experiment with air power, and therefore did not lose its air arm to the independent Air Force. And unlike the Air Force of the 1950s, the Navy never developed a narrow doctrine for air power which insisted on its independence from surface forces. Instead, naval aviation remained a member of a combined arms team.

In comparing these alternative approaches to space in the new security environment, one conclusion seems clear, which is that it would be a mistake for DOD to centralize all development of military space systems in one location. This does not mean that new organizations devoted to space should not be created, nor does it mean that there are not important efficiencies to be gained through the centralized management of the procurement and operation of military space systems, but it does mean that neither a new, independent space service nor the Air Force should be given an absolute monopoly of control over the development of military space systems. The best analogy for such a move to centralize all space development activity in one organization at a time of both great technological ferment and budgetary limitation would be the British decision after World War I to concentrate all aviation activity, including naval aviation, in the newly independent Royal Air Force. This move seriously hampered the development of British naval aviation during the interwar period, with grave consequences for the Royal Navy during World War II.[34]

New sensors such as carrier-borne SAR/MTI radars….

new sources of forward deployed payload such as converted Trident SSBNs….

and new weapons such as the Advanced Land Attack Missile . . .

how today’s Navy . . . when networked together, will transform fights.

Naval Platforms, Weapons, Sensors, and Networks in the New Security Environment

The new security environment has a near and a more distant term. A major challenge will be to meet the near term demands of that environment while simultaneously preparing to meet the less certain but potentially more threatening demands that may arise in the more distant future. Many have identified this challenge and most agree that it will demand innovation, and some believe, truly radical innovation. This paper agrees that innovation will be necessary and in this last of three sections, suggests an overall strategy for achieving it, as well as specific, existing programmatic examples of opportunities for innovation in each of the mission areas discussed above. The basic strategy recommended is for the Navy to build on the capabilities of its existing and already planned platforms by pursuing near term opportunities for new weapons, sensors, and networks to link them together.

Two factors argue for this approach. First, because it is more relevant in the new security environment, there is less need for the Navy to engage in the truly radical innovation that that will be required of the Air Force and Army if they are to remain relevant in that same environment.[35] And second, an aggressive drive by the Navy to develop new weapons, sensors, and networks for its existing platforms in the near term will leave it well prepared for a more radical transformation should one become necessary in the more distant term.

Unlike the Air Force and the Army, the Navy’s major platforms do not present fixed targets to an opponent when they are projecting power against that opponent, nor do they require permission from other countries to operate from their sea base. Thus, the Navy is less effected by access constraints, whether political or military, than are the Air Force and the Army. Certainly the Navy will face access constraints of its own, but meeting these challenges in the near term will not require radical transformation.

On the other hand, meeting the near term access challenges that the Navy will face will require a much fuller embrace of net-centric warfare than is the case today. In making this embrace, the Navy will need to give its existing platforms weapons, sensors, and networks linking them together that they do not have now. In doing so, it will sustain a process that has already begun, and which could lead to a more radical transformation should one become necessary.

Naval Platforms in the New Security Environment

In focusing on ways for the Navy to build on the capabilities of its existing platforms I am not implicitly arguing against developing and deploying new platforms, nor against increases in force structure. Rather, I am arguing that the weapons, sensors and networks described below, or others like them, will be both necessary and affordable in any future scenario. On the other hand, there remains uncertainty as to whether all of the Navy's currently planned platform modernization programs will be affordable under future defense budgets. This uncertainty is exacerbated by the fact that current shipbuilding accounts are already funding too few ships to sustain a 300 ship Navy for the long haul.[36] A Navy of at least 300 ships is needed to maintain a robust forward presence along the Mediterranean-Indo-Pacific littoral, and in the new security environment, that presence is the only way of assuring first-day-of-the-war access for U.S. forces in the future conflicts they are likely to face.

In broad terms, four defense budget scenarios may result from the Bush administration's ongoing defense review. Which scenario occurs will depend upon whether the DOD topline is raised or held steady, and whether budget shares among the services are held roughly equal or are reallocated based on a new national military strategy. The arguments I have made in the first section argue for a scenario in which the Navy gets an increased share of the DOD budget, whether the overall DOD budget rises or holds steady. In both cases, the Navy would receive more funding, but both outcomes presume the adoption and forceful implementation of a new military strategy in which the prime measure of effectiveness for U.S. forces is the ability to gain and exploit access. Absent such a military strategy, and past history would certainly argue against expecting one, service budget shares are likely to remain roughly equal. In this case, a rise in the DOD topline would still lead to more naval funding, but less than in the first two cases, and of course no rise in the DOD topline would leave the Navy where it is today.

In all these scenarios, the Navy will likely face roughly the same set of external demands, because the forward presence and first-day-of-the-war combat power it already provides so closely match the demands of the new security environment. At one extreme, this means that the Navy faces the potential challenge of significantly improving its ability to gain and exploit access at roughly today's budget levels, with the ships and aircraft it already has or which are already in production. In this scenario, the Navy will have no choice but to focus with some urgency on improving the weapons, sensors, and payloads of its existing platforms due to funding constraints. I will show below that there are substantial opportunities for such improvements. Furthermore, these improvements will be necessary in any funding environment, because the capabilities they provide will be needed

regardless of which major platforms the Navy buys, and regardless of the eventual size of the fleet that results.

At the same time, it is important to note here what the costs will be if the Navy is forced by funding constraints to forgo modernization and replacement of some its existing platforms. I assume that because the Navy's forward presence translates directly into first-day-of-the-war access, because the degree of forward presence is directly dependent on force structure, and because today's 300 ship Navy already falls short of providing the level of presence desired by regional CINCs and national agencies, it is unlikely, even if it so desired, that the Navy would be allowed to fund future platform modernization accounts with reductions in force structure. More likely, if the Navy's budget stays constant, is the opposite scenario, in which some degree of future modernization is forgone in order to maintain today's force structure.

The two naval platform modernization programs most commonly described as politically vulnerable are Joint Strike Fighter (JSF) and DD-21.[37] Both share the political burden of having to compete in some eyes with modern platforms that are just entering production, the F-18E/F and Flight 2A DDG-51. But JSF and DD-21 will also provide significant new capabilities if successfully developed and deployed.

The Case for JSF

The Navy variant of JSF will arguably be the most capable strike fighter in the world if it is developed and deployed. It will have all aspect stealth, a 900 mile unrefueled radius of action, and double the internal payload of the other JSF variants as well as F-22.

All aspect stealth will reduce JSF's radar cross section both against other fighters and against ground-based radars. Compared to non-stealthy aircraft, JSF will therefore reduce and in some cases eliminate the need for dedicated defense suppression/destruction escorts. Its 900 mile radius of operation will give at least a portion of the carrier's air wing an ability to conduct unrefueled strike operations at more than triple the range of today's F-18C. And with the ability to carry both air-to-air armament and a pair of 2000 lb. bombs internally, the Navy JSF will essentially combine the air-to-ground capability of the F-117 and the air-to-air capability of the F-22, making it the only stealth fighter that will truly replicate the multimission payload capabilities of today's non-stealthy strike fighters.

These capabilities will have particular utility in an access-constrained security environment because in combination they will greatly improve both the freedom of maneuver and the first-day-of-the-war deep strike capability of the carrier force.

The Case for DD-21

DD-21 will enable four potentially revolutionary steps if it is developed and deployed. Its two 100 mile range 155mm guns are being developed explicitly to support the Marine Corps' Ship-to-Objective-Maneuver (STOM) concept. Deployed on DD-21s beyond line-of-sight from an enemy's coastline, these guns will clear the landing areas for long range V-22s and provide fire support to the troops those aircraft deliver from over-the-horizon amphibious ships. At the same time, TBMs launched from its 120 VLS cells will provide counter-battery fire against opposing artillery systems within a 200 mile radius, thereby helping to protect V-22 landing zones from indirect fires.

DD-21 will have a much smaller radar and IR cross section than DDG-51, which itself has a lower cross section in both spectra than traditional destroyers and frigates. This dramatic reduction in cross section will both reduce the acquisition range of an antiship missile's terminal seeker and greatly increase the effectiveness of the ship's countermeasures against that seeker.

DD-21 will also be a more automated ship, with a design goal of a crew of less than 100 compared to the 350 person crew of a DDG-51. This will significantly reduce operating costs, and therefore lifecycle costs, which along with a unit cost goal of $750 million, will produce a revolution in surface ship cost-effectiveness.

Last, DD-21 will introduce, or more accurately, reintroduce electric drive into the fleet. In the near term, electric drive will also contribute to the revolution in cost-effectiveness by allowing for the more efficient operation of the ship's propulsion plant, reducing fuel consumption which is another major operating cost driver for today's surface combatants. More important in the longer run, electric drive will also enable the development of an all electric ship.

An all electric ship could freely and rapidly shift all of the power it generates between propulsion and other uses, and in the future those other uses will likely include solid state lasers and electro-magnetic guns. The marriage between an all electric ship and powerful solid state lasers could produce a highly effective cruise and ballistic missile defense system with an infinite magazine, as well as an organic, anti-satellite surveillance asset. The marriage between an all electric ship and electromagnetic guns would significantly expand magazine capacities by eliminating the need to store shell casings. And last, by eliminating large hydraulic and mechanical systems, an all electric ship built out of modules connected only by power and data cables would introduce the concept of "life cycle modularity" in which new ship modules could much more easily be added or replaced over the course of a ship's lifetime.

Sensors, Weapons, and Networks for Gaining and Exploiting Access

The need to gain and exploit access in the new security environment will drive the Navy toward better sensors and weapons, and toward networks that link them together and process their output more effectively. There are both immediate opportunities in this regard, and opportunities which demand further development. The rest of this section will look at each of the warfare areas described in the second section, and describe some of these opportunities, and show how they address the access challenges the Navy needs to meet.

Undersea Warfare

The ASW and Mine Countermeasure problem in the littorals will always be difficult. But tremendous progress has been made in the ten years since the end of the Cold War on the main challenges in these areas. Compared to other warfare areas, ASW and MCM pose particular challenges in the areas of sensors and, to a slightly lesser extent, weapons. Networks are very important in ASW, but the networking technology needed is less demanding in many ways than the networking requirements in AAW. Networks are less important to MCM.

ASW Surveillance Sensors. The primary ASW challenge has always been wide area surveillance, and the main challenge initially posed by the new security environment in this mission area was a wide area search problem. Sound propagates better in deep water than in shallow water, and non-nuclear submarines can remain silent for extended periods when allowed to patrol small areas near their home ports at low speed. Using passive acoustics to search for such submarines is much more difficult than it was to search for relatively loud Soviet submarines operating in deep water during the Cold War. On the other hand, active sonars encounter serious problems with clutter in shallow water, much as early radars did when forced to look down at targets flying over land. And even in shallow water, the water column still remains relatively opaque to non-acoustic energy, limiting the role of RF and laser radars as long-range sensors.

Two new systems stand out as first steps toward gaining a wide area search capability in the littorals. The first is called the Advanced Deployable System (ADS) and the second is called Distant Thunder. ADS is a passive ocean bottom array that can de deployed by a surface ship, and whose output is currently collected and processed ashore via fiber-optic cable. Distant Thunder is primarily a signal processing adjunct to existing ASW combat systems, combined with legacy, air-droppable, active sound sources and a relatively simple data link that uses existing UHF radios on participating platforms.

Unlike the Cold War Sound Surveillance System (SOSUS) arrays, which listened for low frequency, narrow band tonals propagating outward horizontally along the deep sound channel, nodes in an ADS array look upward along what is called the Reliable Acoustic Path (RAP). ADS is a derivative of the Cold War Fixed Distributed System (FDS) program,

which was an attempt to repair the ASW barrier strategy by using many simple passive sensors in an upward looking array that used the reliable acoustic path (essentially the direct path) rather than the deep sound channel. Each sensor would cover a small cone of the ocean column, and fiber optic cable provided the bandwidth to network a vast array of these small sensors and bring their output ashore for processing.

Distant Thunder adds commercial off the shelf (COTS) processing to existing towed arrays on ships (and potentially, submarines) and air-deployed sonobuoys, and links the processors together using legacy radios with modems to form a network that can do bistatic or multistatic processing of the echoes from the air-dropped sound source. The essence of Distant Thunder is that it uses both spatial and temporal processing to extract a submarine's echo from the clutter and reverberation. Long wavelength towed arrays allow spatial processing that can eliminate clutter and reverberation entering the array's sidelobes, and temporal processing allows reverberating echoes from the same object to be compared over time, thereby exploiting the fact that a submarine's echo loses less of its higher frequency spectrum in that time than do objects sitting on the bottom or floating on the surface.

One of the original concerns about Distant Thunder was that variations in bottom topography and content would interfere with its temporal processing capability, but worldwide experiments have demonstrated excellent performance over a wide range of environments. Like all acoustic sensors, performance will vary in practice depending on many circumstances, but Distant Thunder promises to return a substantial portion of the detection ranges initially lost when the Navy first shifted its focus to shallow water ASW. Another benefit of Distant Thunder is that it demonstrates long range performance under a wide variety of acoustic conditions, including the very common case in the littoral where sound is refracted away from the surface, a condition which drastically reduces the performance of a traditional, hull-mounted sonar.

Distant Thunder is also a great example of the incredible power of networked sensors, and the relative ease of backfitting such a capability onto legacy platforms once the substantial initial challenge of developing the necessary signal processing algorithms is completed. Distant Thunder can be backfitted onto any towed array ship or submarine, and onto LAMPs helos and P-3s. For example, on surface ships with the SQQ-89 ASW system, the physical footprint of a Distant Thunder backfit consists of one server and two laptops.

Specialized periscope or mast detection radars can also play an important role in the ASW search problem. Even during the Cold War, Soviet nuclear submarines regularly exposed a periscope when seeking a torpedo fire control solution against the fast ships of a Battle Group. And of course radar has an important role to play in preventing diesel

submarines from snorkeling to recharge their batteries. Thus, a combination of speed, and radar deployed to search within the limiting lines of approach created by that speed, have always been an important ASW tactic against all submarines. Likewise, radar flooding in which a large area is flooded with RF energy so as to set off a submarine's radar warning alarm whenever it exposes a mast is also a traditional tactic against diesel submarines. But specialized mast detection radars like the APS-137 experience tremendous false alarm rates caused by both sea state and other floating objects and debris when their detection threshold is set low to maximize range.

The Automatic Radar Periscope Detection and Discrimination (ARPDD) program is developing the capability to process APS-137 returns in such a way as to allow very low detection thresholds (i.e. long range) and very low false alarm rates. Very impressive results have already been demonstrated in shipboard experiments, but unlike Distant Thunder, ARPDD needs further development time to simplify the massive processing capability it now requires before it can be backfitted onto legacy P-3 and LAMPs platforms.

ASW Weapons. Torpedoes remain the primary ASW weapon in the littoral environment, although this environment also presents them with great challenges, particularly lightweight torpedoes, which are fire and forget weapons. Like all fire and forget weapons, the relatively small aperture and limited signal processing available to a lightweight torpedo's active seeker makes for problems in shallow water where there is a lot of clutter and the target is relatively small and moving slowly. The Mk. 50 modification to the Mk. 46 lightweight torpedo provides an initial response to this problem, and the more ambitious Mk. 54 a more robust response in a few years.

There is also an alternative ASW weapon opportunity that grows out of the intersection between MCM and ASW. One of the challenges in the organic MCM program is to do in stride mine neutralization and clearance from a helicopter, and the Rapid Airborne Mine Clearance System (RAMICS) program's approach to this problem may provide another ASW weapon opportunity as well. RAMICS is discussed in more detail below.

A Common ASW Operational Picture. One of the legacies of the formidable passive acoustic detection ranges possible in ASW during the Cold War is the tradition of relatively autonomous operation amongst the Navy's main ASW platforms. When the Soviet Navy finally deployed very quiet nuclear submarines near the end of the Cold War, the need for more coordination arose. Today, coordination is even more important, especially to give the ASW commander and all of his forces a wide area picture of the ASW battlefield. Such a picture would allow better utilization of multiple, often evanescent contacts against the same target produced by different sensors; it would give units knowledge of environmental conditions over a wide area, allowing them

to better predict the performance of their sensors as they move about the battlefield; and it would identify resulting “holes” in ASW coverage where search assets could be concentrated efficiently.

Most of the individual pieces of work needed to accomplish this task are relatively simple, such as using common operational protocols when processing and communicating data, and using the same environmental models. But the task is complicated by the need to integrate these activities across many platforms.

MCM Sensors. As with ASW, sensor performance is central to success. And again, the beginning of the problem is always to detect and identify the mines in the first place. In the new security environment, this challenge is further complicated by the need to make such a mine hunting capability organic to the Navy’s forward deployed Battle Groups, Amphibious Groups, and Submarines.

The key opportunities in this area lie in the prospects for very compact, imaging sonars and lasers able to detect and identify mines in the water column and on the bottom. Because these sensors can be made very small, they can be towed by smaller helicopters such as the CH-60, put on a surface ship-launched and controlled, semi-submersible vehicle, or even inside a torpedo-sized unmanned underwater vehicle (UUV) launched and recovered from a submarine. Through the regular, peacetime employment of these sensors, the Navy can map the ocean bottom, particularly near key approaches or chokepoints. Doing so will facilitate the location of mines, or the “deltas” from the peacetime picture, that will allow the Navy to rapidly focus on areas to avoid, or if they are critical, areas to clear. The unique advantage of the submarine-UUV combination is that this sensing can occur regularly without raising suspicion.

Many of these sensors will be common to the dedicated and organic MCM force once fully developed, but in many cases, full development will not occur until the middle of this decade. In the interim, hull-mounted mine avoidance systems that are adjuncts of legacy high frequency sonars on forward deployed forces will be needed, as will a full commitment to the preservation of the dedicated MCM force and to the continued forward deployment of a portion of it.

MCM Weapons. Once identified, mines need to be neutralized or destroyed. In many cases, the instruments that accomplish this purpose are not really weapons, but so called influence devices designed to create the signature needed to set off the mine in a way that does not destroy the mine sweeping platform. An influence sweep usually requires a platform that will not itself set off the mine, but which can tow a vehicle that will, hence the long tradition of relatively small, dedicated minesweeping ships with low magnetic and acoustic signatures. More recently, helicopters have been employed to tow influence sleds, but the size of the latter has required the towing services of heavy lift helicopters like the massive CH-53. Some of the

same trends which will allow smaller MCM sensors will also allow smaller influence sleds, enabling an eventual transition to a CH-60 platform, and in turn allowing forward deployment on existing carriers, surface combatants, and amphibious ships.

In addition to influence sweeps, MCM forces also must have the ability to individually approach and remove or destroy all the mines it has found, because influence sweeps trade off speed for a reduced certainty that a minefield has been truly cleared. Here, one encounters perhaps the slowest and most labor intensive naval warfare area, in which today's dedicated MCM force utilizes explosive ordnance disposal (EOD) divers, marine mammal systems (MMS), and remotely operated underwater vehicles

New approaches to this problem designed for use by organic MCM forces focus on helicopter-deployed systems. In the nearer term, a helicopter-delivered, remotely operated underwater vehicle will be deployed that can approach an already identified mine and explosively destroy both itself and the mine. In the longer term, the RAMICS system described above is being developed. RAMICS will combine a LIDAR and a Gatling gun firing supercavitating, 20mm projectiles. The LIDAR would be used to search for and identify mines, and the gun's projectiles would disable or neutralize it by penetrating the mine's shell and injecting a chemical initiator into it.

The MCM Network. Unlike sophisticated networks like Distant Thunder, and those that will be described below for AAW and strike warfare, the main network in MCM is human, and the center of this network is the dedicated MCM force. This is to say that even more than ASW, MCM success is not a science but an art that requires practice and extensive, detailed knowledge, and which is therefore extremely perishable. A dedicated MCM force is the home for this expertise, because it is the only place in the Navy where officers will do nothing but train for MCM, and where the intelligence on foreign mines will be sustained.

Also, the nature of the entire undersea warfare threat, and particularly the mine threat, is that its most challenging manifestations have primarily "purple" and "green" consequences. In other words, an aggressive, inshore mining campaign by an opponent will more directly impact the projection of Army and Marine Corps power than it will purely naval power, and even when the Navy does face a serious mine threat, it will usually arise when it is operating in direct support of the Marines, as in the NSFS mission. Combined with an aggressive MCM program, this might lead some to advocate the eventual dissolution of the dedicated MCM force for narrow budgetary purposes. A salutary warning of the likely consequences of such a decision is provided the consequences of the Air Force's decision after the Gulf War to retire its dedicated air defense suppression assets in the belief that stealth would make such a dedicated force unnecessary.

Antiair Warfare

Throughout the Cold War, the main AAW threat to U.S. Navy Battle Groups was the long range, air and submarined-launched, antiship missile. This threat presented itself at great distances from the Soviet homeland, and was supported by an ocean wide surveillance system. The seriousness of this threat provoked major attempts by the Navy to deal with it at every step in the engagement sequence. Efforts were mounted to defeat or fool the surveillance system, to attack the launch platforms before they could launch their weapons, to take multiple shots at the weapons themselves if they leaked through a battle group's outer defenses, and to defeat the weapon's seeker in the terminal phase with both active and passive countermeasures. All of these defensive measures required depth, and depth was naturally provided in this Cold War mission area by the great range at which Soviet sea denial operations against U.S. Battle Groups were mounted.

The main problem with the littoral AAW threat is that this depth is largely absent, both because the U.S. Navy seeks to close with its adversaries, and because those adversaries are generally constrained anyway to operations within the littoral battlespace. This means that an adversary's launch platforms will be buried in the clutter and noise of the littoral environment, either on land or in shallow inshore waters where it is easy for them to hide. It also means that the surveillance system that cues those launchers need not approach ocean-wide coverage, but rather must only aspire to cover a radius of several hundred miles outward from the coast. And finally, because ASCM weapon engagements will usually occur over an even shorter range within the contested littoral battlespace, the specific weapons used can be relatively short range, sea skimming missiles rather than the high arcing AS-6s and SS-N-19s of Cold War fame.

All of these factors conspire to radically compress an AAW engagement in space and time, reducing the role of the outer air battle, and reducing the number of shots available during the inner air battle. For the most serious sea skimming ASCM threats, launched from platforms that have successfully approached a Battle Group in the littoral clutter, the AAW engagement will begin when the attacking missile approaches the targeted ship's radar horizon – say 20 miles – and will be over, for better or worse, within one or two minutes.

Three interrelated steps need to be taken to counter this threat. First, elevated sensors need to be developed which can eliminate or greatly reduce the clutter in the littoral environment which allows ASCM launchers to hide, and which also prevents missile detection until the terminal phase of an engagement. Second, weapons need to be developed that can function in the same cluttered environment against small, fast targets. And third, these sensors and weapons need to be linked together in such a way as to allow an elevated sensor to provide

the information needed for another platform to launch a defensive weapon against the incoming weapon from over the radar horizon.

If ASCMs are an old threat presenting itself in a new way, TBMs are a new threat that presents itself in a way that early pioneers of the Cold War outer air battle will recognize. TBMD engagements may occur in a relatively compressed time frame, but they also occur over great distances, and once again, the challenge is to fill that extended battlespace with multiple engagement opportunities, each of which will require the same tight integration between sensors, weapons, and data networks as will ASCM defense. The difference in the geometry of the intercepts will mean however that sensors for TBMD will generally be upward looking from the surface instead of downward looking from the air. They will therefore not face clutter problems, but they will need to precisely track small targets at long ranges, moving at great speed, and incoming from very high altitudes.

In principle, ballistic missiles can be attacked at any point in their trajectory, and for long range ballistic missiles, each of the main segments of its trajectory offers an opportunity for a specific form of attack possessing a unique set of advantages and disadvantages.

The boost phase offers a brief opportunity for a shot at the missile when it is most vulnerable, when it is easiest to discriminate from its background, and when the debris from a successful attack will fall well short of its objective. However, boost phase intercepts must be completed before the booster burns out, which creates very demanding engagement timelines, and under many combinations of booster burn time and geography, makes it impossible to implement using surface or air-launched interceptors that must stand well off from an opponent's launch sites if the latter are well inland. This is the reason that Cold War advocates of missile defenses were driven into space in an attempt to gain the benefits of boost phase defense against Soviet ICBMs, while today, ironically, opponents of today's National Missile Defense program propose ground or sea-based boost phase defenses because, for geographic reasons, they would be ineffective against Soviet and Chinese ICBMs, but quite effective against a notional North Korean ICBM. Under most circumstances, ground or sea-based boost phase defenses will not be effective against very short range TBMs, such as the SCUD, because their booster burn times are so short that there are essentially no geometries in which a boost phase intercept would be feasible.

The mid-course phase of a missile's trajectory is most relevant for longer range missiles which leave the atmosphere during this phase. This is by far the longest phase, extending from booster burnout to atmospheric reentry, which means that it gives the opportunity for multiple shots, and because it is a gravity and drag free environment, very small kill vehicles with very precise IR seekers can be used to attack targets at this stage. On the other hand, the same environment

also makes it very difficult to distinguish between a missile's warhead and any debris surrounding it, whether that debris is generated accidentally or intentionally as a countermeasure, because there is no atmosphere to filter out the heavy from the light objects. TBMs of all but the longest range do not ever completely leave the atmosphere, which does not mean that they do not have a mid-course phase, but it does mean that the IR seekers that long range interceptors use in this environment must be cooled to prevent atmospheric heating from blinding them.

The terminal phase of an engagement, defined either as that period after a long range missile has begun entering the atmosphere, or after a shorter range missile begins diving on its target, is again very short, offering fewer shots, but allowing for discrimination between warheads and debris based on the differential rate that the atmosphere decelerates their fall. More important from the TBMD perspective, the terminal phase is the only phase that allows a collocated surface-based radar and interceptor to begin and complete an intercept.

This discussion will focus on the near term opportunities for responding to the near term TBM threat, which if it carries a WMD payload, will likely be chemical rather than nuclear, but is most likely to carry a conventional payload and possess more accurate guidance, making them a much greater threat to ports and air bases ashore than were the Iraqi SCUDs.

Linebacker Projects TBMD Ashore. Air bases, ports, and other soft, fixed, high value targets will all be threatened by opposing TBMs, and the land-based forces which must use these bases face a double bind in trying to protect them. TBM defenses will be necessary to limit the threat to these bases, but land-based TBMD systems are themselves among the most difficult units to deploy, consuming large quantities of scarce, outsize airlift, which in turn limits the rapid deployment of the forces those TBMD systems are designed to protect early in a conflict when they are needed most.

Out of this conundrum, the Navy developed Linebacker, a TBMD system that is an evolution on the existing Aegis-Standard Missile capability. Linebacker involves minor modifications to the Aegis radar system itself, a more substantial modification to the SM-2 Block IV missile's fuzing and warhead section, and Link-16 compatible data links and processing upgrades that allow both receipt and transmission of missile tracking cues, either from other radars or from national systems.

The fewest number of modifications were necessary to the Aegis SPY-1 radar because it has already demonstrated repeatedly in real world situations that it can track TBM targets, including repeated tracking events during Desert Storm and in the waters off of Taiwan in March, 1996. The Block IVA modification to the SM-2 adds a forward looking fuze to the warhead which utilizes angular rate information from a new IR sensor, and range and range-rate information from a new very high

frequency RF transceiver, or radar. In addition, the Block IVA will retain the original Block IV's capabilities against aircraft and cruise missiles, which means that Linebacker will not require a dedicated SM-2 variant. And finally, the Link-16 compatible networking used for Linebacker is primarily used to exchange track cues that allow better radar energy management.

For example, a Linebacker ship might receive a track cue from a national sensor that told it to look up at a certain quadrant of the sky. By focusing its RF energy on that spot, it will see the TBM target much sooner than if forced to search the entire sky for it itself. By seeing the target sooner, the Linebacker ship may also get several shots at it rather than only one. In the same way, an Aegis ship may also share track cues obtained by its own SPY-1 with a Patriot PAC-3 battery ashore.

Beyond Linebacker: Theater-Wide and Directed Energy. Linebacker, and the Area Wide System that it will evolve into as it is widely deployed on Navy CGs and DDGs, will provide relatively limited geographic coverage, requiring that Linebacker ships remain very close to the targets they are defending ashore. This is a constraint common to all terminal phase defenses. One challenge therefore is to further extend the TBMD battlespace out into the mid-course phase. This is the objective of the Navy's theater-wide program, which will use a specialized SM-2 variant with a kill vehicle like that used in the NMD program. Theater-Wide embraces considerably more risk than does Area-Wide, in return for a considerable potential gain in capability.

The risk inherent to Theater-Wide will be resolved over the course of the coming decade, which is also the period during which WMD-armed ballistic missile threats are expected by some to emerge. The main role of Theater-Wide will be in dealing with this threat, because a credible response to this threat will require the full utilization of the TBM engagement sequence in order to get as many shots as possible. Credibility in this mission is crucial because Theater-Wide's role will not be limited to actually defending against these threats in the relatively unlikely case that they are actually used. It will also play the all-important role of extending defense to important potential allies in peacetime, which do not possess their own deterrent forces, and which need therefore to be provided reassurance that a decision to provide the United States access will result in a concomitant decrease in their exposure to nuclear
blackmail.

At the other TBMD extreme from Theater-Wide is the eventual development and wide deployment of conventional TBMs with precision, GPS guidance and wide area, sub-munition payloads. Systems like Area-Wide and Patriot PAC-3 will not be well-suited to countering this type of threat if and when it becomes truly ubiquitous, which has already led to an interest in directed energy, or laser weapons for highly

capable terminal defenses. In the effort to develop such lasers, the Navy will lead in the effort to produce solid state or free electron lasers which are powered by electricity, rather than the chemically-fuelled lasers under development in the Air Force and the Army.

TBMD and the Navy's Surface Combatants. The importance of ship-based TBMD in the new security environment has consequences both for the Navy's current shipbuilding and modernization programs, as well as its future research and development. In the first category, the wide deployment of first the Area-Wide and then the Theater-Wide system will require vigorous execution of the Navy's Cruiser modernization program, a four stage set of upgrades to its fleet of 27 Aegis cruisers that will unfold over the coming decade.

In the more distant term, the likely future conventional TBM threat argues for an aggressive pursuit of the all electric ship toward which DD-21 is a first step. The synergy between electric drive and solid state lasers is a powerful one in that electric drive allows the majority of a ship's power to be diverted from propulsion to another purpose, and solid state lasers can use that electricity to create a terminal phase TBMD system with an essentially unlimited magazine.

Important elements of the Navy's TBMD and ASCM defense programs are common. The Block IVA SM-2 and the SPY-1 are common to both efforts, as is the Cooperative Engagement Capability (CEC) which I discuss separately below. On the other hand, the main sensor in the ASCM defense effort must be elevated and able to look down in the littoral clutter. Also, the networking requirements for ASCM are more demanding than those required for Linebacker. And finally, the ASCM problem demands better terminal ASCM defenses, which are irrelevant to the TBMD problem.

E-2 Radar Modernization Will Reduce Littoral Clutter. Central to the ASCM defense problem is a much better wide area picture of the littoral air space, particularly at the low altitudes relevant to the ASCM problem. The E-2 is the Navy's primary AAW surveillance system but it is not currently well equipped for this task. As a relatively low frequency UHF radar, the existing E-2 APS-145 radar has tremendous difficulty detecting targets in the littoral for two basic reasons.

First, more than higher frequency radars like that on the Air Force's E-3, the E-2 has trouble picking out so-called low doppler targets on the littoral. A low doppler target is one whose closure rate relative to the surveillance radar is low. Historically, the prime radar signal processing routine for look down radars has been designed to exploit high doppler targets, i.e. ones closing on a path normal to the surveillance radar at a very high rate. An ability to track low doppler targets in the littorals is critical because ASCMs, as well as aircraft, all present themselves as low doppler targets no matter how fast they are going unless they are flying normal to the overhead surveillance radar.

Second, mechanically scanned UHF radars have inherently larger sidelobes than do higher frequency radars, which makes them more susceptible to both intentional jamming, and to inadvertent electromagnetic interference (EMI). EMI is particularly troublesome at the lower, roughly 400 MHz frequencies where the APS-145 operates because there are so many powerful commercial occupants near this band.

The E-2 radar modernization program (RMP) will defeat these problems using two techniques that will sound broadly familiar from the earlier discussion of Distant Thunder. First, the APS-145 will be replaced by a digital, phased array radar called the ADS-18, whose 18 element array will allow electronic scanning over 160 degrees, and which will mechanically rotate to provide 360 degree coverage. The phased array antenna allows the radar to reduce its sidelobes electronically, significantly reducing the jamming and EMI problem. It also provides more gain in the main lobe, giving better detection ranges. Second, the ADS-18 will also allow temporal processing by providing three complete sets of measurements of the RF energy returning from a single spot, which will allow it to distinguish the moving target within the fixed clutter background of that spot because the target will move slightly during the interval between each of the three pulses.

ADS-18 will provide a quantum leap in the ability of the E-2 to detect ASCMs in the littoral environment, as well as a raft of other important targets. The next step is for the E-2 to provide its track information to surface ships in a way that maximizes their ability to shoot down the missile. This can be done in three ways, roughly corresponding to degrees of both capability and risk, and the Cooperative Engagement Capability (CEC) is central to all three.

The Centrality of CEC. CEC is a very sophisticated data link that allows different platforms to share tracking information on targets with a speed and accuracy that allows one platform to shoot a weapon at a target that another is tracking. In practice, CEC enables both very accurate cueing, to provide warning to another platform that it is under attack by a target it cannot yet see, and to maximize that platform’s radar energy management so that it can begin defending itself as soon as possible. More ambitiously, it allows for actual over the horizon engagements, where one platform launches a weapon that another guides to the target. In all cases, CEC extends the battlespace available to combat the ASCM threat, and this is particularly the case when CEC is combined with E-2 RMP, as it will be if the latter program is funded.

At a minimum, CEC can give warning to any ship with terminal ASCM defenses that it is going to come under attack from a very specific azimuth, allowing it to aim its ship self defense systems at that point on the horizon and to prepare to deploy decoys.

For ships with Standard missile or Sea Sparrow capability, CEC will provide cueing that allows search radars to focus their energy on the

horizon, and will in some cases enable missile launch before the ASCM has broken the target ship's radar horizon.

Most ambitiously, and here an X-Band illuminator must be added to E-2 RMP, CEC could enable SM-2 intercepts flown at the very limit of their kinematic range by using the E-2 for both target track and illumination. Such a capability was demonstrated in the Mountain Top experiment in January, 1996.

Evolved Sea Sparrow and SeaRam. Even with E-2 RMP, Aegis, CEC, and Block IVA SM-2, some ASCMs will leak through, and each of the Navy's major combatants needs a robust set of terminal defenses, both active and passive, to deal with this challenge. The Evolved Sea Sparrow Missile (ESSM) and the Rolling Airframe Missile (RAM) are two approaches to creating an "outer" terminal defense, while CIWS is the inner ring. ESSM is a semi-active radar guided missile that can fit four at a time into existing VLS cells, while RAM is a shorter ranged system based on the Sidewinder AAM airframe, and has both an IR and a passive RF guidance mode. For the most modern ASCM threats, CIWS lacks range, and SeaRam is a program to replace CIWS with RAM using the same ship footprint.

For the most demanding missions, there may be a case for including both ESSM and SeaRam where possible. These systems will need to be combined with passive defenses which attempt to present false radar targets to the incoming missile which distract it from the real target. Here, radar stealth can play an important role for surface combatants, as DDG-51 has already demonstrated, and as DD-21 is designed to demonstrate further.

F-18E/F and Overland Cruise Missile Defense. Just as cruise missiles pose serious threat to ships in the littoral, they also pose threats to targets ashore. Overland cruise missile defense presents all the problems described above, with the additional challenge that the endgame of the engagement is more challenging because small aperture AAMs have more difficulty picking out cruise missiles from ground clutter than they do at sea. One element in the solution to this more challenging problem will be to use electronically scanned radars on strike fighters which can better guide AAMs into the narrow basket in which their terminal seekers can function against small cruise missiles. This is just one reason for the Navy to stick to its plan to fund an AESA radar for the F-18E/F starting in FY 05.

Strike Warfare

Four new factors dominate the strike warfare mission area. First is the revolution in precision weapon effects, the opportunity for which first became manifest in the Gulf War. Bombs which once needed to be dropped en masse by entire formations of aircraft to produce even a reasonable probability of hitting a single target can now be dropped in pairs or even individually by a lone aircraft against several targets with a high probability of success. And this capability will only grow in importance in cases where the threat of weapons of mass destruction demands the destruction of these weapons (and their supporting infrastructure) through precision strikes in the early hours of a conflict.

Second, because precision weapons have suddenly made successful attacks against fixed targets seem automatic, they have also highlighted shortfalls in the U.S.'s ability to attack mobile targets. The need to get better at attacking mobile targets will depend both on better sensor networks for detecting, identifying, and tracking them, but also on the more rapid delivery of weapons cued or targeted by those sensor networks.

Third, in a theme which has infused this paper, sensors, weapons, and weapon delivery platforms will all need to be linked together by data networks. These data networks will perform two crucial functions. They will enable the signal processing within sensor networks that will allow those networks to provide targeting rather than just cueing information to weapon platforms, and they will communicate that information to those platforms in real time, and in a format that enables the immediate launch of a precision weapon in response.

Fourth, traditional approaches to suppressing mobile radar-guided SAMs are facing diminishing returns in effectiveness. This is important because modern SAMs form the heart of the integrated air defense systems of the U.S.'s potential opponents, and those defense systems create access problems to the extent that they limit strike warfare capabilities.

Underlying these general factors effecting strike warfare are factors unique to the U.S. Navy in the new security environment. There is relatively more demand for strike from the sea capabilities because they face relatively fewer access constraints than do land based forces. In meeting this demand, the Navy needs not only to focus on better sensors, weapons, and networks, but also on maximizing the forward deployed payload that ultimately constitutes the upper bound on its strike warfare capability early in a conflict when that capability is most valuable.

A specific driver for more forward deployed payload at sea will be the need to preserve the option of large, surprise attacks against the delivery vehicles and command and control infrastructure of WMD-armed

opponents, and against the ground-based infrastructure of those opponents with an over-the-horizon ocean surveillance system. The Navy has already taken one of the steps necessary to meet the demands for more strike from the sea capability, which was to make every combat aircraft in its carrier wings a precision strike fighter. With F-18E/F it will take another step down this road, both by producing a more capable precision strike fighter, and by further increasing the utilization of the carrier deck by reducing the number of separate aircraft types that must be operated and maintained on it.

On a parallel path, and again as a result of the precision revolution, both the surface and submarine communities have quickly grown to become partners with aviation in strike warfare. Here, the precision revolution enables the participation of these platforms because it allows them to stand well off from the battlefield and still produce precision effects on it. And this positive trend is being reinforced with the development of weapons like Tactical Tomahawk, which will provide an increase in capability over today's Tomahawk at half the price, and in the introduction of ship and submarine-launched TBMs like LASM and later, Advanced Land Attack Missile (ALAM).

The marriage of standoff precision weapons with the surface and submarine communities has already produced an additional quantum leap in what the Navy brings to strike warfare from the sea. But the new security environment has additional demands. The first is for more forward deployed naval payload, the second is for a better capability against mobile targets, and the third is for a strategy to transition seamlessly from today's approach to defense suppression to one that results in defense destruction. In describing the opportunities to meet these demands, the following discussion will look first at the highest leverage path to more forward deployed payload, which will include a discussion of both platforms and weapons. Then it will look at the opportunities in sensor networks for targeting mobile targets, and show how increasing the number of sensors in the network improves the precision of the targeting data it produces. Third, it will look at the future defense suppression/destruction challenge in light both of what is necessary in the near term, and what sensor networks may make possible in the more distant term.

Platforms and Weapons For Increasing Forward Deployed Payload. The aircraft carrier is a forward deployed platform, and its air wing is in some senses its weapon, and this combination is a relatively mature system. Interesting and valuable work is being done to improve the sortie generation capacity of existing and planned carriers and air wings, but the resulting improvements will not be revolutionary. Because the carrier will remain the centerpiece of the Navy's strike warfare capability, these incremental improvements need to be pursued, but another major source of forward deployed payload that can be exploited lies in the surface and submarine forces. This is because of

the revolutionary progress made in long range, standoff precision weapons that surface and submarine platforms can deploy in their vertical launchers. This is particularly true in the area of TBMs, which represent the shortest distance between a strike weapon launcher and its target because they have such short times of flight. Short time of flight weapons will in turn play a key role in time critical strike, both as an element of the solution to some parts of the mobile target problem, and as a means of attacking fixed targets like air bases and weapon depots, whose value can change quickly and dramatically with time, particularly when they may contain weapons of mass destruction. The best vehicle to exploit this opportunity is the ALAM program, which is currently focused on meeting longer term Marine Corps fire support requirements, but which will also be an important strike warfare tool.

Also, for both TBMs and cruise missiles, GPS/INS accuracies are improving by an order of magnitude every few years, and will soon be measured in feet rather than tens of yards. As accuracies improve, the size of the warhead needed for a given lethality against a fixed target goes down as the cube of the reduction in miss distance, which means in turn that as payload weights go down, missile throwweights go down, missile sizes go down, and finally missile costs go down.[38]

The same trends that will improve the lethality and reduce the costs of standoff weapons will also improve the payload capacity of their launchers. This is because smaller missiles with the same lethality as weapons like the Tomahawk or LASM virtually give both submarines and surface ships much larger magazines without changing the internal volume of their vertical missile tubes. This is what engineers call a virtuous rather than a vicious circle and it represents a perfect example of the difference between increasing rather than decreasing returns on investment.

A final step forward in the capability of these weapons that should be grasped is the ability to provide real time bomb impact or damage assessment (BIA or BDA). Tactical Tomahawk will already provide the beginning of such a capability, and ALAM should be given it as well. At a minimum, standoff weapons should be designed to “scream” their last position prior to impact over a simple RF channel. More ambitious are schemes to allocate a small portion of the missile’s payload to a visual sensor that would deploy prior to impact, view the results, and broadcast them back over a more capable RF circuit.

Real time BIA and BDA are important because they reduce the number of weapons that need to be allocated to an attack, and the time needed to complete those attacks. BIA and BDA reduce the number of weapons needed because “shoot-look-shoot” tactics can be used, which eliminates the need to allocate two weapons for every target simply to compensate for the expected unreliability of a small portion of those weapons. Instead, additional weapons can be allocated after an initial salvo of

one weapon per target only to compensate for those weapons that actually failed in the first salvo. Real time BIA and BDA reduce the time needed to make this compensation, thereby reducing the time during which the targets missed in the first strike remain uncovered. It is this last improvement provided by real time BIA and BDA that is most important, because current approaches to this problem often take hours or days, and against high value, time urgent targets like WMD sites, planners cannot afford to wait.

Additional forward deployed VLS payload compounds the advantages provided by further standoff weapon development. For example, using the roughly 20 inch diameter/20 foot length weapon template established by today's VLS tube, one can measure the benefits produced by using improved accuracy to increase payload. Assuming a 20 meter CEP, and using existing propellants, a TBM with a 250 lb warhead and a 500 km range could be developed with the same diameter and two thirds the length of today's VLS cell. Modest improvement in the specific impulse of its propellant would further reduce its length to 10 feet, allowing double stacking in a VLS tube. This would double the number of LASM-type weapons that a surface combatant could deploy, meaning that in its currently planned version, DD-21 could carry 256 rather than 128 LASM equivalents.

More dramatic in the near term would be the effect of converting Trident SSBNs into conventional, guided missile submarines, or SSGNs. Four Tridents are now available for SSGN conversion, and more may become available if deeper cuts are ordered in strategic offensive forces. In the cheapest conversion, with half the launcher volume unused, a Trident SSGN could carry seven VLS-equivalent weapons like Tomahawk or ATACMS in each of its 24 tubes for a total of 168.[39] With double stacking, this total could eventually be increased to 346. And finally, a smaller TBM designed from the beginning to be double-stacked in a surface combatant's VLS tube could be quadruple-stacked in packs of seven in each of an SSGN's missile tubes for a total of 672.

These additions to forward deployed payload are not important just because they will enable time critical strikes against mobile targets found by new sensor networks, but also because they will greatly expand the size of the "first night of the war" salvo available to a Battle Group commander tasked with the job of taking out an opponent's WMD and ocean surveillance infrastructures.

Near Term Sensor Networks For Targeting Mobile Targets. There is a strong mutual interaction between the accuracy of the target location information that a sensor network produces, the quality of the target classification information that it provides, and the strike assets which use that information to attack the target. In broad terms, the less precise the location and classification information, the more capability that needs to be organic to the strike asset. For example, a sensor network might provide wide area surveillance which provides

only cueing quality target location information and little or no classification. In this case, the strike asset will need to be able to reacquire the target with its own sensors, positively identify it, and deliver ordnance on it should it not prove a false target. In general, this describes the situation today in mobile target strike, where the best surveillance assets are the first generation airborne SAR/MTI radars symbolized most strongly by JSTARS. These surveillance platforms provide limited geographic coverage of the battlefield, modest classification capability of moving targets, and target location information that is sufficiently imprecise to prevent direct targeting with GPS-guided weapons.

Of course, this capability alone is a giant step forward from the past, when mobile target strike consisted of strike aircraft flying low in daylight and visually searching for mobile targets, a tactic that would produce very high loss rates in the face of today's short range air defenses. For the near term, the road ahead in mobile target strike is therefore to more fully populate the battlefield with airborne SAR/MTI surveillance, and to improve the ability of strike aircraft to use the cueing information thereby provided.

From a naval perspective, this means guaranteed Battle Group access to a SAR/MTI surveillance platform, F-18E/F AESA with a SAR/MTI mode for reacquiring cued targets, an advanced tactical FLIR for cases when the target is not yet fully classified, and something like the GPS Aided Targeting System (GATS) to allow an autonomous targeting capability for GPS-guided weapons like JDAM and JSOW. Link 16 is central to this future because it will allow cueing information to flow from the surveillance platform to the two seat F-18F FAC in real time and in a format that allows immediate display on the latter's head up displays. Link 16 will come back into play once the FAC has reacquired, classified, and geolocated the target or targets by allowing it to pass targeting information in real time to an inbound F-18 strike package in a format that allows immediate insertion of GPS coordinates for their weapons.

The biggest question mark in this roadmap today concerns guaranteed Battle Group access to a SAR/MTI surveillance platform. P-3 AIP will provide SAR radar surveillance and precision targeting, but not an MTI mode, and even P-3s are sometimes denied access to some parts of the Indo-Pacific littoral. Global Hawk will often be available if bought in sufficient numbers, but it's payload is weight and power limited, one result being a limited MTI capability compared, say, to JSTARS. A serious opportunity for the Navy to consider is a Precison Surveillance and Targeting (PS&T) SAR/MTI platform based on the E-2 airframe, or even on a ship-launched medium to long endurance UAV. A PS&T E-2 would combine the SAR/MTI functionality of JSTARS with an Inverse SAR (ISAR) mode that enables surface search and mast detection. The development of the radar itself is low risk, but the integration of PS&T and RMP in

the same air frame is at the low end of high risk. A near term alternative to full integration would be to backfit PS&T onto low time, pre-Hawkeye 2000 air frames that have had APS-145 removed. This option would be modeled on the ES-3 force model, with a total of 14 air frames filling two six plane squadrons available for Battle Group deployment and one two plane replacement air group.

Longer Term Sensor Networks for Targeting Mobile Targets. At the other extreme from the near term sensor network described above is one where the sensor network detects, identifies, and continuously tracks mobile targets with GPS-targeting quality precision. Provided such a network, large standoff weapon carriers would launch cruise missiles that the network would update in flight with sufficient frequency to bring within the very narrow reacquisition basket of a very simple terminal seeker. These weapons would be so precise that their payloads could be kept very small, which would reduce their size and cost, and allow their use in very large numbers. And finally, the data links enabling all of this would be both extremely jam resistant and covert, and their terminals would be small and cheap enough to be deployed on all platforms and weapons.

As a future to strive for, this picture is a worthy goal, but in its details it poses many significant technical challenges. Perhaps the most relevant of these challenges in the near term is the goal of having sensor networks that provide targeting information of sufficient quality to target time urgent GPS weapons. This challenge is relevant in the near term for two reasons. First, because of its true all weather performance, GPS/INS is rapidly becoming the preferred mode of precision weapon guidance. And second, most mobile targets spend most of their time sitting still, which from a targeting perspective makes them fixed targets that occasionally move at unpredictable points and for unpredictable durations. Thus an intermediate step in addressing the mobile target problem will be to develop sensor networks that track these targets while they are moving but precisely geolocate them only when they stop, and to develop time critical strike capabilities that can respond to this targeting information quickly enough to put a weapon on the designated aimpoint before the target moves again.

The key to sensor network precision is to put multiple rather than single sensors within line-of-sight of the target to be located, and to network those sensors so that their collective output can be processed. In general, two sensors with the capability to give an accurate bearing to the target, and separated by a fairly long baseline, can be used as a long baseline interferometer if networked properly. But errors creep into this system at multiple points. For example, the bearing information has an uncertainty of plus or minus x degrees, and the two sensor platforms only know their positions within a radius of x feet. Such targeting information is still useful, but would demand

prosecution by a GPS-guided weapon with an expensive terminal seeker or submunitions.

Three sensors with better angular resolution, and better location information will do better, and work is now being done by DARPA to look at such a network of airborne SAR/MTI radars. Part of the technical risk in such networks lies in assuring the seamless transition from the MTI to the SAR mode or vice versa such that individual target tracks are not lost. As progress is made in this area the cost of the weapons needed to respond to network targeting will fall, because they will be asked to make up for less and less targeting imprecision in the terminal endgame.

Defense Suppression in the Near and Mid Term. The defense suppression/destruction problem is a subset of the mobile target problem, and it is simultaneously an access problem. Efforts now mounted to suppress defenses automatically subtract strike capabilities, because the same platforms perform both missions. These efforts also put an upper bound on aircraft strike capabilities, because U.S. forces now have more precision strike capability than they have defense suppression capability to assure it access. Hence, the new concept of a low density/high demand (LD/HD) asset. Thus, the defense suppression/destruction problem is one where effective new approaches to the problem would provide high payoff in freed strike assets, and fortunately it is also a problem that is uniquely suited to a networked sensor-time urgent weapon approach in the mid rather than the far term.

That is because mobile radar-guided SAMs like the SAM-6 and the SAM-10 differ from other mobile targets in that they must not only stop and remain immobile while they are performing their mission, but they must also emit high power RF signals during at least a portion of the time they are immobile in order to be effective. This is significant because it is easier to construct a very precise, passive RF emitter location system than it is to construct a radar-based system for tracking non-emitting mobile targets. A passive network of three sensors can exploit time-difference-of-arrival (TDOA) signal processing, which eliminates the tradeoff between accuracy and the angular resolution of the individual sensors, allowing for much cheaper, non-directional sensors, like the relatively simple Radar Warning Receivers (RWRs) that all tactical aircraft already carry. A TDOA network does requires a data link with very precise timing information, but Link 16 already provides that, and a TDOA network is still sensitive to errors in the position of its nodes, and errors will exist in an airborne network, though again, steady overall improvement in GPS system accuracies will continue.

Such a network, whether using airborne platforms, or in the more distant future, using unattended ground sensors, will enable defense suppression/destruction operations that resemble the way the Army now

conducts counter-battery fire. In the Army case, a radar determines the location of enemy artillery batteries by observing their fires, and targets counter-battery fire that can be in the air before the incoming shells land. Forward deployed, TBM-firing surface ships and submarines will be in position to attack SAM batteries as soon as they light up their radars if a TDOA network is in place. Either Link 16 or UHF SatCom can be used by the network to communicate targeting information, and both surface ships and submarines will be able to maintain continuous connectivity at these frequencies.

In the nearer term, elements of this preferred mode of operation will at any rate need to be inserted into today's defense suppression forces in order for that force to keep pace with today's threat. But in addition, there are elements of today's defense suppression force that may not be part of a future, more net-centric approach to this problem, but which are both so important and so relatively scarce in today's security environment that their capabilities must be improved. One such program is the EA-6B ICAP update, and the other, more developmental program, is the AARGM/Quick Bolt upgrade to the HARM antiradiation missile.

EA-6B ICAP and AARGM/Quick Bolt. The ICAP program is important for four main reasons. First, it will introduce all digital jamming pods that are both easier to maintain and easier to update with new threat information. Included will be the first pods covering the lower frequencies of interest: including VLF surveillance radars that can track stealthy aircraft, and which are very hard to permanently take out because their antennas are so easy to repair or replace. Second, it will add a "look while jamming" capability to its receivers, allowing EA-6s to serve both as an ESM platform and a jammer, and allowing real time jamming responses to pop up emitters. Third, ICAP will introduce a long baseline interferometric antenna that enables it to calculate the range to an emitter, allowing it for the first time to target HARMs in the most effective "range known" mode. Finally, ICAP will introduce Link 16 onto the EA-6B for the first time.

AARGM/Quick Bolt is actually two separate development programs aiming to upgrade existing HARM air frames. AARGM is a nearer term program that seeks to give HARM a better capability against SAM radars that shut down in the midst of an engagement. It does this by giving its antiradiation homing (ARH) seeker the ability to use GPS to take several, inflight DF cuts on the signal it is homing on. This will reduce the initial rather large target location error inherent to current HARM targeting systems, making it possible to put a simple millimeter wave radar on the front of the missile which will search for and home on any vehicles in its view if and when the ARH loses its signal.

Quick Bolt is a more ambitious program that seeks further improvements against radar shut downs, better BDA, and a replacement motor that will give longer range at higher speeds in a smaller package. With regard to the motor development program, it seeks to make HARM faster and longer-legged, to better fight the “F-pole” battle against SAM-10s, and at the same time to make it shorter, because if launched from a non-stealthy platform, it will likely still lose the F-pole battle, which means that the HARM launcher will need to be stealthy, and current HARMs are too long for F-22s and JSFs to carry internally.

Forward deployed naval forces will be the keystone of the United States' ability to project power rapidly in the new security environment, because naval forces are less vulnerable to the constraints on access faced by forces that rely on land bases, and because naval forces can be used to reduce or eliminate those constraints on access for land-based forces.

Conclusions

The forward deployed Navy is both a source of immediate power projection capability, and a means of enabling power projection by the other services. The Navy encounters its greatest access challenges when it is enabling power projection by others, not when it is projecting power alone. The programs described in the previous section are important not so much because the Navy needs them to project power itself, but because the Army, the Air Force, and the Marine Corps need the Navy to have them. The nature of the threats that animate these programs make them urgent, even in the near term. Left untended, these threats will make long range power projection by joint forces a protracted rather than a rapid enterprise, and in some cases will deter the projection of joint forces altogether.

Forward deployed Battle Groups, armed with Tomahawk cruise missiles and strike fighters refueled from organic tankers, can stand off more than 300-400 miles from an enemy's coastline and launch strikes when and where they choose. The number of targets struck daily under such circumstances would be less than the maximum possible, but on the other

hand, opponents will have a very difficult time finding and tracking the Battle Group when it is operating independently in this way. Forward deployed submarines can operate with even more impunity, launching surprise cruise missile attacks deep into an opponent's territory, and Trident SSGNs will provide five to ten times the payload for such strikes compared to today's attack submarines. If all the nation needed from the Navy was long range, precision strike from the sea capability, it would already have what it needed today.

Instead, it needs a Navy whose Battle Groups and submarines can close with the enemy, launching surprise cruise missile and TBM strikes and sustained, high volume air strikes large enough to take out key time urgent or mobile target sets such as WMD-armed ballistic missiles, and to destroy rather than merely suppress air defense assets, enabling high payload Air Force bombers such as the B-1 to halt or slow opposing ground forces early in a conflict. It needs a Navy whose surface combatants can close within 20-25 miles of a hostile coastline and provide the on call, precision fire support needed to enable ship-to-objective maneuver by Marine Corps expeditionary units. It needs a Navy whose aircraft, surface combatants, and submarines can quickly find and destroy opposing submarines and mine fields, enabling the rapid closure of pre-positioning and surge sealift vessels carrying the arm of decision – the Army's armored forces. It needs a Navy that can project defenses against ballistic missile attack ashore, so that sealift ports of debarkation can be kept open, air expeditionary force bases can be protected, and allies reassured. And it needs a Navy whose ships can survive in this challenging environment in the face of ASCM attacks that emerge with little warning out of the littoral clutter.

If the United States does not get the Navy it needs, relatively small numbers of opposing submarines and mines, mobile SAM batteries, and mobile ballistic missiles will, if wielded intelligently by an opponent, greatly reduce the speed and weight of the power that it can project. In the extreme case, an opponent can have this effect without even drawing blood.

One Argentine submarine operating in the shallow waters around the Falkland Islands caused the Royal Navy to expend nearly all of its ASW ordnance without lethal effect. The submarine sank no ships, though some claim it bounced a dud torpedo off the hull of one of Britain's precious aircraft carriers, but its presence imposed powerful constraints on the fleet's operations throughout the conflict. The mobile SAM-6 batteries deployed by the Serbs during Allied Force shot down few if any aircraft, but forced the allies to limit the tempo of their strike operations to what could be sustained by its scarce defense suppression assets. And even though over 1000 HARMs were expended, many against SAM-6s, most SAM-6 batteries survived the war intact. And finally, Iraq's wildly inaccurate SCUD attacks destroyed

no allied military targets during Desert Storm, but because of their potential political effects, thousands of allied strike sorties were diverted from other important missions in a largely futile attempt to stop those attacks at their source.

Furthermore, these are yesterday's threats. The Navy needs to take the steps described in the previous section to give it the ability both to project its own power in the littoral battlefield, and to ensure the timely and decisive access of the other services to that battlefield against these already existing threats. Taking these steps will not transform the way the Navy looks, nor increase its size, but they will transform the way it fights. Yet they will not be sufficient if the other services do not engage in the more radical transformations necessary to make them significantly less dependent on oversea bases than they are today. The military threats posed by asymmetric weapons to access by joint forces will grow significantly if and when opponents adopt more modern systems, such as mobile TBMs with reasonably precise GPS guidance and large, sub-munition payloads. As these new threats emerge, joint forces will need to transform, or the Navy will need to grow to fill the void.

Endnotes

1. See, for example, William C. Wohlforth, "The Stability of a Unipolar World," and Michael Mastanduno, "Preserving the Unipolar Moment: Realist Theories and U.S. Grand Strategy after the Cold War," in Michael E. Brown, Owen R. Cote Jr., Sean M. Lynn-Jones, and Steven E. Miller (eds) America's Strategic Choices, Revised Edition (Cambridge, MA: MIT University Press, 2000) pp. 273-349; Mark S. Sheetz, "Correspondence: Debating the Unipolar Moment," International Security, Vol. 22, No. 3 (Winter 1997/1998) pp. 168–175; and Samuel P. Huntington, "The Lonely Superpower," Foreign Affairs, Vol. 78, No. 2 (March/April 1999) pp. 35–50.

2. This is not to say that there will be peace along these borders, or that the United States will not have interests at stake should conflict occur along them, just that it will be unnecessary for the United States to provide the main source of balance on the ground among the competing powers in the form of a large, forward deployed Army. For a strong statement of this view regarding Germany and Russia, see John J. Mearsheimer, "Back to the Future: Instability in Europe After the Cold War," International Security, Vol. 15, No. 1 (Summer 1990). I make the same assumption here regarding China and Russia for similar reasons.

3. For a summary of this debate, see Harvey M. Sapolsky and Jeremy Shapiro, "Casualties, Technology, and America's Future Wars," Parameters, Vol. 26, No. 2 (Summer 1996), pp. 119–127.

4. The best account of those events is Mark Bowden's masterful Black Hawk Down: A Story of Modern War (New York: Atlantic Monthly Press, 1999).

5. Stephen Walt, "Muscle-bound: The Limits of U.S. Power," Bulletin of Atomic Scientists, March–April 1999, p. 44.

6. On this threat, see John Stillion and David Orletsky, Airbase Vulnerability to Conventional Cruise Missile and Ballistic Missile Attacks: Technology, Scenarios, and U.S. Air Force Responses (Santa Monica, CA: Project Air Force, RAND, 1999).

7. Prepared Statement of Lt. General Marvin Esmond, DCS, USAF, House Armed Services Committee, October 19, 1999, p.1.

8. General John Jumper, CINC USAFE during Allied Force, in David Fulghum, "Security Leaks and the Unknown Bedeviled Kosovo Commanders," Aviation Week and Space Technology, November 1, 1999, p. 33.

9. For more on the defense suppression problem and alternative approaches to solving it, see Owen Coté, Mobile Targets From Under the Sea, MIT Security Studies Conference Series, December 1999, pp. 25–31 at <http://web.mit.edu/ssp/>.

[10] On the antisubmarine warfare challenges posed by modern non-nuclear submarines and antiship guided missiles, see Owen Coté, Antisubmarine Warfare After the Cold War, MIT Security Studies Conference Series, June 1997, <http://web.mit.edu/ssp/>.

[11] Conduct of the Persian Gulf War (Washington, D.C.: U.S. Department of Defense, April 1992), p. 35.

[12] Peter Grier, "Pentagon Speeds Forces to Hot Spots, " Christian Science Monitor, October 18, 1994, p. 1.

[13] Douglas Jehl, "Saudis Admit Restricting U.S. Warplanes in Iraq," New York Times, March 22, 1999, p. 6.

[14] The U.S. Commission on National Security, New World Coming (Washington, D.C. August 1999) p. 7 <http://www.nssg.gov/Reports/>.

[15] Report of the National Defense Panel, December 1997, pp. 12–13 <www.dtic.mil/ndp/>.

[16] Current U.S. ground force deployments in Europe do have the additional benefit of being partially subsidized by their host nations; as long as these subsidies continue, these deployments may make sense for budgetary rather than strategic reasons.

[17] On the United States being an offshore balancer of last resort, see Christopher Layne, "From Preponderance to Offshore Balancing: America's Future Grand Strategy," International Security, Vol. 22, No. 1 (Summer 1997), pp. 112–123. I am predicting that the United States will adopt that broad role for reasons quite different from those proposed by Layne, but his description of how such strategy might work in practice is useful. On Britain's historic role as an offshore balancer in Europe, see Daniel A. Baugh, "British Strategy during the First World War in the Context of Four Centuries: Blue-Water versus Continental Commitment," in Daniel Masterson, ed., Naval History: The Sixth Symposium of the U.S. Naval Academy (Wilmington, Del.: Scholarly Resources Inc., 1987), pp. 85–110.

[18] The most comprehensive treatment of the technology underlying this statement is Naval Studies Board, National Research Council, Technology for the United States Navy and Marine Corps, 2000–2035, Vol. 5: Weapons (Washington, D.C.: National Academy Press, 1997), especially pp. 106–120.

[19] For an excellent analysis of the prospects for using long-range fires to halt an armored/mechanized force attack, see David A. Ochmanek, Edward R. Harshberger, David E. Thaler, and Glenn A. Kent, To Find and Not to Yield: How Advances in Information and Firepower Can Transform Theater Warfare, Project Air Force, The Rand Corporation, 1988.

[20] Douglas Barrie, "India Begins To Receive Russian Missiles for Subs," Defense News, October 23, 2000, p. 60.

[21] Of course, nuclear war plans did envision defense suppression strikes by ICBMs and SLBMs, but the Air Force sought bombers which were not dependent on such strikes in order to assure their ability to penetrate under all circumstances.

[22] For a vivid description of these early LGB operations, see Jeffrey Ethell and Alfred Price, One Day In A Long War (New York: Random House, 1989).

[23] Only F-111Fs, A-6Es, F-117s, and a small number of F-15Es combined a FLIR with a self-lasing capability.

[24] Cruise missiles, though largely dependent on INS/GPS, rely on a terminal seeker which compares what it sees during the last phase of the missile's attack with a pre-stored image of what it should be seeing.

[25] There will always be exceptions to this rule when the target demands a weapon whose characteristics prevent standoff delivery, as will perhaps some deeply buried targets that require weapons of such size that their launch platform will need to overfly the target.

[26] NATO expended more than 1000 HARMs in Allied Force. Philip Klass, "New AGM-88 Missile Will Be Smarter," Aviation Week & Space Technology, November 15, 1999, pp. 90-92.

[27] Four other allied aircraft without direct Wild Weasel escort were lost to radar-guided SAMS, and 33 other allied aircraft were lost to other air defense assets for a total of 38 aircraft lost out of about 70,000 combat sorties. Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Summary Report, Washington, D.C., 1993, pp. 229-230.

[28] DOD News Briefing, Thursday, 10 June 1999, Air Defense BDA slide. Available in archives at http://www.defenselink.mil/news/.

[29] In Desert Storm, the Allies flew about 70,000 strike sorties and expended a little over 1900 HARMs, while in Allied Force, the numbers were 35,000 sortis and a little over 1000 HARMs. In the latter case, the cost of the HARMs expended was at least $250 million.

[30] A critique of this decision is one of the main themes of Michael Gordon and Bernard Trainor, The General's War: The Inside Story of the Conflict in the Gulf (Boston: Little Brown, 1995).

[31] On the origins of SAR and MTI radars, see Charles A. Fowler, "The Standoff Observation of Enemy Ground Forces: From Project Peek to JointSTARS", Aerospace and Electronic Systems Society Magazine, June 1997. Also, see the discussion with John Entzminger in

David Fulghum, “Future UAV Sensors to Scan Vast Areas,” Aviation Week and Space Technology, February 7, 2000, pp.58-61.

[32.] There are two excellent histories of the Navy and space during the Cold War: Gary Federici, From the Sea to the Stars, Center for Naval Analysis, June 1997 and Norman Friedman, Seapower and Space: From the Dawn of the Missile Age to Net-Centric Warfare (Annapolis, MD: U.S. Naval Institute Press, 2000).

[33.] Though much has been written recently about the threat to U.S. satellites and the need for space control, little analysis has been done since the last Cold War debate about ASATs in 1986. For the satellite-antisatellite balance then, see Ashton B. Carter, “Satellites and Anti-Satellites,” International Security, Vol. 10, No. 4 (Spring 1986), pp. 46-98.

[34.] On the decision to concentrate aviation in the Royal Air Force, see Norman Friedman, Thomas C. Hone, and Mark David Mandeles, American and British Carrier Development, 1991-1941 (Annapolis, MD: U.S. Naval Institute, 1999). For an excellent comparison of the wartime consequences of the U.S. and British approaches to naval aviation development, see J. L. Moulton, A Study of Warfare in Three Dimensions: The Norwegian Campaign of 1940 (Athens, OH: Ohio University Press, 1967).

[35.] For one view of how the Army and the Air Force will need to be transformed, see Owen R. Cote Jr., “Buying ‘…From the Sea’: A Defense Budget for a Maritime Strategy,” in Cindy Williams (ed), Holding The Line: U.S. Defense Alternatives for the Early 21st Century (Cambridge, MA: M.I.T. University Press, 2001) pp. 141-179.

[36.] On the mismatch between current spending and the long term cost of today’s naval force structure, see Ronald O’Rourke, Statement Before the Senate Armed Services Committee, Subcommittee on Seapower, March 2,2000.

[37.] See, for example, Stephen Green, “Battle Rages Over Warplane of the Future,” San Diego Union-Tribune, December 27, 2000, pg. A-1 and Loren B. Thompson, “Navy Shipbuilding Faces Funding Crisis,” Defense Week, February 20, 2001, pg. 1.

[38.] On the benefits that flow from improved accuracy, see Committee on Technology for Future Naval Forces, Naval Studies Board, Technology for the United States Navy, Volume 5, p. 117.

[39.] The current plan to fill SSGN tubes with only 7 Tomahawks only uses half the tube’s volume and is a measure to avoid the cost of developing a double stacking technique. It reflects a desire to minimize the cost of the initial SSGN conversion rather than a concern about the technical feasibility of double stacking.