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TRIAD, DYAD, MONAD?

SHAPING THE US NUCLEAR FORCE FOR THE FUTURE

Dr. Dana J. Johnson
Dr. Christopher J. Bowie
Dr. Robert P. Haffa

Mitchell Paper 5

Brig. Gen. Billy Mitchell

On September 12, 1918 at St. Mihiel in France, Col. William Mitchell became the first person ever to command a major force of Allied aircraft in a combined-arms operation. This battle was the debut of the US Army fighting under a single American commander on European soil. Under Mitchell's control, more than 1,100 allied aircraft worked in unison with ground forces in a broad offensive—one encompassing not only the advance of ground troops but also direct air attacks on enemy strategic targets, aircraft, communications, logistics, and forces beyond the front lines.

Mitchell was promoted to Brigadier General by order of Gen. John J. Pershing, commander of the American Expeditionary Force, in recognition of his command accomplishments during the St. Mihiel offensive and the subsequent Meuse-Argonne offensive.

After World War I, General Mitchell served in Washington and then became Commander, First Provisional Air Brigade, in 1921. That summer, he led joint Army and Navy demonstration attacks as bombs delivered from aircraft sank several captured German vessels, including SS *Ostfriesland*.

His determination to speak the truth about airpower and its importance to America led to a court-martial trial in 1925. Mitchell was convicted, and resigned from the service in February 1926.

Mitchell, through personal example and through his writing, inspired and encouraged a cadre of younger airmen. These included future General of the Air Force Henry H. Arnold, who led the two million-man Army Air Forces in World War II; Gen. Ira C. Eaker, who commanded the first bomber forces in Europe in 1942; and Gen. Carl A. Spaatz, who became the first Chief of Staff of the United States Air Force upon its charter of independence in 1947.

Mitchell died in 1936. One of the pallbearers at his funeral in Wisconsin was George Catlett Marshall, who was the chief ground-force planner for the St. Mihiel offensive.

ABOUT THE MITCHELL INSTITUTE: The General Billy Mitchell Institute for Airpower Studies, founded by the Air Force Association, seeks to honor the leadership of Brig. Gen. William Mitchell through timely and high-quality research and writing on airpower and its role in the security of this nation.

ABOUT THE AUTHORS: Dr. Dana J. Johnson is a senior analyst with the Northrop Grumman Analysis Center; Dr. Christopher J. Bowie is Corporate Director, NGAC; and Dr. Robert P. Haffa Jr. is Corporate Director, NGAC. (See p. 32 for biographies.)

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PREFACE

"Sixteen hours ago, an American airplane dropped one bomb on [name deleted] and destroyed its usefulness to the enemy." So wrote President Harry S. Truman in the opening line of the official, three-page White House press release announcing the dropping of the atomic bomb on the Japanese city of Hiroshima on Aug. 6, 1945.

At that moment, Air Force bombers became America's prime instruments of nuclear strike and, in time, nuclear deterrence. Thousands of bombers and countless air crew and ground personnel have maintained the nuclear bomber force as it grew from the first handful of B-29s to the B-52s and B-2s of today. More than a decade passed before land-based intercontinental ballistic missiles and submarine-based missiles came on alert, joining the bombers to form the nuclear Triad.

America's strategic nuclear triad has been the core of deterrence ever since, but that may be about to change. The authors of this Mitchell Paper—Dr. Dana Johnson, Dr. Chris Bowie, and Dr. Robert Haffa—point out that America is sliding almost inevitably toward a radical revision of the Triad. It's not just about pending cuts in warhead totals as the Obama Administration seeks new agreements with Russia. As the authors note, failures to modernize the Air Force bomber fleet and bomber nuclear weapons have the nation teetering on the edge of a "de facto dyad."

Every President from Truman to Obama has carried a heavy responsibility, being the person singularly entrusted with restraining or unleashing the power of the atom in time of war. To some, the burden may seem light today compared with the era of growing Soviet nuclear power and the massed arsenals of the Cold War. In fact, the nuclear deterrent has long relied on a "delicate balance of terror" to use the famous phrase by Albert Wohlstetter as recalled by the authors.

The burden on the President today is different, but no less acute or delicate. Long gone is the cold clarity born of facing a hostile Soviet Union and its nuclear forces. Peer threats remain, and proliferating threats are judged by many to be likely to grow. As the authors observe, "projections of peer and near-peer future nuclear capability give US planners much to ponder" as they seek to ensure that, in the future, a down-sized nuclear force "provides the required deterrence and stability." If the roster of nuclear actors expands, America may need more diversity from its deterrent.

The task of deciding how best to provide deterrence has become very difficult. Investment in strategic forces has plummeted. Calculated in FY 2008 constant dollars, the Pentagon invested $82 billion in strategic forces in 1962. For 2013, that number was projected to be just $8.8 billion. Yet all legs of the Triad require modernization. For the Air Force, the task is particularly tough since its bombers are the only part of the Triad currently available for conventional operations.

The urgent, subtle message of these three scholars is that America cannot do without a robust ICBM force and a new bomber to provide long-range airpower. Their innovative contribution to the debate is to recommend serious discussion of gradually eliminating the bomber from the main nuclear deterrent force. They would withdraw the venerable B-52s completely and the B-2s almost completely, leaving the stealth bomber with something of a niche nuclear mission. The result would be a dyad.

Johnson, Bowie, and Haffa note that the bomber force and its nuclear capability rely on both weapons and airframes. Retired Air Force Lt. Gen. Robert J. Elder, former commander of 8th Air Force, said as much earlier this year in remarks on why the Air Force was hoping for a new bomber by 2018. "Interestingly enough, it doesn't have to do so much with the B-52s going out, but I believe it's really tied to when the ALCM [air launched cruise missile] is getting ready to go out of the inventory," Elder observed to a group of defense writers in April.

With money so tight, Johnson, Bowie, and Haffa suggest nixing any research and development money for a new, nuclear-capable ALCM and redirecting it toward a conventional-only bomber. They recommend that the 20 B-2s retain their direct attack capability. The B-2 is exceptional in its stealth and nuclear hardening, designed to fly potential low-altitude missions where nuclear bombs had already gone off. Therefore, the B-2 can still carry out a direct attack role less dependent on stand-off weapons.

It is an astute argument, although one that the Air Force may find hard to embrace. Air Force officials have not wavered from their commitment to the nuclear bomber force. To date, top Air Force officials have been quietly persistent about the requirement for the next bomber and for nuclear capability on that next bomber. The bomber force retains unique abilities in signaling, and a flexibility that could be very important over the next several decades.

The work of these authors acknowledges the flexibility of the bomber force. However, by opting for a dyad of ICBMs and SLBMs, they transfer the remainder of the small, nuclear-capable B-2 force into the same category as F-16s with nuclear missions. The triad is discontinued and the bomber force reverts to a theater mission, albeit with highly desirable advantages in range.

Their work is bound to spark debate, and it should be welcomed for its bold effort to stimulate pragmatic thinking on the practicalities of nuclear deterrence. None dispute that the original Triad was an effective structure for deterrence. Yet the time has come to think through the capability that provides the best structure going forward.

No less a voice than Gen. Kevin P. Chilton, commander of US Strategic Command, has called for a return to serious thought about how to deter, who to deter, and what to deter with. Following the end of the Cold War, "we've skipped a generation of thought" about nuclear deterrence strategies. There has been a "holiday away from thought, serious thought, about deterrence," he told a Capitol Hill audience in mid-November 2009.

Read on for an excellent start to that re-evaluation of deterrence, the Triad, and the art of the possible.

Rebecca Grant, Director
Mitchell Institute for Airpower Studies
December 2009

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Shaping the US Nuclear Force for the Future

EXECUTIVE SUMMARY

The United States Department of Defense is currently engaged in a Congressionally mandated Nuclear Posture Review (NPR) to develop recommendations for future US nuclear forces. An important facet of this review is the ongoing negotiation with Russia over reducing planned numbers of deployed warheads and launchers. Under the terms of the Strategic Offensive Reductions Treaty (SORT, also known as the Moscow Treaty) US nuclear forces currently field about 2,200 warheads. Defense Secretary Robert Gates has indicated that the US could reduce to a floor of 1,500 deployed warheads, but cautioned going below that level owing to concerns regarding nuclear weapons proliferation and Russian and Chinese strategic force modernization.

This paper evaluates potential nuclear force posture options at the level of 1,500 deployed nuclear weapons using a range of metrics and cost considerations. Based on this analysis, we conclude that the United States should gradually shift to a Dyad of submarine-launched ballistic missiles (SLBMs) and land-based intercontinental ballistic missiles (ICBMs) as it shapes its nuclear force posture for the future.

The US is already moving in this direction: ICBMs and SLBMs remain robust, with modernization scheduled and funded, but the bomber force's future is in doubt. The aging Air Launched Cruise Missile (ALCM) calls into question the value of the B-52 fleet, while the modernized but very small B-2 force is assuming a niche role. Unless this path is altered, the United States will soon field a de facto nuclear Dyad.

For the near-term, we recommend that the United States should:

- Maintain the 450 ICBM force in light of the declining bomber leg
- Maintain the current ballistic missile submarine (designated SSBN) fleet and continue plans to develop the Ohio-class replacement
- Maintain and modernize the B-2 force to retain the capability to conduct discrete and selective nuclear strikes
- Phase out the B-52 from a nuclear role as ALCMs are retired from service
- Divert any planned investments dedicated to maintaining the B-52 in a

nuclear role—including research and development of a new ALCM— into a new conventional bomber, which could be manned or unmanned. Given that conventional long-range strike capabilities will be even more important in the emerging security environment, the R&D of a new nuclear cruise missile and a new nuclear bomber do not appear to be prudent investments in an era of nuclear force reductions.

INTRODUCTION

What should US strategic nuclear forces look like in the future? The United States Department of Defense has once again embarked on a Congressionally mandated Nuclear Posture Review (NPR) to establish nuclear deterrence policy, strategy, and force posture for the future.[1] This paper suggests a framework for analysis and makes recommendations regarding the future posture of the US nuclear deterrent force.

Previous nuclear policy reviews have made major adjustments to US nuclear strategy and forces. The 1993 NPR, following the "Bottom Up Review" of conventional forces and strategy, noted that the post-Cold War role of nuclear weapons in US security had diminished substantially and the United States could, with prudent hedging, reduce its nuclear arsenal.[2] In 2002, DOD conducted another nuclear policy review within an environment of uncertainty, military transformation, and capability-based planning.[3] While the traditional Triad of intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and long-range bombers was maintained, a "New Triad" included nuclear and non-nuclear strike capabilities, active and passive missile defenses, and a responsive nuclear weapons infrastructure. The review called for "the lowest number of nuclear weapons consistent with the security requirements of the US"[4] and set the stage for a significant reduction in operationally deployed nuclear warheads. The Strategic Offensive Reductions Treaty (SORT, also known as the Moscow Treaty) committed the US and Russia to reduce their number of operationally deployed nuclear warheads to 1,700-2,200 by the end of 2012.[5]

As a follow-on to the Strategic Arms Reduction Treaty (START, due to expire in December 2009) and possibly to SORT, the US and Russia are again engaged in arms control talks. In July 2009, the US and Russian Presidents signed an initial agreement to reduce strategic warheads to a range between 1,500 and 1,675, and their delivery vehicles to between 500 and 1,100. While the United States achieved the SORT force levels well before the deadline, it is unclear what future US nuclear forces should look like under these new limits.

This paper examines alternative options for optimizing deterrence and stability while reducing numbers of operationally deployed warheads (ODW) and strategic delivery vehicles. Here we focus on deterring the nuclear forces of peer or near-peer states—Russia and the People's Republic of China

(PRC)—and do not address threats posed by rogue states, fractured states possessing weapons of mass destruction (WMD) capabilities, or global terrorist threats. While not addressed in this paper, we presume that future force planning will take appropriate steps to deter and defend against these emerging threats.[6]

Both Russia and China are developing new strategic nuclear delivery systems. Although Russian strategic nuclear forces are projected to shrink over the next decade in accordance with arms control agreements, Russia is also developing new land and sea-based forces to replace aging inventories.[7] For example, Russia "completed the deployment of the silo-based Topol-M in late 2008 with 50 operational missiles,"[8] bringing its total to 383 ICBMs of five types carrying 1,350 nuclear warheads. The general in charge of the Russian ICBM force declared, "At least 96 percent of all missile systems are ready for deployment within several dozen seconds … the highest readiness level" within the Russian nuclear Triad.[9] The Russian Navy is also modernizing its SSBN fleet and the associated SLBMs. The SSBN fleet currently counts 10 SSBNs carrying 160 launchers and 576 warheads. The much-delayed Borey-class SSBN remains behind schedule, but plans for eight of those boats, armed with the new Bulava SLBM, are to compose "the core of Russian naval nuclear forces until 2040."[10]

The 2009 DOD report on Chinese military power asserted: "China has the most active land-based ballistic and cruise missile program in the world. It is developing and testing offensive missiles, forming additional missile units, qualitatively upgrading certain missile systems, and developing methods to counter ballistic missile defenses."[11] Over the last few years China has developed and deployed the new DF-31 missile, with projections by US intelligence that 75 to 100 ICBM warheads will be targeted against the United States by 2015.[12] At present, China has only one Xia-class SSBN but is building at least two more. Again, US intelligence predicts a fleet of perhaps five SSBNs, with capability similar to that of Britain and France's nuclear deterrent with "a near-continuous at-sea SSBN presence."

These projections of peer and near-peer future nuclear capability give US planners much to ponder as they seek to ensure that a future, downsized nuclear force provides the required deterrence and stability. We begin our analysis with a brief primer on the evolution of the US strategic triad, focusing on the concepts of deterrence and stability, and then turn to force structure options for the future.

THE EVOLUTION OF THE US NUCLEAR TRIAD

The detonation of the first atomic weapons over Hiroshima and Nagasaki in 1945 generated a fundamental rethinking of US national security strategy. As national leaders, strategists, and military officers attempted to come to grips with the implications of the new weapon, the first Soviet nuclear tests

and the development of the even more destructive hydrogen bomb further complicated these efforts. Given the stakes—national survival—much strategic debate ensued. Massive retaliation, counter-value, counter-force, escalation, unacceptable damage, mutual assured destruction—these are just some of the concepts and terms that became part of the discussion. The focus of this debate was on deterrence. As Bernard Brodie wrote in 1946 in his seminal work, *The Absolute Weapon: Atomic Power and World Order*, "thus far the purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them." But how to convince an adversary equipped with such weapons that any attack would risk their own destruction? And how to declare that intent without increasing instability—that is, posture nuclear deterrent forces to assure destruction without increasing an adversary's incentive to strike first?

Concurrent technical advancements in nuclear weapons and in the vehicles used to deliver them complicated the strategic debate and shifted force planning and investment. Propeller-driven bombers were supplanted by jet bombers. Land-based liquid fueled missiles launched from complex gantries were replaced by solid-fueled missiles housed in concrete silos. Giant nuclear submarines armed with highly accurate, sub-surface-launched ballistic missiles entered the force. Weapons miniaturization enabled bombers and missiles to carry multiple warheads while advances in guidance systems increased accuracy and lethality. The pace of technological change was both steady and breathtaking.

With these developments came the recognition of the vulnerability of these forces to a preemptive first strike by an opponent. Thus, the concept of a synergistic, mutually supportive "Triad" of strategic nuclear forces evolved. A Triad of forces underpins nuclear deterrence and stability by reducing the possibility that US nuclear capability could be eliminated by a single point of failure. Moreover, the Triad added increased credibility and assurance of the "nuclear umbrella" extended to US friends and allies. Consisting of long-range bombers, land-based ICBMs, and SSBNs, each leg of the Triad brought not only the ability to assure the adversary's destruction, but also a range of factors and attributes to maintain stability and complicate an adversary's attack planning.[13]

DETERRENCE

As the number of atomic weapons and their destructiveness increased in the 1950s and 1960s, US nuclear strategy focused on deterrence. Deterrence by punishment meant that no matter what type of attack was mounted, the attacker would be hit with a devastating riposte—an "assured second strike capability"—outweighing any prospect of expected gain. The characteristics of a nation's nuclear force posture were critical to assuring deterrence. Yet the desired capabilities of that force depended on how national decision-makers chose to answer the question, "what deters?"

One answer, "the ability to inflict assured destruction," emphasized survivable, second strike forces and counter-value targeting. But an alternative response, "the ability to wage nuclear war," led to a more robust and flexible counterforce capability.[14] Given the enormity of the consequences should deterrence fail, US Cold War decision-makers essentially chose both targeting strategies. As the Triad of forces evolved, efforts to maintain deterrence in a long-term competition of action-reaction emphasized the number of warheads on alert, the related number of aimpoints posing targeting challenges for an adversary considering a first strike, the promptness of the force in retaliation, and the ability of that retaliatory force to penetrate any enemy defenses. Because we will, in later pages, use this framework to evaluate the shape of the future US nuclear force, some elaboration of each of these attributes is useful here.

The number of weapons on alert: As David Rosenberg has documented in his study of early US nuclear strategy, from the time of the nation's first Single Integrated Operational Plan (SIOP), the force planning emphasis was placed on capabilities, rather than objectives, mandating large nuclear forces in what was termed a "background of plenty" in nuclear weapons and delivery vehicles.[15] Rosenberg notes that both the Truman and the Eisenhower Administrations promoted expansion of US strategic nuclear forces, and the fielding of an ICBM force in addition to the existing bomber fleet simply added to the numbers of weapon systems on alert.[16] By the time Defense Secretary Robert S. McNamara sought to rationalize US nuclear forces in the mid-1960s, he did so on the basis of extremely conservative assumptions. While original assumptions of the number of warheads required for deterrence had suggested that the ability to destroy in retaliation 25 percent of the Soviet population and 50 percent of its industrial capacity was sufficient, assignment to meet this requirement to each of the legs of the Triad resulted, by 1968, in the ability of US forces to destroy 50 percent of the population and 80 percent of the USSR's industry.[17]

As the US-Soviet strategic competition moderated during the Cold War, and concepts of "strategic sufficiency" took hold, arsenals on both sides were stabilized, and then reduced, often under the mantle of arms control agreements. SALT I, the first series of Strategic Arms Limitation Talks, extended from November 1969 to May 1972. In a summit meeting in Moscow, after two and a half years of negotiation, the first round of SALT was brought to a conclusion when President Richard Nixon and General Secretary Leonid Brezhnev signed the Anti-Ballistic Missile (ABM) Treaty and the Interim Agreement on strategic offensive arms. The principal focus of the Strategic Arms Reductions Treaty (START I, first proposed by President Ronald Reagan in the early 1980s) was to establish counting rules limiting each side to 6,000 nuclear warheads. As the number of deployed warheads was reduced, so were alert levels, with the understanding that under a nuclear détente, the fear of a "bolt-from-the-blue" strike had receded. Post-Cold War, the United States removed its bomber force from nuclear alert in 1991, while maintaining the full ICBM fleet on alert and a significant portion of the SSBN fleet at sea to hedge against a sudden nuclear crisis.

The number of aimpoints: The first step in any calculation determining nuclear force levels is to determine the number, type, and location of enemy targets that must be held at risk. Driving the large number of US nuclear forces in the 1950s, multiplied by a strategy emphasizing counterforce targeting, was a SAC target list totaling 3,261, with estimates suggesting that list would grow to more than 10,000 by 1970.[18] US basing plans for its own forces did not reach those levels, but a planned force of 3,000 Minuteman ICBMs and basing for more than 900 bombers would surely complicate the life of a Soviet war planner. Clearly, as force levels have been reduced, so have aimpoints on both sides. But to strengthen deterrence, with a nod to stability, the thrust has generally been to distribute warheads across a number of aimpoints, rather than to concentrate them in a single target base. In the ICBM force, for example, reductions in the total number of deployed warheads over the last 15 years have been partially achieved by retiring the Minuteman II, the Peacekeeper with its multiple warheads, and moving to a distributed force of Minuteman IIIs predominantly fitted with single warheads. Thus, deterrence was strengthened by complicating the enemy's targeting calculus with multiple aimpoints.

The ability to penetrate: Another important factor in the calculation of strategic force requirements is the ability of each type of vehicle to penetrate possible enemy defenses. For warheads on either sea- or land-based intercontinental missiles, the only challenge to penetration was any missile defense system the adversary might deploy. Cold War analyses, however, judged that the Soviet Union could easily negate any ballistic missile system by simply overwhelming it with multiple targets, decoys, and warheads.[19] The 1972 Anti-Ballistic Missile Treaty established the primacy of deterrence over defense and limited the development and testing of ballistic missile defenses for both the United States and the Soviet Union. Successful target penetration remains an issue for US systems.

As for the bomber fleet, active air defenses on both sides, including ground-based defenses and air defense fighters armed with nuclear air-to-air missiles challenged the bomber's ability to penetrate. Countermeasures to increase penetration included routing around defenses, low-level flying, electronic jamming, escort fighters, and defense suppression. A case study here was the proposal for the B-70 bomber, planned to replace the B-52 in the 1960s. But the B-70 was poorly designed to penetrate enemy defenses, particularly the surface-to-air missile threat, owing to its high-altitude profile and large radar and infrared signature. The solution for the bomber fleet was to stand off from those defenses and to launch long-range cruise missiles, as the B-52 has been equipped to do, or to resort to stealth as featured in the B-2. Yet both of these approaches remain problematic against sophisticated and integrated air defenses. Regardless of platform, the weapons themselves must also be highly reliable to bolster the probability of target destruction. Periodic testing and exercises can thus demonstrate to an adversary that, when required, missiles and bombers will be able to launch and execute their missions—and warheads will detonate when delivered.

The promptness of the response: Deterrence based on assured destruction depended on retaliating with forces that had survived a first strike. Thus, US Cold War declaratory policy was not to launch on warning, but rather to ride out an attack before responding. Nevertheless, to enhance deterrence and assure that some portion of the land-based force would survive, ICBMs, with their high alert rates and readiness, were capable of being launched under attack. This "prompt retaliatory launch" capability, which might also apply to SLBMs on station if they were alerted in times of crisis, was seen as adding to the adversary's uncertainty in calculating the probability of success of a first strike. The ability to respond promptly also went to the command, control, and communications networks in place, especially missile warning systems using multiple phenomenologies (electro-optical/infrared and radar) for confirmation of attack. Owing to the ICBM's high alert rate and continuous secure communications links, it has been that leg of the Triad that has promised the most immediate response. Of course, it was the vulnerability of the ICBM silos that led to such an option in the first place; if the surviving portion of the land-based missile force was judged to be too small to carry out the targeting strategy, then some portion of that force would be required to launch under attack.[20]

STABILITY

As the US nuclear triad evolved to underwrite deterrence, it became clear that forces that could not survive a first strike would not only fail to deter, they might actually invite attack, particularly in times of crisis. And if one side detected a weakness that might be exploited in a first strike, then that calculation might certainly be responded to in kind by the other—resulting in a spiral of preemptive moves that could spin out of control. Thus, US strategic nuclear forces were judged not only on their destructive power, but on their ability to "reduce the pressures facing either superpower leader in a crisis to launch a nuclear first strike against the homeland of the other."[21] Missile silos were hardened, bombers were dispersed and submarines made quieter, all in pursuit of the goal of lessening the vulnerability of those forces to a first strike. But as Albert Wohlstetter had warned in his classic *Foreign Affairs* article, the "balance of terror"[22] remained delicate, the sources of safety were not permanent, and continued efforts were required to assure that the leader of a nuclear superpower would not be pressured by the posture of his forces to strike first in a time of crisis. In examining requirements for stability in a future force, we revisit the characteristics that contributed to stability during the Cold War: the survivability of the force (day-to-day and generated); the connectivity and ease of retargeting the force; and the ability to signal readiness changes through states and stages of alert.

Day-to-day survivability was a critical element in reinforcing stability. SSBNs armed with SLBMs relied on the constantly changing ocean environment to hide from enemy forces—if the submarines could not be located, an adversary could not target them. Bombers could disperse to a wide range of

bases to complicate an enemy's targeting problem. From these locations, bombers on alert could flush upon warning to make it very difficult to destroy them on their bases; in severe crises, bombers could maintain continuous airborne patrols to further complicate an enemy's attack strategy.

In the 1950s, ICBMs were mounted on above-ground launchers that were fixed in location. A nuclear strike detonating close to the launcher could disable the missile. Moving the missiles into hardened silos required an adversary's attack to be extremely accurate to knock out the missile; ICBMs housed in silos were hardened targets only vulnerable to almost direct hits. Moreover, the silos were distributed over large areas to ensure some would survive a strike. Mobile ICBMs, as developed and fielded by the Soviets, and as flirted with by the US in the Peacekeeper and Small ICBM programs, could use their mobility to enhance survivability.

Generated alert and crisis stability: Technological advances on both sides posed additional challenges to stability. Ballistic missiles can fly intercontinental distances in a matter of minutes and are viewed as "prompt" systems. Their high speed engenders instability, since an adversary may be able to strike before the targeted nation is able to generate forces and respond. The development of Multiple Independently targetable Re-Entry Vehicle (MIRV) missile payloads also generated significant instability. A large missile, such as the Soviet SS-18 or the US Peacekeeper, could carry up to 10 MIRVs, resulting in two destabilizing attributes. First, a single missile could theoretically destroy five to 10 enemy targets—an attractive first-strike cost-benefit ratio. Second, each side had a strong incentive to attempt to destroy the multi-warhead SS-18s or Peacekeepers before launch to limit damage in an exchange. Therefore, each side had an incentive to strike first with MIRVs, while retaining single-warhead missiles as a means of reestablishing intra-war deterrence after a counterforce exchange. To avoid this situation, the United States has moved to single warhead ICBMs to maximize stability and encouraged Russia to adopt a similar course. Thus, there was a decided difference in the stabilizing properties of the legs of the Triad under generated alert scenarios. Because ICBMs had to rely on the hardness of their silos or an ability to be launched under attack—a destabilizing strategy—they became stabilizing by having fewer warheads and becoming a less lucrative target. The other two legs, under generated conditions, increased their weapons load along with their mobility: Bombers could be placed on alert or vertically or horizontally dispersed, and SSBNs could sortie from their ports to seek sanctuary (and assure destruction) from their designated sub-surface launch points.

Connectivity and ease of retargeting: Command system vulnerability was always a concern in a nuclear scenario and various measures were established to ensure connectivity with each Triad leg.[23] These measures included command and control (C2) survivability through the Looking Glass aircraft, and airborne and missile-launched relays to ensure the Emergency Action Message (EAM) was successfully transmitted to the force. SSBNs received perhaps the greatest attention here owing to the fact that deployed sub-

Table 1: Estimated O&S and Replacement Costs by Triad Leg
Billions of FY2010 Dollars

Launcher	Annual O&S	Required Programs	RDT&E/Acq 2010-50
ICBM	$1.1	various modifications	$44.0
SLBM (SSBN)	$2.6	SLBM-X (Ohio-class replacement)	$104.0
Bomber	$1.7	new bomber	$68.0

Note: Assumes 450 ICBMs, 336 SLBMs, 19 B-2s, and 76 B-52Hs.
Sources: See Appendix.

marines enjoyed a high probability of survival after a nuclear strike, but C2 systems did not. However, other legs of the Triad were stressed as well: Launching ICBMs under attack would certainly stretch the capabilities of connectivity, and once airborne, bombers had a narrow time window to receive attack orders or any change to their pre-assigned mission. Connectivity calculations, therefore, were different for each Triad leg, and those calculations were very dependent on the function of time. Therefore, each element of the Triad deserved to be evaluated in terms of connectivity and flexibility according to its own operational needs. Submarines, for example, do well as a retaliatory force against pre-planned targets, but are not very suitable for a prompt response. ICBMs are challenged by the communications ability to launch under attack, as well as making effective use of the operational missiles that survive a first strike. Bomber operations, possessing the advantages of recall and retargeting, are perhaps the most complex of the three in terms of connectivity. Dispersal, positive control launch, target release messages, and rerouting or retargeting are distinct phases of airborne operations requiring a layered, secure, and redundant C2 system.

Signaling alert/readiness changes: An important element of stability is the capability to send signals during a crisis. Bombers are the most flexible tool in this regard. Bombers can be used to signal concern by increasing alert levels, dispersing, or flying to airborne alert orbit locations, but because of their slow flight speed (relative to missiles), they do not pose a serious threat of a surprise "bolt-from-the-blue" attack. Bombers can also be recalled once launched—a capability that missiles do not possess. SSBNs can embark from their ports to increase the number of submarines on station—transmitting highly significant signals that alert levels (and concern) are increasing. Conversely, SSBNs on station can surface to show themselves or return to port, demonstrating that tensions have eased. Mobile ICBMs, like SSBNs, can also deploy from garrison to send signals, but ICBMs in silos have little capability in this regard. In all of these moves, there is a delicate relationship between sending signals of resolve, thus enhancing deterrence, and positioning forces for a strike, thereby decreasing crisis stability.

Costs: While not on par with other Triad attributes, cost plays an important role in future strategic force planning. Each leg of the Triad requires different levels of investment to own and operate. Table 1 (above) provides an esti-

mate of the annual operating cost of each Triad leg and the estimated costs of replacing or sustaining each leg over the next 40 years. The numbers of forces in each leg are derived from current US strategic nuclear forces under START and SORT. (Table 2 below)

Based on US experience, ICBMs in silos are the lowest cost system to operate and can be maintained on high levels of alert. The current missiles will remain effective, with some modest upgrades, for the next 20 years (to 2030).[24] Both bombers and SSBNs/SLBMs are significantly more expensive to operate and procure. SLBMs cost about the same to acquire as ICBMs, but require a very expensive and sophisticated launch platform, the SSBN. Bombers are also expensive (relative to ICBMs) to operate and procure, though these are the only elements of the Triad that currently also provide conventional capabilities. The US has employed both B-52s and B-2s in the Kosovo, Afghanistan, and Iraq campaigns. As we move to develop our future forces, resource constraints will play an important role in US deliberations.

Table 2: US Strategic Nuclear Forces Under SORT and START

	SORT		START	
System	**Platforms**	**Weapons**	**Platforms**	**Weapons**
ICBM				
Minuteman III	450	550	500	1,200
Peacekeeper	0	0	50	400
SLBM				
Trident II	288 (+48*)	1,152	336	2,688
Trident I	0	0	96	576
Bomber				
B-1B	0	0	71	n/a
B-2	19	184	19	n/a
B-52	76	240	126	n/a
unallocated	0	0	0	712
	833 (881*)	**2,126**	**1,198**	**5,576**

Note: The term "weapons" refers to operationally deployed bombs and warheads.
****Sea-based leg under SORT assumes 12 on-station SSBNs (two others in overhaul), each with 24 tubes.***

Sources: US Department of State Bureau of Verification, Compliance, and Implementation, "The Legacy of START and Related US Policies," Fact Sheet, July 16, 2009 (http://www.state.gov/t/vci/trty/index.htm); Robert S. Norris and Hans M. Kristensen, "Nuclear Notebook: US nuclear forces, 2009,"* Bulletin of the Atomic Scientists, *March/April 2009, p. 61; US State Department, Bureau of Verification, Compliance, and Implementation, "START Aggregate Numbers of Strategic Offensive Arms"; contribution from National Institute for Public Policy.

STATUS OF THE US TRIAD

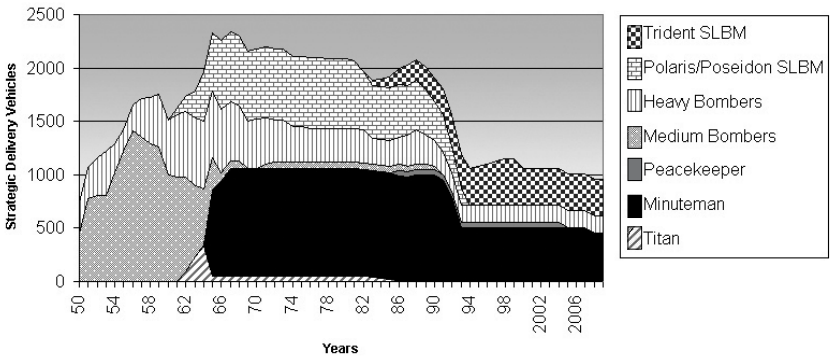
Figure 1 (below) shows the evolution of the US nuclear Triad in terms of strategic nuclear delivery vehicles from 1950 to the present day. Following World War II, the bomber was the only platform available—the US force structure consisted primarily of medium bombers (B-29s followed by B-47s and B-58s) and a growing proportion of heavy intercontinental bombers (B-36s followed by B-52s, then B-1Bs and B-2s in the 1980s-90s).

Ballistic missiles were also developed and used in World War II and entered US operational service in the late 1950s. Initially, intermediate range missiles based overseas were followed by the first intercontinental systems, such as the liquid-fueled Titan and then the smaller solid-fueled Minuteman. The latter, housed in hardened silos, became the backbone of the ICBM leg.

As the US Air Force fielded 1,000 ICBMs at missile fields located primarily in the center of the country, it simultaneously retired almost all its medium bombers and a significant portion of the heavy bomber force. The speed at which the bomber-centric USAF conducted this revolutionary shift was spurred in part by the rapid development and fielding of the US Navy's Polaris missile submarine force. The Navy combined the long-endurance nuclear submarine with solid-fueled missiles capable of being launched underwater. By the mid-1960s, the general shape of the Triad was in place.

Throughout the Cold War each leg was modernized to meet an evolving threat. B-52s were fitted with cruise missiles and then augmented by low-flying B-1s and stealthy B-2s. Minuteman and Peacekeeper missiles added MIRVs with greater accuracy. Polaris submarines were replaced by the more

Figure 1: Evolution of the US Nuclear Force Posture



Sources: The USAF force structure is drawn from an Air Force database compiled by Col. James Ruehrmund, HQ USAF, in 2005, and the US Navy Force Structure compiled by http://www.shipbuildinghistory.com/ from Naval History Center and Naval Vessel Registry (http://www.shipbuildinghistory.com/today/statistics/force.htm).

capable Ohio-class equipped with the longer-range and more accurate Trident missile, increasing potential patrol areas and options for employment.

Since the end of the Cold War, the US national security community has deliberated potential changes in nuclear policy and force planning to meet a reduced but more diverse threat. The post-Cold War Nuclear Policy Reviews recognized that the Triad of nuclear forces were somewhat anachronistic, but also acknowledged that the principles of deterrence and stability could not be easily abandoned. The vision of a world in which nuclear weapons play a diminishing role had widespread appeal. How should the current Triad of strategic forces be both downsized and modernized to support those objectives?

The USAF currently fields 450 Minuteman III ICBMs in three missile fields. The missiles are always on alert, meaning that any number of them could be launched immediately after a Presidential decision to respond to an attack. Minuteman III modernization and sustainment programs are extending the life of the system out to 2030. The Air Force is currently exploring whether to extend Minuteman's operational life to 2050 or to design and field a new ICBM.

The US Navy currently deploys 14 Ohio-class SSBNs, each equipped with 24 missile tubes fitted with the Trident D-5 missile. Two of the 14 submarines are in overhaul at any one time, leaving 12 boats for deployment. Of these, two SSBNs are in firing locations and two submarines are at sea on their way to relieve the boats on station. The Navy plans to retire the Ohio-class submarine fleet beginning in 2027. The FY10 defense budget allocates funds to begin developing a new SSBN that should be operational by 2025. The Navy plans to reduce the number of boats to 12 (10 in deployment, two in overhaul), and the number of tubes per boat will likely range between 16 and 24 (to be decided after the 2009 NPR). Furthermore, the D-5 missile's life is planned to be extended to 2042.

Of the three Triad legs, the air-breathing leg has encountered the most turbulence. In the 1980s, USAF planned to procure 100 B-1Bs and 132 B-2s, enabling retirement of the B-52. Post-Cold War, the B-2 procurement was cut to just 21 aircraft, requiring maintaining portions of the B-52 fleet. In the 1990s, largely because of arms control reductions, the B-1Bs were reconfigured to carry only conventional weapons, leaving the B-2s and B-52s in a nuclear role. Subsequently, the B-2s were upgraded with improvements in radar cross section, avionics, communications gear, and armaments to enhance their capability to penetrate enemy air defenses. The B-52s, assigned a stand-off delivery role, are armed with two types of cruise missiles: the ALCM, dating back to the 1970s, and the stealthy Advanced Cruise Missile (ACM) fielded in the 1990s. Currently, the Air Force maintains an arsenal of 1,140 ALCMs, but intends to cut the total number to 528 in support of Moscow Treaty reductions. A Service Life Extension Plan (SLEP) to extend ALCM service life to FY30 is in place, but concerns remain about the aging cruise missile fleet, largely because components and support equipment are becoming both obsolescent and unaffordable.[25] ACM procurement was halted

at 460 missiles in lieu of the originally planned 1,460, the last missile was delivered in 1993, and the Air Force is retiring the ACM because of reliability issues and higher maintenance costs.[26]

Overall, then, the bomber leg consists of just 20 B-2 penetrating bombers and 94 B-52 standoff bombers armed with weapons of questionable reliability. USAF had begun development of a new bomber scheduled for fielding in 2018, but in April 2009, Secretary Gates suspended funding for the program, leaving bomber modernization in disarray. Consequently, given the overall weakness of the bomber leg, the US strategic nuclear Triad may be moving to a "de facto dyad."

Arms control and strategic arms limitation agreements between the former Soviet Union, now Russia, and the United States have shaped the current Triad and will continue to do so. Table 2 provides an overview of current US nuclear forces in terms of strategic nuclear delivery vehicles and the numbers of operationally deployed warheads under the 1991 START and 2002 SORT treaties. About half of the warheads are in SLBMs; about 25 percent are in ICBMs, and the remaining warheads are carried by bombers.

For the ICBMs, silos count as platforms; the United States currently has more silos than warheads due to the retirement of the Peacekeeper ICBM. While SLBMs are currently armed with about four warheads per missile, the ICBMs are moving toward single warheads as being more stabilizing—that is, they provide a less lucrative target in times of nuclear crisis.

As noted earlier, the United States and Russia are engaged in treaty negotiations and have signed an initial agreement as a follow-on to START. The new levels agreed to are reducing strategic warheads to between 1,500 and 1,675, and delivery vehicles to between 500 and 1,100. Prior to the signing of the July 2009 initial agreement, US Defense Secretary Gates stated that he envisioned a strong possibility of going below the 1,700 to 2,200 deployed warheads, but he had concerns about discussions of going below 1,500, given the array of worldwide proliferation and Russian and Chinese modernization.[27] Given the US is now at the 2,200 level, what is the best way to eliminate about 700 ODW, while maintaining the deterrent value and stabilizing characteristics of the Triad? We now turn to an exploration of a range of force structure options.

ALTERNATIVE FORCE STRUCTURE OPTIONS

There are a number of ways to reduce the overall Triad force posture from 2,200 to 1,500 warheads, and some alternatives are shown in Figure 2 (page 20).

We started first with the Triad as a frame of reference for assessing the other potential alternatives. Of the possible Monad alternatives, we focused on the SLBM Monad based on historical examples of British and French

strategic forces. Of the possible Dyad alternatives, we considered the three potential cases shown in Figure 2.

As discussed earlier, a number of factors—stability, survivability, reliability, credibility, responsiveness, and cost-effectiveness—serve to shape and size the current Triad. Key attributes that contribute to the deterrent value of each leg of the Triad can be derived from these factors and used as means of evaluation of the options. To enable a comparison, we developed a "spider chart" format as illustrated in Figure 3 (page 21). Each of the options was compared to the current Triad using these attributes to provide a visualization of their performance. With exception of warheads on alert, these attributes are subjective judgments based on our collective knowledge to provide a basis for analysis and discussion. We also examined the combined deterrent value of the option by using shading to illustrate the extent to which the Triad attributes are satisfied.

The following criteria define the axes of the "spider" charts shown for each option:

■ **Warheads on Alert (Alert Rate) (829 today):** Bombers (B-2s and B-52s) are currently not on alert, hence zero percent. For SSBNs, four of 14 boats are on patrol (though typically only two are in firing boxes).[28] Typically, 99 percent of the ICBMs are on alert.

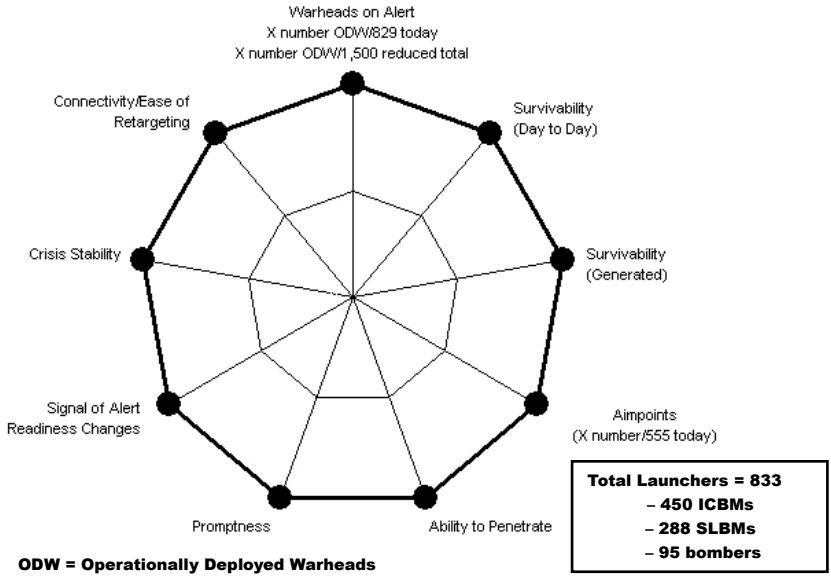
■ **Survivability (Day-to-Day):** This estimates the potential vulnerability of each leg to a "bolt out of blue" strike. Bombers currently are not generated, hence could be caught on their bases. SSBNs at sea are highly survivable, but those in port are not. ICBMs with high alert rates could either ride out an attack (risking loss) or launch while under attack. Launch on warning is a de-

Figure 2: Potential Posture Options Considered for Reduced Warhead Count

Relative to today's Triad (ICBMs, SLBMs, long-range strategic nuclear bombers), what are the capabilities of potential alternatives?

Range of Alternatives	Alternatives Examined
■ Triad – ICBMs, SLBMs, bombers	■ Triad – ICBMs, SLBMs, bombers
■ Monad – SLBMs only – ICBMs only – Bombers only	■ Monad – SLBMs only
■ Dyad – SLBMs and bombers – ICBMs and bombers – SLBMs and ICBMs	■ Dyad – SLBMs and bombers – ICBMs and bombers – SLBMs and ICBMs

Figure 3: Potential Posture Options Are Measured Against Existing Triad Attributes



stabilizing strategy not considered here, but an adversary could, of course, not dismiss such a potential reaction.

■ **Survivability (Generated):** The SSBN and bomber legs of the Triad become more survivable as they are generated and depart their fixed bases or ports. But these high generation rates cannot be sustained for long periods of time.

■ **Aimpoints:** The total number of submarine and bomber bases and individual ICBM silos at risk from an attack equate to enemy counterforce aimpoints. Currently the US maintains two submarine ports (Bangor, Wash., and Kings Bay, Ga.) and three strategic bomber bases (B-52s at Minot AFB, N.D., and Barksdale AFB, La., and B-2s at Whiteman AFB, Mo.); three missile wings have 550 ICBM silos spread across five Western states. Options with a small number of aimpoints are less stabilizing because an adversary could have an incentive to strike during crisis.

■ **Ability to Penetrate:** Due to their high speed and the difficulty of intercepting their re-entry vehicles, ICBMs and SLBMs feature a higher probability of surviving defenses than do penetrating bombers or air launched cruise missiles.

■ **Promptness:** The entire force of ICBMs can strike targets within 30 minutes of launch. The same holds true for SLBMs from patrol positions, but does not hold true for those submarines in port or out of launch position. Bombers are hours away from striking after launch.

■ **Signal of Alert Readiness Changes:** Bombers and submarines offer the most potential to send signals to an adversary. Bombers can be armed and positioned on alert pads or launched to conduct airborne alerts. SLBMs at sea offer little capability to send signals given the risks of compromising their location, but sending submarines to sea to increase the number on patrol would send a powerful signal of US concern. ICBMs offer minimal capability to signal increased alert levels to an adversary owing to their consistent high level of readiness.

■ **Crisis Stability:** One of the fundamental tenets of the Triad is to reduce incentives for adversaries to strike first. Each leg contributes to stability differently depending on the number of aimpoints it presents to an adversary, pre-strike survivability characteristics, and speed or time to target.

■ **Connectivity/Retargetability:** Links to in-flight bombers and SSBNs are more limited compared to the ICBM fleet, which has dedicated land lines combined with other communications. Bombers, unlike missiles, can be retargeted or recalled once in flight.

With these attributes in mind, we will evaluate each of the potential posture options.

Monad Option

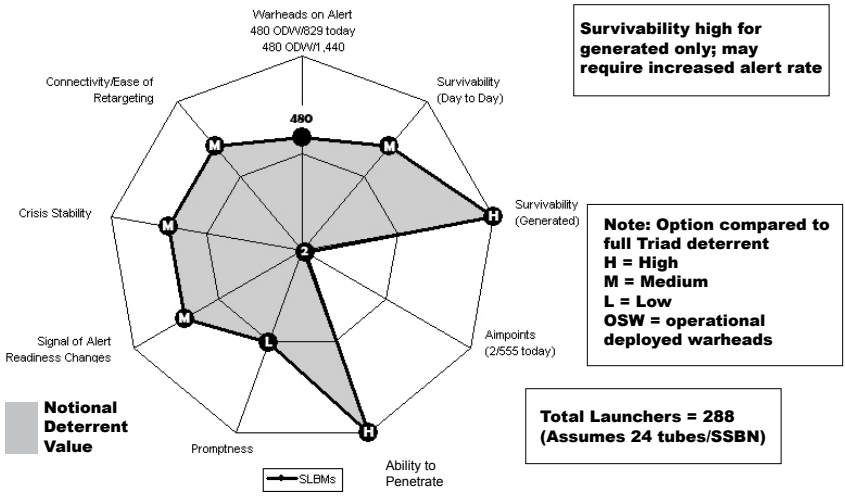
If the United States were to choose a Monad for its future strategic force, the SSBN would probably be the leg of choice owing to its survivability at sea and flexible weapons loads. Currently, the US fields 1,152 SLBM warheads, so meeting a 1,500 warhead goal would require adding additional warheads (MIRVs) to some number of Trident missiles, or increasing the number of SSBNs.

SSBNs at sea are highly survivable, but those submarines in the two coastal home ports would be vulnerable to a small attack (and even to a potential strike by terrorists). To reduce vulnerability, the US could increase alert rates, but such a decision would increase operational costs and decrease the service life of the force. In addition, going to a SSBN Monad runs the risk of an anti-submarine warfare breakthrough, or a single technical point of failure rendering the force vulnerable or incapable.

Figure 4 (page 23) illustrates the relative performance of the SSBN Monad against the current Triad. The number of warheads on alert is less than half of the current Triad. Increasing the number of boats at sea could increase the number of warheads, but, as noted previously, would cost more and eat into the life of the submarine. In terms of survivability and penetrability, the Monad option is relatively similar, but fares far less well in other important attributes, notably numbers of aimpoints (two) and connectivity.

To signal concern, additional SSBNs could be put to sea, but this is a significant escalatory step that could, over time, stress the submarines and their crews.

Figure 4: SLBM Monad Assessment



Dyad Option 1: SLBMs and Bombers

The first of the Dyad options examines a combination of SLBMs and bombers (per Table 1, 288 Trident D-5s, 76 B-52s, and 19 B-2s).

Here the US has added flexibility to the SSBN leg with the strategic bomber force. Combining the SLBMs and bombers would yield approximately 1,600 ODW and would require a slight reduction to reach the 1,500 goal. Reductions could be met by retiring SSBNs and adding warheads to the bombers, or, more likely, retiring some portion of the bomber fleet and keeping the 14 SSBNs.

This option presents the worst case for survivability of all the options. In a "bolt from the blue" attack, just five dedicated nuclear strikes could take out all three strategic nuclear bomber bases and the two submarine bases, leaving the US with just the SSBNs at sea.

Figure 5 (page 24) assesses this Dyad option, and it clearly shows that except for the signaling potential, the bombers do not add much to the SSBN-based Monad. Alert rates and survivability could be raised for both legs, but this would also increase day-to-day operating costs. Overall, this does not appear to be an attractive option.

Dyad Option 2: Bombers and ICBMs

The second of the three Dyad options assumes the deterrent force rests on ICBMs and bombers. Here, all SSBNs are retired, meaning the US would need to install additional warheads on some of the ICBMs or convert some of the B-1Bs back to the nuclear role to achieve the 1,500 warhead goal.

Figure 5: Dyad Option 1 (SLBMs and Bombers) Assessment

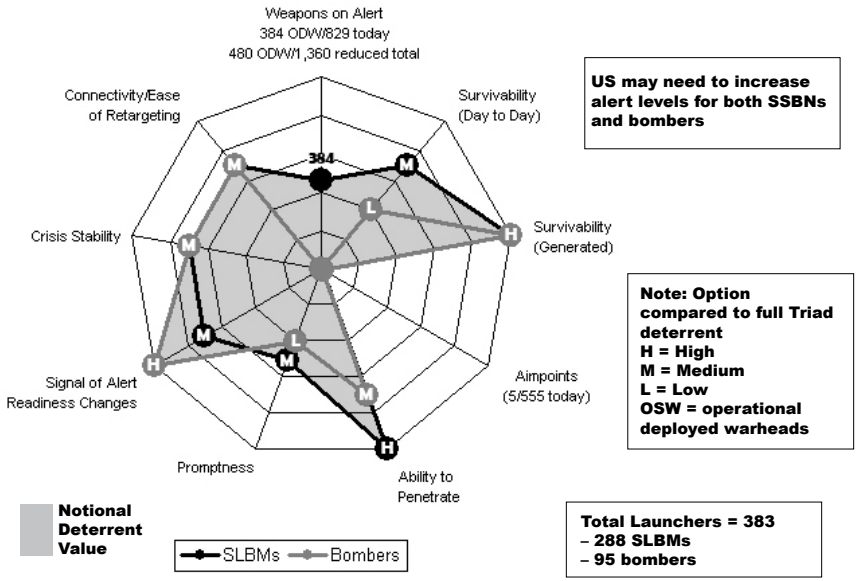
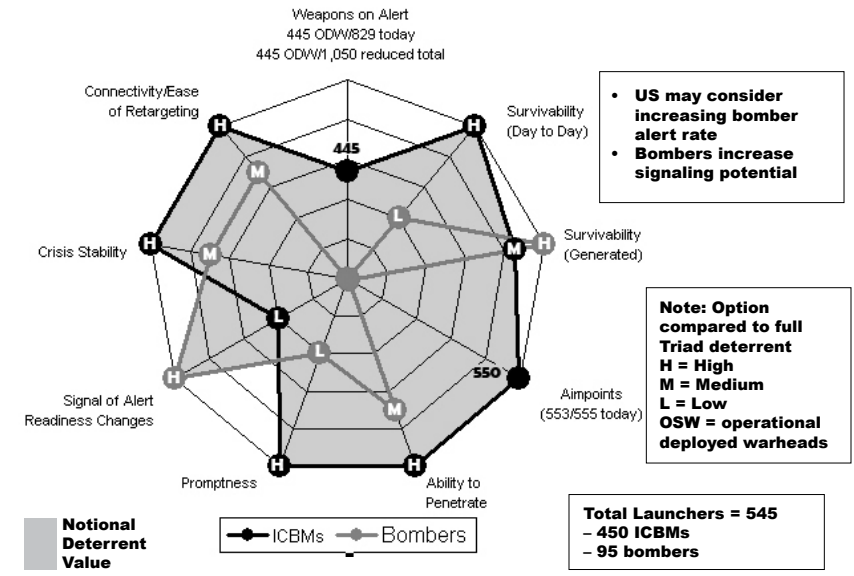


Figure 6: Dyad Option 2 (ICBMs and Bombers) Assessment



While single-warhead ICBMs enhance stability, increasing the warhead count on the ICBM leg might adversely affect crisis stability, as a single missile with MIRVs becomes a much more lucrative—and, in times of crisis—a more tempting target.

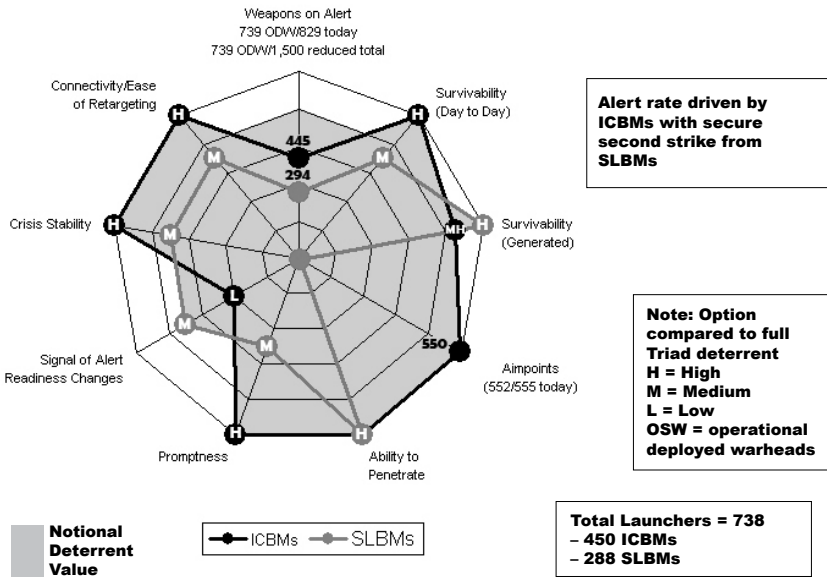
Figure 6 (page 24) reveals that the attractiveness of this option lies primarily in the ICBM leg. With the exception of signaling potential carried by the bombers, the ICBMs dominate this force, having the greatest number of aimpoints—550—of all three legs, and satisfying the majority of the current Triad attributes. While signaling is a bomber advantage, the bomber leg in this option offers few benefits comparatively. The United States could consider increasing bomber alert rates, if day-to-day survivability became a concern, but this would significantly increase day-to-day operating costs.

Dyad Option 3: ICBMs and SLBMs

The third Dyad option combines ICBMs and SLBMs. The bombers are assumed to be retired or converted to a conventional role. The total warheads represented by the two legs approximate 1,700, thus requiring some reductions. This could be done by retiring SLBMs or ICBMs—or to enhance stability, by reducing the warhead count on the SLBMs slightly.

Figure 7 (below) illustrates the clear advantages that this option has over the other Dyad options and that it compares favorably to the existing Triad in deterrent value and stability. The number of operationally deployed war-

Figure 7: Dyad Option 3 (ICBMs and SLBMs) Assessment



heads on alert for this option is close to what is in the Triad today: 445 ICBMs and 294 SLBMs equate to 739 ODW. SLBMs offer a secure second strike capability and can help in sending signals of US concern. The ICBM force offers a large number of warheads on alert (445), a large number of aimpoints (550), connectivity, promptness, and crisis stability. In terms of day-to-day survivability, the large number of aimpoints makes it difficult for an adversary to strike without expending a significant proportion of its warheads. For generated survivability, the ICBMs are probably slightly more vulnerable to a strike than SLBMs (though the US could launch under attack to minimize its ICBM losses).

Overall, if the US adopted a Dyad, this option offers the maximum deterrent value relative to today's Triad, and maintains its stabilizing properties.

Comparing the Options

The Triad remains the most attractive overall strategic force structure option. But maintaining the Triad's viability for the future requires a significant investment in the bomber leg—an investment that, thus far, the US has been unwilling to make.

The SLBM Monad does not appear attractive. Changing submarine operations, tactics, and doctrine would be required to make it a survivable force. Furthermore, it opens up the United States to technological surprise that could place the strategic deterrent at risk.

Of the Dyads we examined, the ICBM/SLBM combination offers the greatest similarity to the attributes of the current Triad and appears to offer the most attractive alternative from a deterrence standpoint.

Cost Considerations

Up to now in our analysis of alternative force structure options we have not addressed cost considerations, and a preliminary estimate is now warranted. Table 3 (page 27) compares the costs of the various options in two areas: annual operating cost and investment cost (development plus procurement). The Triad, the most attractive strategically, is also the most costly in both operating and investment costs. Of the three legs, the ICBMs require the least investment—essentially, modification and upgrade spending—and are also the lowest cost to operate on a day-to-day basis. Both of the other legs, however, will require significant investment. The Navy must develop and procure a new submarine force, estimated at roughly $123 billion. For the bomber force, the delay in the development of a new aircraft means that USAF must first procure a new ALCM to keep the B-52s viable (estimated at a cost of roughly $15 billion) and then a new bomber (estimated at roughly $105 billion).

Because of the low cost of retaining the ICBMs, the most attractive Dyad option (ICBMs and SLBMs) is roughly the same cost as the SLBM Monad and would clearly be preferable.

Table 3: Costs of Alternative Nuclear Force Postures
Billions of FY 2010 Dollars

OPTION	O&S COSTS ANNUAL	RDT&E/ACQ COSTS FY 2010-50
Triad	(Assumes 450 ICBMs, 14 SSBNs, 336 SLBMs, 19 B-2s, 76 B-52s)	
ICBM	$1.1	$10.0
SLBM (SSBN)	$2.6	$141.0
Bomber	$1.7	$89.0
Total	**$5.4**	**$240.0**
Monad	(Assumes current numbers of SSBNs and SLBMs but with increased MIRVs)	
SLBM (SSBN)	$2.6	$141.0
Total	**$2.6**	**$141.0**
Dyad No. 1	(Assumes maintaining 14 boats and retiring 25 B-52s to meet 1,500 ODW)	
SLBM (SSBN)	$2.6	$141.0
Bomber	$1.4	$89.0
Total	**$4.0**	**$230.0**
Dyad No. 2	(Assumes adding MIRVs to 450 ICBMs and maintaining 95 bombers to meet 1,500 ODW)	
ICBM	$1.1	$10.0
Bomber	$1.7	$89.0
Total	**$2.8**	**$99.0**
Dyad No. 3	(Assumes maintaining 450 ICBMs and reducing SLBM MIRVs to meet 1,500 ODW)	
ICBM	$1.1	$10.0
SLBM (SSBN)	$2.6	$141.0
Total	**$3.7**	**$151.0**

Note: In all SLBM options, number of SSBNs remain at 14. All options with ICBM assume ICBM mods; all options with sea-based systems assume SLBM-X and SSBN-X; all options with bombers assume new bomber and ALCM-X.

Sources and assumptions: See Appendix.

CONCLUSIONS AND RECOMMENDATIONS: A DE FACTO DYAD

Based on this analysis, we conclude that the US Department of Defense should pursue an ICBM/SLBM Dyad as it moves to reshape its nuclear force posture at lower warhead levels. Essentially, the US is already moving in this direction: the ICBMs and SLBMs remain robust, with modernization scheduled and funded, but the aging ALCM calls into question the value of

the B-52 fleet, while the modernized but very small B-2 force is assuming a niche role. In short, the United States will soon field a de facto nuclear Dyad.

Rather than evolving to a Dyad by default, we believe that the following steps should be taken as a way to hedge against force structure changes, policy developments, and budgetary uncertainties. For the near term, the United States should:

- Maintain the 450 ICBM force as a substitute for the declining bomber leg.

- Maintain the current SSBN fleet and continue plans to develop the Ohio-class replacement.

- Maintain and modernize the B-2 force to retain the capability to conduct nuclear strikes.

- Phase out the B-52 from a nuclear role as the ALCMs are retired from service.

- Divest any planned investments dedicated to keeping the B-52 in a nuclear role and put them into a new conventional bomber that could be manned or unmanned. This divestiture would also include R&D funding of a new nuclear-capable ALCM. Although conventional long-range strike capabilities will be even more important in the emerging security environment, the research and development of a new nuclear cruise missile and a new nuclear bomber do not appear to be prudent investments in an era of nuclear force reductions.

These steps will enable the United States to leverage the strengths of the ICBM and SLBM forces while minimizing the weaknesses of the nuclear-capable bomber as that leg of the Triad is phased out. Prudent decisions about nuclear weapons and delivery vehicles for the future—under arms control ceilings limiting deployed weapons and launchers—demand deliberation within a framework of deterrent attributes and stabilizing outcomes such as offered here. We believe a Dyad of modernized ICBMs and SLBMs will provide for strategic nuclear deterrence and stability in the years ahead, while allowing and encouraging needed investments in long-range conventional strike. ■

APPENDIX: COST ANALYSIS

Sources

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Methodology and Assumptions

SSBNs/SLBMs: Current SSBN count consists of 12 operational SSBNs and two SSBNs in overhaul, 24 tubes per boat. Ohio-class Replacement lifetime = 42 years, to 2070; D-5 SLEP to 2045, with new SLBM-X afterwards; RDT&E and Acquisition cost number includes 12 boats planned with tubes per boat likely to be between 16 and 24 (to be decided after 2009 Nuclear Posture Review). Development and procurement costs derived from Kosiak. Operations and sustainment (O&S) estimates for SSBNs derived from CBO and inflated to $FY10.

Bombers: New Bomber costs derived from Kosiak; another source assumes 100 aircraft at $60-80 billion, averaged to $70 billion; see O'Rourke, p. 10. O&S for bombers derived from GAO and inflated to $FY10. ALCM-X costs assume ACM unit cost of $14.5 million ($FY10), excluding warhead costs, from Brookings.

ICBMs: Assumes $250 million per year investment in ICBM upgrades and modifications for 40 years. Operations and sustainment (O&S) estimates for ICBMs derived from CBO and inflated to $FY10.

END NOTES

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4. US Department of Defense, "Findings of the Nuclear Posture Review," January 9, 2002 (http://www.defenselink.mil/dodcmsshare/briefingslide/120/020109-D-6570C-001.pdf).

5. Donald H. Rumsfeld, "Nuclear Posture Review Report" Cover Letter transmitting document to Congress (Washington D.C.: Department of Defense, January 9, 2002). The actual report is classified. (http://www.defenselink.mil/news/Jan2002/d20020109npr.pdf)

6. Nevertheless, those existing and emerging nuclear threats must be considered in US nuclear strategy and forces, whether they be additive or inclusive to the force options developed here. More to the point, but beyond the scope of this paper, new actors in a "second nuclear age" may be less deterrable than those who occupied the first. To meet those new challenges, the US "nuclear umbrella" of the future may need to be reinforced by long-range conventional strike systems and missile defenses. See Robert Haffa, Ravi Hichkad, Dana Johnson, and Phil Pratt, "Deterrence and Defense in the 'Second Nuclear Age' " (Washington, D.C., Northrop Grumman Analysis Center, March 2009) (http://www.northropgrumman.com/analysis-center/paper/assets/Deterrence-and-Defense-in-seco.pdf).

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8. Norris and Kristensen.

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10. Norris and Kristensen.

11. US Department of Defense, "Annual Report to the Congress: Military Power of the People's Republic of China 2009," 48.

12. Norris and Kristensen, "Nuclear Notebook: Chinese nuclear forces, 2008," *The Bulletin of the Atomic Scientists*, July/August 2008 (http://thebulletin.metapress.com/content/25094v7235832574/fulltext.pdf).

13. This discussion of deterrent factors and attributes is drawn from Haffa, Hichkad, Johnson, and Pratt, 14-16.

14. See the opposing arguments advanced by Robert Jervis, "Why Nuclear Superiority Doesn't Matter," and Colin Gray, "Nuclear Strategy: The Case for a Theory of Victory," in John F. Reichart and Steven R. Sturm (eds.), *American Defense Policy* (5th edition) (Baltimore: The Johns Hopkins University Press, 1982) 161-187.

15. David Alan Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," *International Security* Spring 1983 (7:4).

16. Rosenberg: When Eisenhower left office, SAC had 538 B-52s, 1,292 B-47s, 19 B-58s, plus 1,094 tankers. Twelve Atlas ICBMs had been deployed with construction plans calling for 650 ICBMs and fourteen Polaris submarines, each armed with sixteen missiles.

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