CHAPTER 22

PRECISION-GUIDED CONVENTIONAL WEAPONS

Yevgeny Miasnikov

The signing of the New START Treaty in Prague raised hopes that the United States and Russia would, once it entered into effect, pursue their dialogue to overcome the burdensome legacy of the Cold War represented by mutual nuclear deterrence, which to this day remains a real impediment to greater efforts on nuclear disarmament. During the upcoming stage, however, the two sides will most likely continue to be constrained by the old paradigms for defining the roles and composition of nuclear weapons. Thus, in reviewing the possibilities for subsequent strategic arms reductions, one main criterion will continue to be the survivability of the future strategic forces under any conceivable event scenario. This conclusion is particularly applicable to Russia, where for nearly two decades doubts have been raised about the survivability of the country's strategic forces.

The counterforce capabilities issue has been a continual topic in previous bilateral strategic arms negotiations. The survivability of strategic forces is affected by such factors as nuclear arms that may effectively disable fixed and mobile ICBM launchers. However, conventional weapons may also threaten the survivability of strategic forces, particularly if they possess stealth capabilities, high precision, and lethality, and could reach their targets relatively quickly. Today, this class of weapons includes long-range sea-launched and air-launched cruise missiles (SLCMs/ALCMs) and powerful air bombs and guided missiles, which can be delivered by U.S. heavy bombers and tactical aviation deployed close to Russian territory. In the future, ICBMs and SLBMs, as well as hypersonic glide vehicles, could be fitted with conventional warheads. These weapon types will be referred to in the present article collectively as "precision-guided weapons" (PGWs).[1]

A number of experts believe that PGWs pose a greater threat to the survivability of Russian SNFs over the medium term than do ballistic missile defenses, since over this timeframe no technological breakthroughs are anticipated that could significantly improve the effectiveness of BMD against ICBMs, while at the same time the United States has already amassed a considerable counterforce capability for its PGWs, which in the future will only grow.[2]

The decisions currently being made by the United States with respect to the development of its armed forces have served only to reinforce Russia's concerns. Recent U.S. Department of Defense policy papers have emphasized the development of precision-guided weapons and their supporting information technology and infrastructure. U.S. military doctrine has also been gradually shifting from a reliance upon its nuclear arsenal to precision-guided conventional weapons.[3]

One rather striking example of this trend can be seen in the appearance of the Global Strike strategy, which provides for maintaining a capability to conduct rapid, remote high-precision strikes against remote targets anywhere on the globe.[4] Under this new concept, some strategic delivery systems have currently been reconfigured for "non-nuclear" missions. Programs for converting U.S. strategic bombers to such missions have existed since the 1990s. In 2008, work was completed on refitting four Ohio class nuclear-powered submarines to carry long-range SLCMs. Each submarine is capable of carrying up to 154 Tomahawk SLCMs. The stealth capabilities of the Ohio class submarines and the lack of reliable technical means for detecting SLBMs at launch or in flight, as well as the increased destructive capability of the prospective types of Tomahawk cruise missiles, suggest that even with conventional warheads, these systems may have a significant counterforce capability, and thus evoke natural concern among the Russian expert community.[5] The U.S. Navy and Air Force are currently carrying out scientific research projects aimed at developing effective conventional warheads to be used for arming strategic ballistic missiles, and only restrictions imposed by the U.S. Congress have prevented the full-scale deployment of such weapons.[6] According to documents published in February 2010 (the U.S. Defense Department's Quadrennial Defense Review Report and the proposed annual Defense Department Budget for Fiscal Year 2011), this trend will accelerate.[7] The April 2010 Nuclear Posture Review Report also underscored the need to develop non-nuclear strategic weapons.[8]

In his well known policy address delivered in Prague on April 5, 2009, not long after he had assumed office, U.S. President Barack Obama announced that the goal of the United States was to free the entire world of nuclear weapons. Many Russian experts interpreted this appeal as being nothing other than a U.S. attempt to secure strategic invulnerability for itself and to conduct a more aggressive foreign policy in light of the overwhelming conventional weapons superiority that the United States already enjoys over other nations.[9]

One of the most important tasks facing the Soviet Armed Forces since at least the early 1980s was to defend the nation's strategic forces against the threat of enemy attack involving conventional weapons delivered through the air and space.[10] Over recent years, such dangers have also been highlighted in documents that define the positions of the military and political leadership in the Russian government. Both the Russian National Security Strategy to 2020 and the Military Doctrine of the Russian Federation (approved in 2009 and 2010, respectively) identified deployment of strategic conventional precision-guided arms as one of the main military threats facing the Russian Federation, along with the development and deployment of strategic missile defenses and the militarization of space. At the same time, the Military Doctrine notes that one characteristic feature of contemporary military conflicts is a massive use of weapons and military equipment based on new physical principles that are comparable to nuclear weapons in terms of effectiveness.

The Counterforce Capabilities and Development Outlook of U.S. Precision-Guided Weapons

In previous works, the author has examined in some detail the existing U.S. precision-guided weapons that might possess counterforce capabilities.[11] Such weapons systems would include a broad range of weapon types, from laser-guided bombs to long-range, air-launched and sea-launched cruise missiles, and could be delivered either by strategic delivery vehicles (such as heavy bombers or nuclear submarines) or non-strategic ones (tactical aviation and combat ships). As these assessments show, by 2015 the U.S. armed forces could potentially maintain some 130 delivery vehicles (B-2 and B-52 heavy bombers and nuclear-powered attack submarines armed with long-range SLCMs) capable of covert strikes. Overall, these systems could potentially deliver around 3,000 high-precision weapons to their targets. The potential range of PGW delivery vehicles capable of challenging Russia's strategic nuclear forces may very well increase by several fold in the future if Russia's air defense and antisubmarine capabilities should decline to a level that could allow an adversary to establish dominance over the air space or at sea near the country's borders. In such a case, Russia's strategic sites could also be subject to attack by B-1B strategic bombers, sea-launched SLCMs, U.S. naval carrier aviation, and NATO's tactical aviation (if based in the Baltic region or the Transcaucasus). Even B-1B strategic bombers alone would be capable of delivering some 1,600 PGWs to their targets.

A review of the U.S. Department of Defense's ongoing weapons development programs that are being conducted under the Global Strike strategy is presented below.

In October 2002, the U.S. Strategic Command (STRATCOM), which historically had only been involved in nuclear planning, merged with the U.S. Space Command (SPACECOM), with the resulting agency gaining much broader functions, including to maintain a capability of conducting rapid, remote high-precision kinetic (both conventionally armed and nuclear) and non-contact strikes (using space or information weaponry) against targets anywhere on the globe.[12] The Global Strike strategy was developed with this very mission in mind.

According to the Global Strike strategy, the United States could face an urgent need to launch a pre-emptive strike in order to quickly destroy a limited number of either stationary or mobile targets lying beyond the reach of forward deployed forces (regionally deployed Air Force and Navy tactical aircraft). For example, ICBMs and SLBMs could deliver their payloads nearly anywhere in the world within just 30 to 40 minutes. It would take substantially longer to plan and conduct such missions using tactical aircraft and would require the permission of neighboring states to overfly their territories. Moreover, tactical aircraft would also be vulnerable to the actions of the air defenses of the country under attack.

Potential targets that are usually mentioned for the systems being developed under the Global Strike strategy are anti-satellite and air defense systems, ballistic missiles, and sites containing weapons of mass destruction (WMDs), as well as such targets of strategic significance as the adversary's command structure.[13] This list of targets could also be expanded to include terrorist bases or stocks of WMDs or their delivery systems under their control.

It should further be noted that within the framework of the Global Strike strategy, the Pentagon is also considering using its non-nuclear capabilities against strategic targets that had previously been targeted by nuclear weapons.[14] The experts believe that between 10 and 30 percent of such targets could potentially be destroyed through the use of non-nuclear strategic weapons.[15]

Implementation of the Global Strike strategy began in August 2004 with the approval by the chairman of the Joint Chiefs of Staff of CONPLAN 8022, which presented conceptual contingency plans for conducting preemptive attacks against targets of a likely opponent, with individual missions developed during the Global Lightning 06 strategic training exercises conducted in October 2005.[16]

In order to apply the goals of the Global Strike concept, strategic delivery vehicles are considered from the standpoint of both their current configuration and their potential new configuration (SLBMs and ICBMs armed with non-nuclear warheads, CAV-type maneuverable hypersonic flight vehicles, and such non-kinetic weapons as lasers, high-power microwave weapons, and information warfare). The ballistic missiles currently in service in the United States are capable of delivering only nuclear warheads, which severely narrows the selection of potential scenarios available to Global Strike. For this reason, the strategic command structure over the past few years has lobbied for accelerating the development of conventional-type warheads that could be precisely delivered to remote targets using such systems as SLBMs, ICBMs, and hypersonic flight vehicles, a concept which has been named Prompt Global Strike (PGS). Over recent years, the development of this concept of PGS has been subjected to significant changes due both to delays in the scientific research and development work, and to Congressional unwillingness to fund the wide-scale production and deployment of such systems. On the whole, Congress has been receptive to the declared need for the military command to have the means to rapidly deliver non-nuclear strategic strikes in remote spots anywhere on the globe. However, programs dealing with the refit of ballistic missiles with non-nuclear warheads continue to encounter quite strong resistance from opponents, who argue that it would be difficult to distinguish between launches of ballistic missiles configured for non-nuclear warheads and launches of ballistic missiles armed with nuclear warheads, and that this could provoke other countries to respond with a nuclear strike. This would be particularly true for the non-nuclear SLBMs slated for deployment on strategic submarines that carry nuclear missiles as well. For this reason, Congress has thus far elected to continue financing the research programs while reducing funding for deployment preparation.

After the new U.S. administration announced its course to be toward the elimination of all nuclear weapons on the planet, the PGS concept gained new impetus for development. The Quadrennial Defense Review Report published in February 2010[17] placed an emphasis on continued development along PGS lines, although in contrast to the review of 2006 it did not spell out which particular strike forces would be deployed first. The Pentagon's research and development budget provides for major spending increases through 2015, which will nearly triple the program's current expenditures.

Non-nuclear ICBMs. For several years, the U.S. Air Force has been developing the concept of using ICBMs in non-nuclear configuration under the Conventional Strike Missile (CSM) program. Although initially not a priority compared to other PGS programs, by mid-2008 this program had come to the forefront.[18]

As a source of potential delivery vehicles, the plan also considered the option of deploying decommissioned Minuteman II and MX ICBMs, which in their non-nuclear configuration have been given the code names Minotaur II and Minotaur III, respectively.[19] Rather than deploying these missiles at existing ICBM bases, the plan would place them in undefended locations along the East and West Coasts,[20] such as Cape Canaveral Air Force Station in Florida or Vandenberg Air Force Base in California. This would enable the U.S. Air Force to meet several objectives simultaneously: to make launches of non-nuclear ICBMs clearly distinguishable from launches of ICBMs armed with nuclear warheads; to avoid having the separated stages of ICBMs fall onto Canadian or U.S. territory (as would happen if they were launched from current bases); to move ICBM deployment sites closer to their potential targets (particularly North Korea and Iran); and, to the extent possible, to avoid having the missiles overfly Russia or China on the way to their targets.

Among the advantages of using ICBMs for PGS operations compared to SLBMs is their greater level of command expeditiousness in executing orders to attack. In contrast to SLBMs, the MX ICBMs are able to carry larger payloads.[21] Also, basing "conventional" ICBMs separately from ICBMs armed with nuclear warheads would theoretically make it feasible to differentiate between launches of such missiles, which would not be possible for missiles launched from submarines.

By early 2009, consideration centered on three alternative weapons configurations for the intercontinental CSMs that could be implemented over the short term.[22] The first version, proposed by Textron Systems, was the modular BLU-108 consisting of 10 cartridges, each of which would contain four further shaped-charge smart Skeet submunitions. The second option, named "Rods from God," was proposed by Sandia National Laboratory and involved the use of high-mass, high-density metal rods of tungsten or uranium possessing great kinetic potential. Each warhead delivered by an ICBM would contain several such rods, which would be released upon reentry into the denser layers of the atmosphere to carpet the target area. The third option, called "Hell Storm," was proposed by Lawrence Livermore National Laboratory and involved warheads containing earth-penetrating elements. In 2008, the Johns Hopkins University Applied Physics Laboratory signed a contract with the Department of Defense to evaluate the effectiveness of each of the three warhead designs for Global Strike operations. Nevertheless, the proposal from Lawrence Livermore National Laboratory has been slated for flight testing and effectiveness evaluation beginning in 2010 or 2011. The U.S. Air Force had planned to begin deploying intercontinental CSMs no later than 2015,[23] although experts have admitted that this might not happen before 2017.[24]

Hypersonic Glide Vehicles. In the more distant future, ICBMs may also deliver the highly maneuverable guided hypersonic glider (engineless) vehicles known as the Common Aero Vehicle (CAV), first developed in 2002 under the U.S. FALCON (Force Application and Launch from Continental U.S.) program jointly by the U.S. Air Force and the DARPA agency. The CAV would be able to alter its flight path perpendicularly to its ballistic trajectory by as much as 5,500 kilometers and would carry a weapons load of around 450 kilograms. In particular, they are expected to be able to carry modular warheads with self-guided elements (such as the BLU-108) or penetrating projectiles able to destroy targets deep underground due to their high speed (up to 1.2 kilometers per second at impact with earth).[25]

When it passed the 2005 budget, the U.S. Congress prohibited any further research into the project (in either its nuclear or conventional configurations) until measures are adopted to remove any potential misinterpretation by third countries of a CAV attack. The Congress also prohibited any testing or research activities related to the vehicle's potential deployment on ICBMs or SLBMs. This required structural changes, as well as a name change, from the CAV to the Hypersonic Glide Vehicle (HGV).

The project is currently at the stage of completing preparations for test launching the two HTV-2 hypersonic test vehicle prototypes aboard Minotaur IV Lite boosters at Vandenberg Space Launch Complex. The glider vehicles must be able to travel at over 15 to 20 times the speed of sound and reenter the atmosphere at altitudes of 50 to 70 kilometers. These experiments are intended to check the durability of the vehicle's thermal insulation, as well as the reliability of the navigation and guidance systems during prolonged hypersonic flight. For the first flight, the hypersonic vehicle (the HTV-2A) "will fly essentially straight downrange, while HTV-2B will travel along more of a curved trajectory to test the vehicle's ability to maneuver significantly cross range."[26] The HTV-2 tests have been delayed repeatedly; as of February 2010 they were scheduled for the third quarter of fiscal year 2010 and the second quarter of fiscal year 2011, respectively.[27] In June 2008, Lockheed Martin signed a contract to modify the HTV-2 to equip it with a warhead. The modified vehicle is due to undergo testing in 2012.[28]

In parallel with the Hypersonic Glide Vehicle project, research and development is also being pursued on the Advanced Hypersonic Weapon (AHW) program, which is also intended to create a hypersonic glide vehicle able to deliver payloads of up to 450 kilograms over intercontinental distances. This project is a joint effort by the U.S. Army and Sandia National Laboratory, and it is seen as being a fall-back option with regard to the HGV. It is anticipated that the glider would be launched from forward positions (Guam or Diego Garcia) using launch boosters developed by Orbital Sciences Corporation for its GBI (ground-based interceptor). Since the ICBM together with the hypersonic vehicle it would carry would weigh only about 20 tons, it is believed that they could be transported by air.[29] Testing on the AHW prototype has been scheduled for the third quarter of fiscal year 2011. This vehicle will be launched from the Kauai Test Facility in Hawaii on a STARS booster, such as has already been used to launch the target missiles for the Missile Defense Agency's GBI interceptor missile tests.[30]

Non-nuclear SLBMs. The United States has been interested in arming its SLBMs with conventional warheads to destroy hard and deeply buried targets since the 1990s, when it concluded that the delivery accuracy needed to be much greater in order for them to be effective.[31] The draft U.S. Department of Defense budget for fiscal year 2003 submitted to Congress for approval included the Enhanced Effectiveness (E2) Initiative, which was expected to be conducted over three years, culminating in early 2007 with full-scale flight testing. However, in both 2003 and 2004 Congress refused to allocate funds for the program, and the Navy subsequently dropped it from its budget request, although Lockheed Martin has continued the research at its own expense.

E2 had been designed to combine the existing inertial guidance system of the Mk4 warhead with a system for adjusting the flight path based upon data received from satellite radionavigation global positioning system (GPS) technologies to achieve a delivery accuracy for the Mk4 of up to 10 meters for stationary targets.[32] Other data suggest that this research program pursued more modest purposes: to expand the spectrum of missions available to the W76 nuclear warhead by improving its accuracy.[33] As part of this research, Lockheed Martin carried out two flight tests using the Trident SLBM. During the experiment conducted in 2002, the practical possibility of improving delivery accuracy through aerodynamic steering during its reentry into the atmosphere was demonstrated. According to a company representative, the second experiment, conducted in early 2005, showed that it was possible not only to steer toward a target with improved accuracy, but also to slow the warhead down and "control the impact conditions."[34]

The U.S. 2006 Quadrennial Defense Review set a deadline of two years to equip the Trident SLBM with conventional warheads.[35] That same year, the U.S. administration included the corresponding Conventional Trident Modification (CTM) program in its draft budget for 2007, designed to arm two of the 24 SLBMs carried by each ballistic missile submarine with non-nuclear warheads. Under the Navy's plan, each "conventional" Trident would carry up to four modified non-nuclear Mk4 warheads.[36] Two types of non-nuclear warheads would be developed. One type would be a metal slug that would land with such tremendous force it could smash a building. The other type of warhead would be a flechette bomb, which would disperse tungsten rods to destroy mobile vehicles and less well-protected targets over a broader area.[37]

Advocates of fitting SLBMs with non-nuclear warheads have cited a number of advantages over ground-based ICBMs:[38]

- SLBMs can be deployed closer to their potential targets than ICBMs, thus reducing flight time;
- unlike the ICBM, SLBM flight paths can be chosen in such a way as to preclude overflying the territory of countries for which such launches could be of concern or even provoke an untoward response. In particular, in an attack against potential targets in North Korea or Iran, land-based ICBMs launched from their current locations of deployment would inevitably fly over Russian territory;
- the relative flexibility of SLBMs in the selection of an optimal flight path also makes it possible to minimize or even altogether exclude incidental damage associated with spent missile stages falling in third countries;
- the Trident enhanced effectiveness program has been developed in more technical detail than the similar program for the Minuteman ICBM; thus, results could be expected more rapidly;
- unlike Minuteman ICBMs, Trident II SLBMs continue to be mass produced; thus, their modification would involve lower costs.

One central technical issue that has continued to complicate the use of ballistic missiles is the need for greater accuracy in delivering conventional warheads to target. According to experts, the existing inertial guidance systems of the Trident II missile can provide a circular error probable (CEP) of up to 50 meters,[39] which elicits some doubt. Although accuracy of this degree might be adequate for neutralizing soft targets over wide areas or carrying out strikes using non-kinetic weapons, it would need to be enhanced by an order of magnitude in order to attack individual targets, especially deeply buried hard targets.[40] The accuracy of warheads delivered by missile can be improved using a GPS signal during the terminal flight phase to make corrections to the flight trajectory, and this was the way the problem had been posed to developers.[41] However, the trajectory correction method suffers from a fundamental drawback in use. During reentry and braking, the reentry vehicle carrying the warhead is enveloped in a layer of high-temperature plasma that completely blocks GPS radio signals. How close U.S. developers have come to solving this problem is difficult to say. According to U.S. Strategic Command Chief General Cartwright, the accuracy achieved during test launches of ballistic missiles has been five meters.[42] These figures would most likely only apply to short-range tests, where the speed of the warhead at reentry is relatively low and the portion of the flight path over which GPS signals are inaccessible is correspondingly short. A statement made by one of the participants in the March 2005 Trident II test launch indirectly confirmed this suspicion by reporting that the warhead had been receiving GPS signals throughout its flight path. It is known that the flat trajectory flown during this experiment was at a record low altitude for this type of SLBM (only 2,200 kilometers) and flight time from launch to warhead impact was 12 to 13 minutes.[43]

Although the Conventional Trident Modification Program had been a top priority for the U.S. Department of Defense for a rather prolonged period, the U.S. Congress had steadfastly refused to fund the plan fully. Nevertheless, the idea of equipping SLBMs with conventional warheads continues to be discussed. In particular, the National Research Council, which had been created to evaluate potential Prompt Global Strike options, concluded that the Trident Modification Program had advantages over the other alternatives in its speed of implementation, financial cost, technical risks, and needed changes to the military doctrine.[44] Scientific research to enhance the accuracy of the conventional warheads for the Trident SLBM has continued in recent years, in spite of Congressional objections. The Life Extension Test Bed-2 (LETB-2) flight testing conducted in early September 2009[45] will be continued at the end of 2012 or early 2013. Although in its 2011 draft budget request the Department of Defense did not seek funding for the Trident Modification Program, the U.S. military command still intends to proceed with research to develop conventionally armed SLBMs.[46]

Funding of PGS Programs. Before 2007, all development of ballistic missiles and hypersonic glide vehicles with non-nuclear warheads was funded through various individual Navy and Air Force programs (including the CTM and the HGV).[47] The Pentagon requested around $208 million for these programs in its draft budget for fiscal year 2008. During discussions on the budget, Congress decided to create a separate integrated PGS program that would have coordinated the development of all PGS kinetic weapons and allocated about $100 million for this task in 2008. At the same time, however, Congress also eliminated all funds that had been requested for the CTM program ($126.4 million). The allocated money had been intended to fund research and development for the HGV and CSM prototypes and preparations for their flight testing. In addition, under the new program funds were allocated for the development of alternative options to support the Navy's research. In its draft budget for fiscal year 2009 the Pentagon requested $117.6 million for PGS, but Congress approved only $69.9 million, refusing to fund the development of a conventional warhead for the Medium Lift Reentry Body (MLRB) vehicle and flight testing of the maneuverable LETB-2 warhead. Moreover, Congress required that no less than a quarter of the allocated funds ($19 million) be used to fund the joint U.S. Army-Sandia National Laboratory Advanced Hypersonic Weapon (AHW) program. The draft 2010 budget provided $166.9 million for the PGS program, which was approved by lawmakers in essentially full measure.

In February 2010, the U.S. Department of Defense published its draft budget for fiscal year 2011, which indicated that it was requesting $239.9 million for the PGS program.[48] These funds were planned for the following uses in 2011:

- continuation of the HGW program – $136.6 million;
- continuation of the AHW program – $69 million;
- preparation of test facilities at Vandenberg Air Force Base – $24 million; and
- further development of the Prompt Global Strike strategy – $10.3 million.

In the future, the Pentagon plans to substantially increase spending on this budget item. According to a most recent document, $238.5 million will be requested for the PGS program in 2012, $274 million in 2013, $374 million in 2014, and $574.6 million in 2015. Curiously, the draft 2009 budget had indicated a much more modest spending level on PGS: $112 million in 2011, $81 million in 2012, and $82.3 million in 2013.[49] This apparently indicates that the U.S. Department of Defense expects to successfully conclude PGS research and development and begin deployment of strategic weapons armed with non-nuclear warheads.

The Counterforce Potential of PGWs: What the Foreign Experts Think

By contrast with the Russian experts, only a few of their American colleagues share the view that conventional weapons must be taken into consideration in future reductions of strategic offensive weapons. This can be partially explained by the fact that over the past twenty years there has been no discussion in the United States on the issue of the survivability of strategic nuclear forces. There was a common perception that the U.S. strategic forces were survivable, simply because strategic submarines are invulnerable. For this reason, Russian concerns have frequently not been fully comprehended in the United States. Nevertheless, it must be noted that there have been a number of papers published in recent years by U.S. experts in which they have attempted to quantify the counterforce capabilities of certain PGWs.

In particular, Dennis Gormley examined the threat posed to silo-based ICBMs by the Tomahawk missile,[50] admitting that neither Russia nor the United States have the kind of air defense systems that would allow them to reliably detect such missiles at launch from a submarine or in flight. Nevertheless, he concluded that Tomahawk cruise missiles do not represent a threat to silo launchers for two reasons: the warheads that the Tomahawk delivers are incapable of effectively disabling silo launchers; and the range of the cruise missiles is too short to attack all missiles in silo launchers deployed within the borders of the Russian Federation.

While it is possible to agree with Gormley's conclusion that high-explosive blast fragmentation or combined effects submunitions pose no threat to silo launchers, the paper does not mention the fact that the U.S. Navy is currently pursuing the Joint Multi-Effects Warhead System (JMEWS) program aimed at developing a tandem shaped charge warhead for the Tomahawk sea-launched cruise missile.[51] Although the warheads of guided anti-tank missiles based upon this principle weigh only a few kilograms, they are capable of penetrating armor that is more than a meter thick. Although publically available documents say little about the destructive power of large shaped charge effect weapons, it is known that they are being developed. In particular, Lawrence Livermore National Laboratory successfully tested a fairly large shaped charge warhead in 1997 that was able to punch a 3.4 meter-long hole in armor plate.[52]

In defending his conclusion that conventional Tomahawk cruise missiles would be technically unsuitable for use in a first strike against Russian land-based missiles, Gormley also asserted that the 2,500 kilometer maximum range of these missiles would allow them to reach only nine of the 14 Russian ICBM deployment areas (see Figure 2). At the same time, the author made the assumption that the Ohio class nuclear submarines carrying cruise missiles would remain confined to an area just outside the 200-mile exclusive economic zone of any of the region's nations.

The reliable detection of modern strategic nuclear submarines, particularly in shallow waters, represents a fundamentally complex problem.[53] It is interesting that the Soviet Navy, the second largest in the world, has never had the ability to reliably monitor its underwater environment under any weather conditions, even within the 12-mile zone, as evidenced by the numerous collisions between submarines. Over the past two decades, the Russian Navy has not improved its effectiveness in controlling the situation under the sea surface. Thus, the assumption that a disarming strike against Russian ICBM deployment sites would come from beyond the 200-mile limit is not completely convincing. In fact, considering the actual state of affairs when it comes to Russian capabilities in defending against Ohio class submarines carrying cruise missiles, the opposite is more likely: the Russian military would be more concerned about an SLCM strike coming from a minimal distance from shore. Possible launch areas for such cruise missiles are shown in Figure 3 (areas of reach are denoted with lines), which clearly demonstrates that a missile having a range of 2,500 kilometers could reach all of its potential targets.

It should also be pointed out that the flight range of a sea-launched cruise missile will depend upon the weight of its payload and its flight mode. Russian experts estimate the maximum range of a prospective advanced Tomahawk cruise missile at 2,900 kilometers.[54] Moreover, estimates made in the early 1990s for nuclear-armed Tomahawk cruise missiles suggest that they would be able to reach much farther.[55]

A recently published paper by Kier Lieber and Daryl Press[56] evaluated the effectiveness of the GBU-32 guided air bomb[57] armed with BLU-109 penetrating warheads in attacking ICBM silos. The BLU-109 penetrator is a concrete-piercing projectile weighing about one ton in a high-strength steel case filled with 243 kilograms of the AFX 70B explosive.[58] The authors considered a scenario in which the bombs would be delivered to their targets aboard B-2 strategic bombers, which are difficult to detect by radar. Although Lieber and Press concluded that a direct hit by such a bomb on the cover of a missile silo would be able to disable it, the arguments used to support their case can hardly be considered technically valid. The problem is that the article attempted to apply criteria that had been previously used to assess the ability of a silo to withstand a certain overpressure of a blast wave created by a nuclear explosion, where the shock wave in calculating the durability of a missile silo could be approximated as a flat wave. In contrast to nuclear weapons, conventional weapons would provide only a localized impact on the cover of an ICBM silo. In assessing the potential damage of such conventional attacks, consideration must be given to a more powerful effect than the blast wave: the kinetic impact of the penetrating warhead.[59]

In addition, the authors believe that combined use of an inertial guidance system corrected by GPS satellite navigation signals would allow these air bombs to achieve a circular error probable of approximately five meters. If the GPS signals were subjected to jamming, the accuracy would fall to about 30 meters. Based on this, they concluded that during an attack by a flight of seven or eight B-2 bombers (each of which is able to carry up to eight one-ton bombs), the probability of all 20 ICBM silos being destroyed would at best be 57 percent or less, and in a situation when GPS signals are being jammed, it would be close to zero. It is important to note that this article referred only to the current capabilities of these bombs. The authors failed to note the fact that in recent years the United States has been working to modernize its air bombs by prioritizing both the improvement of resistance to interference with the functioning of the existing guidance systems and the development of new navigation and guidance systems, as well as the introduction of new guidance systems to supplement the use of an inertial guidance system over the last portion of the flight path corrected by GPS signals. Such an additional system might rely on semi-active lasers, thermal imaging, or radar. At the same time, the program has also been challenged to achieve a CEP of under three meters, irrespective of weather conditions or electronic interference. If this goal is achieved, the air bombs could be made much more effective against ICBM silos than the U.S. authors indicated.

Controlling the Development and Deployment of PGWs

Before it expired in December 2009, START I limited the numbers of ICBMs and SLBMs regardless of whether they were armed with

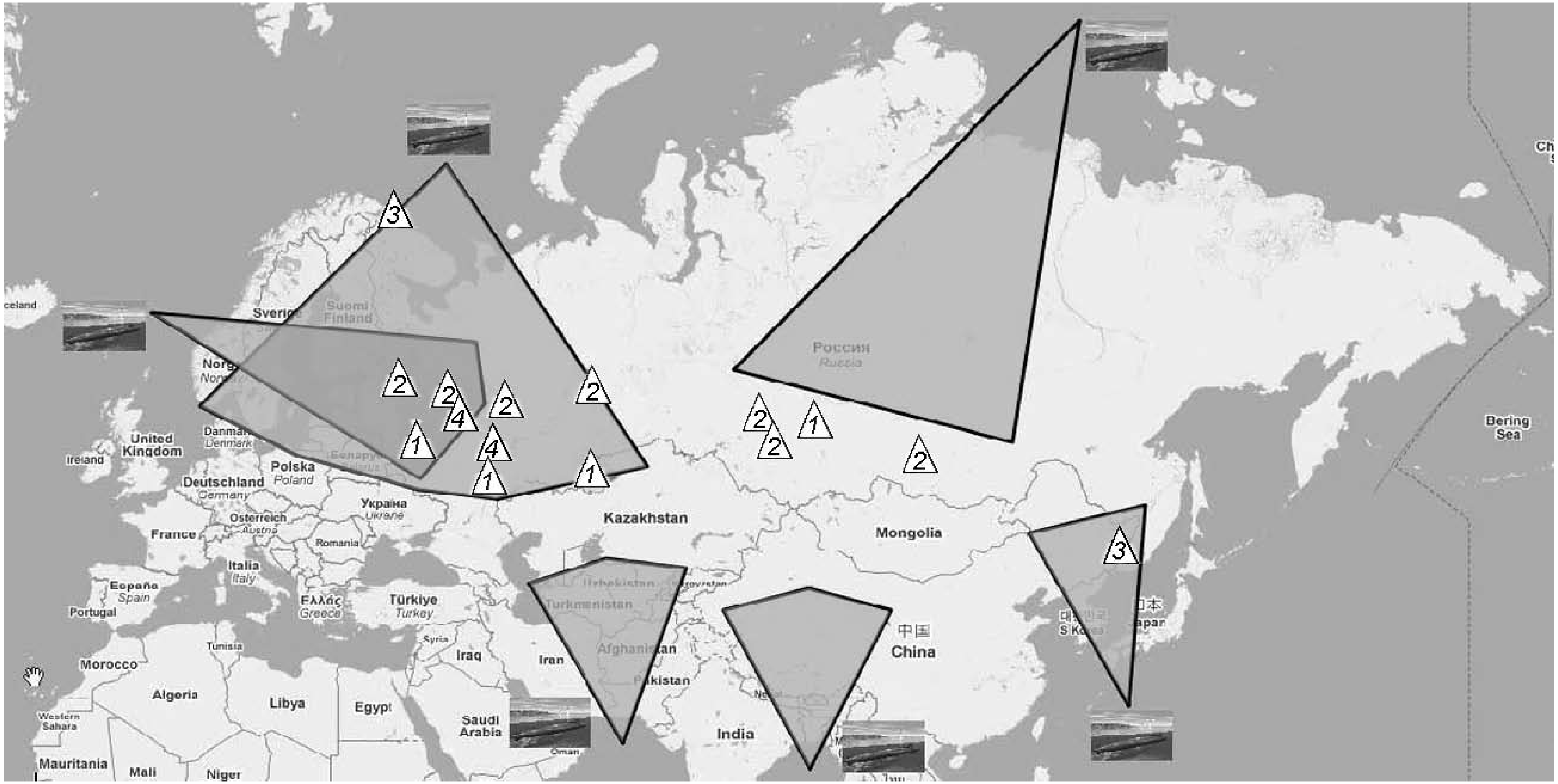

Figure 2. Potential cruise missile launch areas outside of the 200-mile zone

1 — deployment locations of ICBM silos, 2— locations of mobile ICBMs, 3 — locations of strategic submarine bases, 4 — strategic bomber bases. The grey sectors delineate the reach of Tomahawk cruise missiles launched from Ohio class submarines in their probable patrol areas.

Source: D. Gormley, "The Path to Deep Nuclear Reductions."

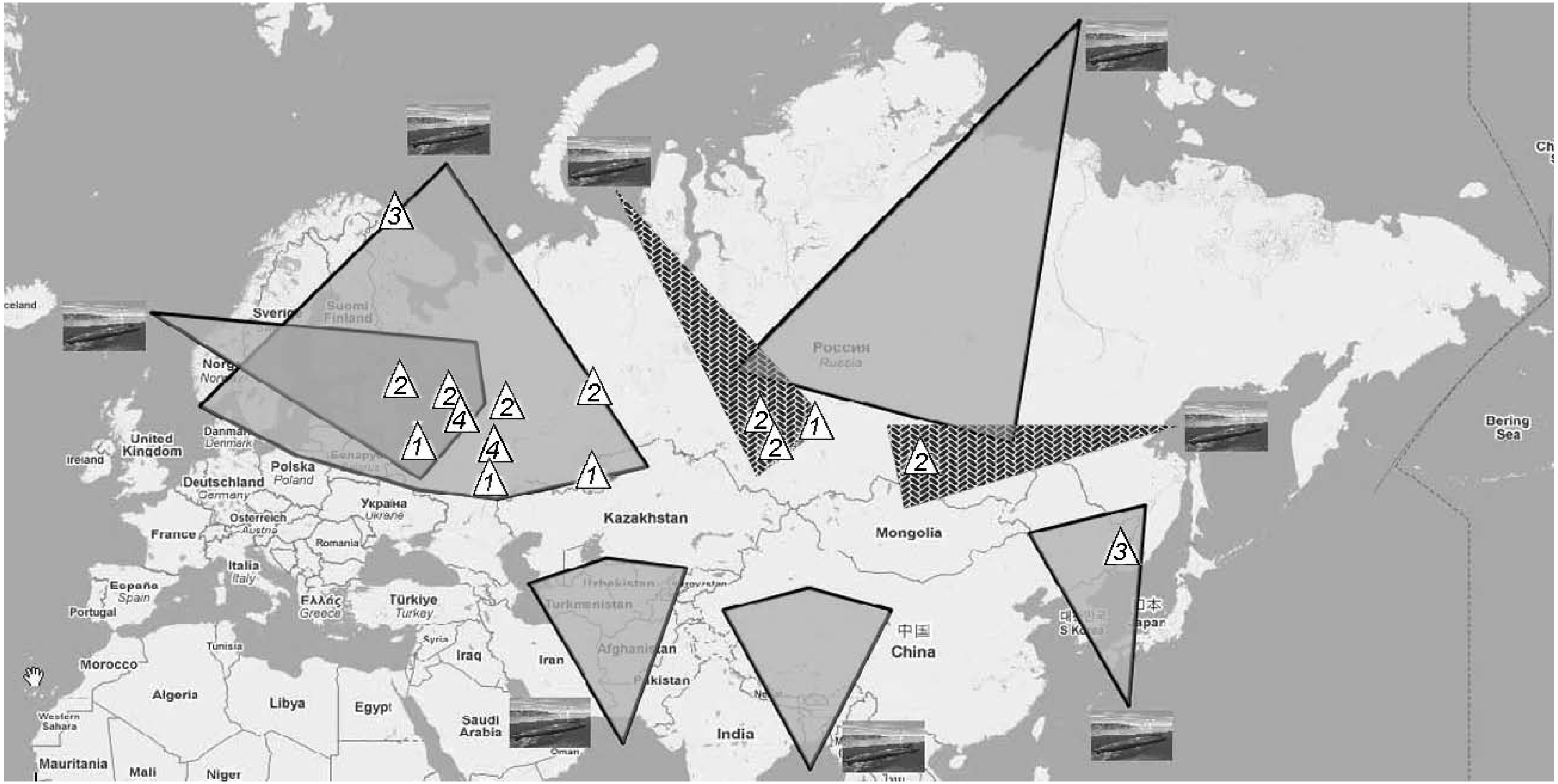

Figure 3. Potential cruise missile launch areas, including the 200-mile zone

1 — deployment locations of ICBM silos, 2— locations of mobile ICBMs, 3 — locations of strategic submarine bases, 4 — strategic bomber bases. The grey sectors delineate the reach of Tomahawk cruise missiles launched from Ohio class submarines in their probable patrol areas.

Source: D. Gormley, "The Path to Deep Nuclear Reductions."

conventional or nuclear warheads. Limitations, controls, and inspections applied to strategic weapon delivery vehicles and launchers as well: ICBMs and their launchers, SLBMs and their launchers, including launchers on those strategic submarines that had been refitted to carry long-range SLCMs, and heavy bombers, including those no longer assigned to nuclear missions.[60]

The START negotiations also discussed proposals to limit PGWs, although these proposals did not come through. In particular, the Soviet Union in the 1980s (and Russia in the 1990s) suggested to the United States that the patrol areas for submarines armed with ballistic missiles and long-range SLCMs be limited, and that anti-submarine activity be prohibited near submarine bases or within ballistic missile submarine patrol areas.

The problem of the counterforce capabilities of precision-guided weapons came under discussion during the New START negotiations. In the end, the sides agreed to implement the following limitations on strategic weapons:[61]

- 700 for deployed ICBMs, deployed SLBMs, and deployed heavy bombers;
- 1,550 for warheads on deployed ICBMs, warheads on deployed SLBMs, and nuclear warheads counted for deployed heavy bombers; and
- 800 for deployed and non-deployed ICBM launchers, deployed and non-deployed SLBM launchers, and deployed and non-deployed heavy bombers.

As follows from the text of the New START Treaty and its Protocol, the Russian side succeeded in counting the ICBMs and SLBMs deployed in non-nuclear configuration against the allowed limits of deployed strategic delivery vehicles, and counting the non-nuclear warheads on such missiles against the allowed limits of deployed strategic warheads. Moreover, the total number of non-deployed ICBM and SLBM launchers and non-deployed nuclear heavy bombers is not to exceed 800.

However, analysis of the text of the Treaty reveals a loophole that could help the parties deploy strategic non-nuclear ICBMs and SLBMs with no limits at all. In particular, the definition presented for "non-deployed ICBM launchers" excludes "soft-site launchers," which are defined in the New Treaty as being any land-based, fixed launcher of ICBMs or SLBMs other than a silo launcher.[62]

At the same time, soft-site launchers are not to be counted against the numbers of deployed launchers, and this puts them outside of the Treaty's restrictions. START I expressly prohibited deploying ICBMs at soft sites, which had been a barrier to U.S. Air Force plans to deploy conventionally armed ICBMs.[63] This is now possible under the New START Treaty.

Although the New Treaty addresses strategic nuclear submarines refitted to carry long-range SLCMs, it also provides unobtrusive procedures that would allow converted submarines to be excluded from the overall count.[64] Moreover, under the New Treaty, individual SLBM launchers, converted in a way that precludes their use as SLBM launchers, may also be excluded from the count.[65]

In contrast to ICBMs and SLBMs, heavy bombers equipped for non-nuclear armaments will not be counted against the total. New simplified procedures have been introduced for converting B1-B heavy bombers (which had been removed from nuclear missions within the framework of the January 2002 U.S. Nuclear Posture Review) into "non-nuclear" bombers.[66] Under the new nuclear posture, a substantial portion of the 76 B-52H strategic nuclear bombers will also be converted into heavy bombers equipped for non-nuclear armaments.[67]

Although the New START Treaty's restrictions on strategic conventional armaments are less rigid than its predecessor's, it is worth noting that its verification system still continues to cover such armaments even after they have been removed from the count. In particular, the system provides for Type Two inspections of ballistic missile submarines that have been refitted to carry long-range SLCMs in order to ensure that the launchers on these submarines have not been reconverted and continue to be incapable of launching SLBMs.[68] Inspections have also been stipulated for heavy bombers equipped for non-nuclear armaments, for similar reasons.

The constructive approach taken by the two sides in preparing the New START Treaty provides grounds to believe that the dialogue begun will not merely end with the signing of the Treaty, but will turn out to be the prelude to substantive discussions on the ways to achieve *real* cuts, rather than just reductions "on paper." The previous U.S. administration, in contrast to the current administration, avoided all discussion on the subject. If such a dialogue should ever begin in depth, it would inevitably include discussions not only on nuclear strategic offensive arms but also on such matters as the problem of ballistic missile defenses, precision-guided weapons, and non-strategic nuclear weapons, as well; in other words, all of the factors that define strategic stability will have to be taken into account.[69]

Which measures to restrict counterforce capabilities of PGWs should be taken at the next stage of negotiations? First of all, it would be important to introduce limits on the numerical parameters and types of deployments allowed for precision-guided weapons, including those that had previously remained outside existing control procedures. For example, it would be possible to prohibit stationing attack aircraft within the borders of the new NATO members. Similar commitments could be undertaken by Russia in respect to its own allies in the Collective Security Treaty Organization (CSTO) and the Commonwealth of Independent States (CIS). It would also be important to limit the patrol areas of submarines carrying cruise missiles to preclude deployment by the United States and Russia of a significant portion of their submarine fleets near the territory of the other country. A measure such as this could also help to resolve the other issues that Russia had previously raised during arms reduction negotiations, such as prohibiting clandestine anti-submarine operations in ballistic missile submarine deployment and patrol areas and preventing collisions between nuclear submarines. Measures such as these would be able to alleviate Russia's near-term concerns substantially and open the way to deeper cuts in nuclear arsenals.

NOTES

1 The technical military literature usually defines "precision-guided weapons" as guided weapons that can disable a target, as a rule with one warhead. This definition can apply to a rather broad range of weapon types, from weapons weighing only a few grams to multi-ton guided bombs and intercontinental ballistic missiles. Within the context of the present Chapter, PGW is considered as applying to the types of guided weapons and their delivery systems that can now and could in the future threaten silo-based ICBMs, which are considered the "backbone" of the Russian Federation's Strategic Nuclear Forces.

2 Yevgeny Miasnikov, "Precision-Guided Weapons and Strategic Balance," The Center for Arms Control, Energy and Environmental Studies at the Moscow Institute of Physics and Technology (MIPT), (November 2000): P. 43, http://www.armscontrol.ru/start/publications/vto1100.htm; Yevgeny Miasnikov, "The Counterforce Potential of Precision-Guided Weapons," in *Nuclear Proliferation. New Technology, Weapons,*

Treaties, ed. A. Arbatov and V. Dvorkin, Carnegie Moscow Center (Moscow: The Russian Political Encyclopedia, [ROSSPEN], 2009), PP. 84-103.

3 "The Status and Development Outlook of U.S. Nuclear Forces," *Zarubezh. voen. obozrenie*, no. 4 (2002): PP. 2-20.

4 Gen. James E. Cartwright, Commander, U.S. Strategic Command, *Statement Before the Senate Armed Services Committee Strategic Forces Subcommittee on Strategic Forces and Nuclear Weapons Issues in Review of the Defense Authorization Request for Fiscal Year 2006*, Apr. 4, 2005.

5 For example, see: V.Yu. Volkovitsky, "Screening Strategic Nuclear Forces – Paramount Objective for the Air Forces, Part 2," *Vozdush.-kosm. oborona*, no. 1 (January-February 2010); Mikhail Volzhensky, "BMD: Disguised for Defenses, Created to Attack," *Izvestia*, May 28, 2007.

6 Amy F. Woolf, *Conventional Warheads For Long-range Ballistic Missiles: Background and Issues for Congress, CRS Report RL33067*, Jan. 26, 2009.

7 *Quadrennial Defense Review Report*, U.S. Department of Defense, February 2010, P. 33.

8 *Nuclear Posture Review Report*, April 2010, http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf.

9 Sergei Karaganov, "One Cannot Take on Trust – We Need a Treaty," *Voen.-promyshl. kurier*, no. 1 (Jan. 13-19, 2010): P. 9; L.G. Ivashov, "The Nuclear Bomb Returns to the Political Arena," *Nezavisimaya Gazeta*, June 2, 2009.

10 V.Yu. Volkovitsky, "Screening Strategic Nuclear Forces – Paramount Objective for the Air Forces, Part 1," *Vozdush.-kosm. oborona*, no. 6 (November-December 2009).

11 Miasnikov, "The Counterforce Potential."

12 Cartwright, *Statement Before the Senate Armed Services Committee*, Apr. 4, 2005.

13 Woolf, *Conventional Warheads.*

14 Elaine Grossman, "U.S. General: Precise Long-range Missiles May Enable Big Nuclear Cuts," *Inside the Pentagon*, Apr. 28, 2005.

15 Ibid.

16 Hans M. Kristensen, "U.S. Strategic War Planning After 9/11," *Nonproliferation Review* vol. 14, no 2 (July 2007): PP. 374-390.

17 *Quadrennial Defense Review Report*, February 2010, P. 33.

18 Elaine Grossman, "Chilton Shifts Prompt Strike Priority to the Air Force," *Global Security Newswire*, Sept. 3, 2008.

19 Woolf, *Conventional Warheads.*

20 Ibid.

21 The throw-weights of the Trident II and the MX are 2.8 tons and 3.95 tons, respectively.

22 Maj. Jason E. Seyer, "Adding the Conventional Strike Missile to the US's Deterrence Toolkit," *High Frontier* vol. 5, no. 2 (2009): PP. 28-35.

23 Ibid.

24 Elaine M. Grossman, "Cost to Test U.S. Global Strike Missile Could Reach $500 Million," *Global Security Newswire*, March 15, 2010.

25 Peter B. Teets, Under secretary of the Air Force, *Report to Congress on the "Concept of Operations" for the Common Aero Vehicle*. Submitted in response to Congressional Reporting Requirements, Feb. 24, 2004, P.2.

26 Michael C. Sirak, "Game Changer," *Air Force Magazine*, September 2009, PP. 30-38.

27 *Department of Defense Fiscal Year (FY) 2011 President's Budget*, Office of Secretary of Defense, Justification Book volume 3, RDT&E Defense-Wide-0400, February 2010, PP. 845-859.

28 Sirak, "Game Changer."

29 Bill Sweetman, "No Place to Hide," *Defense Technology International* (May 2008): PP. 25-28.

30 *Department of Defense Fiscal Year (FY) 2011 President's Budget*, PP. 845-859.

31 Woolf, *Conventional Warheads.*

32 Elaine Grossman, "DoD Defends New Sub-Launched Missiles," *Inside Defense.com*, March 10, 2006.

33 Robert S. Norris and Hans M. Kristensen, "U.S. Nuclear Forces, 2005," *Bulletin of the Atomic Scientists* (January-February 2005): PP. 73-75. It should be noted that the modernized W76 warhead guidance system will be larger, which will keep it from being equipped with nuclear warheads (Elaine Grossman, "More Accurate U.S. Nuclear Trident Faces Controversy," *Global Security Newswire*, August 17, 2007).

34 Woolf, *Conventional Warheads.*

35 *Quadrennial Defense Review Report*, U.S. Department of Defense, February 6, 2006, P. 50.

36 National Academy of Sciences, *Conventional Prompt Global Strike Capability: Letter Report*, May 11, 2007; Grossman, "More Accurate U.S. Nuclear Trident."

37 Michael Gordon, "Pentagon Seeks Nonnuclear Tip for Sub Missiles," *New York Times*, May 29, 2006.

38 Grossman, "DoD Defends New Sub-Launched Missiles."

39 George N. Lewis and Theodore A. Postol, "The Capabilities of Trident Against Russian Silo-Based Missiles: Implications for START III and Beyond," (Paper presented at the meeting "The Future of Russian-US Strategic Arms Reductions: START III and Beyond," Feb. 2-6, 1998).

40 For example, see: Miasnikov, "Precision-Guided Weapons."

41 For example, one U.S. tender invites defense plants to develop a system capable of delivering penetrating ballistic missile warheads to within 10 meters of their targets or better. Moreover, these warheads should have end speeds of 1.2 to 1.8 kilometers per second ("Ballistic Missile Technology Program Research And Development Announcement," *Commerce Business Daily,* Dec. 18, 1998).

42 Gordon, "Pentagon Seeks Nonnuclear Tip."

43 Hans M. Kristensen, "Global Strike. A Chronology of Pentagon's New Offensive Strike Plan," *Federation of American Scientists*, March 15, 2006, P. 39.

44 *U.S. Conventional Prompt Global Strike: Issues for 2008 and Beyond* (National Academy of Sciences, 2008).

45 Elaine M. Grossman, "U.S. Navy Plans August Test for Conventional Trident-Related Technology," *Global Security Newswire*, May 21, 2009; Lockheed Martin, "Lockheed Martin-Built Trident II D5 Missile Achieves Record 129 Successful Test Flights In A Row Over 20 Years," press release, Oct. 21, 2009.

46 This point was raised by Pentagon Vice Admiral Stanley when he briefed reporters about the new *Quadrennial Defense Review Report*: "DoD News Briefing with Undersecretary Flournoy and Vice Adm. Stanley," Feb. 1, 2010.

47 Anatoli Diakov and Yevgeny Miasnikov, "Prompt Global Strike in the U.S. Strategic Forces Development Plans," Center for Arms Control, Energy and Environmental Studies at the Moscow Institute of Physics and Technology (MIPT) (Sept. 14, 2007), http://www.armscontrol.ru/pubs/pgs.pdf.

48 *Department of Defense Fiscal Year (FY) 2011 President's Budget*, PP. 845-859.

49 *Department of Defense Fiscal Year (FY) 2009 Budget Estimates*, Office of Secretary of Defense, volume 3, RDT&E Defense-Wide, February 2008, PP. 514-518.

50 Dennis Gormley, "The Path to Deep Nuclear Reductions. Dealing with American Conventional Superiority," (Proliferation Paper, IFRI Security Studies Center, Fall 2009).

51 *Reactive Shaped Charge Liner*, Navy SBIR 2008.1 - Topic N08-028, http://www.navysbir.com/n08_1/N081-028.htm.

52 Katie Walter, "Shaped Charges Pierce the Toughest Targets," *Science and Technology Review* (June 1998), https://www.llnl.gov/str/pdfs/06_98.3.pdf.

53 For example, see: Yevgeny Miasnikov, *The Future of Russia's Strategic Nuclear Forces: Discussions and Arguments,* (Dolgoprudny: The Center for Arms Control, Energy and Environmental Studies at the Moscow Institute of Physics and Technology, 1995), http://www.armscontrol.ru/subs/snf/sub1006.htm.

54 I. Shevchenko, "Current Status and Development Outlook of U.S. Naval Sea-Based Cruise Missiles," *Zarubezh. voen. obozrenie*, no. 8 (2009): PP. 66-73.

55 George N. Lewis and Theodore A. Postol, "Long-range Nuclear Cruise Missiles and Stability," *Science and Global Security*, vol. 3, nos. 1-2 (June 1992).

56 Keir A. Lieber and Daryl G. Press, "The Nukes We Need. Preserving the American Deterrence," *Foreign Affairs* (November-December, 2009): PP. 39-51, Technical Appendix, http://www.dartmouth.edu/~dpress/docs/Press_FA-2009-Appendix-12-post.pdf.

57 It appears that the authors made a typo and were in fact referring to GBU-31 aviation bombs with BLU-109 warheads. The weight of the GBU-32 bombs is only half that of the GBU-31s, and they carry one BLU-110 warhead.

58 Yevgeny Miasnikov, "Precision-Guided Weapons."

59 These assessment methods and their examples are discussed by: Yevgeny Miasnikov, "Precision-Guided Weapons."

60 For example, see: Anatoli Diakov and Yevgeny Miasnikov, "The Prompt Global Strike Concept and START I," *Nezavisimoe voen. obozrenie*, no. 31, (Sept. 14-20, 2007), http://www.armscontrol.ru/pubs/adem-nvo-pgs.htm.

61 "Treaty Between the Russian Federation and the United States of America on Measures for the Further Reduction and Limitation of Strategic Offensive Arms," Apr. 8, 2010, Prague, http://www.kremlin.ru/news/7396.

62 "Protocol to the Treaty Between the Russian Federation and the United States of America on Measures for the Further Reduction and Limitation of Strategic Offensive Arms," Part One.

63 Diakov and Miasnikov, "The Prompt Global Strike."

64 "The START Protocol," Part Nine, Second Agreed Statement.

65 "The START Protocol," Part Three, Section III.

66 "The START Protocol," Part Nine, First Agreed Statement.

67 *Nuclear Posture Review Report*, April 2010, http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf.

68 "The START Protocol," Part Nine, Second Agreed Statement.

69 Anatoli Diakov, Timur Kadyshev, and Yevgeny Miasnikov, "Further Reductions of Nuclear Weapons," The Center for Arms Control, Energy and Environmental Studies at the Moscow Institute of Physics and Technology (Feb. 3, 2010), http://www.armscontrol.ru/pubs/en/post-start-reductions-en.pdf.