Chapter 7. THE AIR-SPACE THREAT TO RUSSIA

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Addressing the Federal Assembly on November 30, 2010, President Dmitry Medvedev set the goal of strengthening the air-space defense of the country, combining the existing missile and air defense systems, and the missile early-warning and airspace monitoring systems, which will all become subordinate to a unified strategic command.¹ At the concluding session of a Ministry Collegium, Defense Minister Anatoliy Serdyukov announced that a new branch of the Armed Forces – the Air-Space Defense Force (ASD) – would be established as of December 1, 2011.² There were probably a number of reasons behind these decisions.

The first was the U.S./NATO plans to build a European BMD system, which have become a major irritant to U.S.-Russian relations. The Russian side feels that implementation of such plans without consideration of its position would create a threat for Russia's Strategic Missile Force. The decision to form the ASD may represent an asymmetrical response to the plans for BMD deployment in Europe. Such a conclusion becomes particularly plausible after the Russian president issued a statement on November 23, 2011, in response to the U.S. actions, in which as a preliminary measure he ordered that the Kaliningrad early warning radar station be activated immediately and that the ASD enhance its defenses for Russia's strategic nuclear weapons.³ On the other hand, the decision to form the ASD could also be seen as being aimed at increasing cooperation, rather than confrontation, if it represents an attempt to appear to be a potentially strong partner so that the United States might revise its views on the feasibility of building a joint missile defense system with Russia.

The decision may have also had its own purely internal reasons and been a function of the intent to reverse the trend toward degradation of the BMD and AD forces that had resulted from the reforms and transformations of the past twenty years. Many military experts are known to have long argued in favor of integrating the systems of reconnaissance and early warning of air-space attack with those for defeating and destroying an adversary's combat capability and for command and supply into a single system, so that they could be operated "through a single chain of command having a unified mission under a unified ASD command and control structure integrated into the overall command system of the Armed Forces."⁴ These ideas appear to have served as the basis for "The Concept of Air-Space Defense of the Russian Federation until 2016 and in the Following Period" that was approved by the president on April 5, 2006.

Finally, the establishment of the ASD branch may have been prompted by the emergence of qualitatively new kinds of challenges and dangers as well as by a potential that they may pose a threat to the Russian Federation. What qualitatively new threats could these be?

This question was not answered in the presidential address. According to a statement by Lieutenant General Valery Ivanov, Deputy Commander of the ASD Force: "The main mission of ASD is to detect the beginning of an attack and inform the country's leadership so they can make decisions: detect, destroy and suppress, and defend sites."⁵ It is anticipated that the Air-Space Defense system will ensure the defense of the central industrial portion of Russia from the threat of attack by air or space (intercontinental ballistic missiles, cruise missiles, aircraft, or massive air strikes in general).⁶ According to Valery Ivanov, the ASD Force would be able to repulse a massive attack by adversary aircraft and cruise missiles over four sectors divided into layers by altitude and distance.⁷

Russian military experts point to quite a broad range of air-space attack options against which Russia's ASD is intended to defend:⁸

- In space (over 100 km above sea level) spacecraft, intercontinental ballistic missiles, armed hypersonic gliders, strike (combat) spacecraft, and other potential air-space and space-based systems;
- In the stratosphere (at 15-60 km above sea level) intermediaterange ballistic missiles, theater and tactical ballistic missile systems, unmanned aerial vehicles, including high-altitude balloons and advanced strategic bombers;
- In the troposphere (less than 15 km above sea level) air-based

reconnaissance and command posts, strategic and tactical aircraft, ground-launched, sea-launched, or air-launched cruise missiles, unmanned aerial vehicles, including combat and other potential unmanned and manned aerial vehicles.

At the same time, it can be reasonably argued that there is currently no missile defense system that would be capable of fending off both massive nuclear missile strikes as well as attack by a few dozen ICBMs, nor are there any in the offing for the medium-term. It has therefore been proposed that the ASD system be assigned the following realistic mission goals: to repulse attacks by individual or small groups (three to five missiles) of ICBMs, IRBMs, theater ballistic missiles (TBMs), medium- or short-range ballistic missiles, as well as individual, group, or massive strikes carried out using other means of attack by air and the destruction (suppression) of spacecraft and other space-based objects.⁹

Where could such threats come from and how likely are they?

Russian experts must consider a very broad range of potential missile threats. This would include first of all the missile systems of the nuclear states (China, France, Great Britain, and the United States). Aside from these, India, Iran, Israel, North Korea, Pakistan, Saudi Arabia, and Turkey possess nonstrategic offensive systems. It can not be ruled out that other countries will acquire such weapons in the future. Possible scenarios for the use of these weapons might include the following:

- Planned strategic ballistic missile strikes on targets in Russia;
- Nonstrategic ballistic missile strikes in the course of local conflicts and conventional wars;
- Unsanctioned, provocative, or terrorist ballistic missile strikes from waters or territories of other states.¹⁰

Such scenarios theoretically cannot be ruled out; however, they could hardly be described as being rational or of primary concern to Russia now or for the medium-term future. In any case, this conclusion will likely remain valid so long as Russia is able to maintain an effective policy of nuclear deterrence and preserve an ability to adequately react to such scenarios using conventional weapons, or, in extreme cases, nuclear weapons as well.

The scenario that represents the greatest danger for the future would be a disarming strike by the United States against Russian strategic nuclear systems using precision-guided non-nuclear munitions (PGMs).¹¹ If such a scenario could be carried out with a high probability of technical success, it would be a very attractive, since on the one hand it would deprive Russia of the ability to make a retaliatory strike, while on the other hand, unlike in the aftermath of a massive nuclear missile strike, there would be no consequent devastating global environmental damage. In any case, the threat of carrying out such a strike could be used to exert coercive pressure on Russia by Western states in the resolution of one or the other confrontation.

Russian experts are of divergent views regarding the feasibility of a future disarming strike by precision-guided weapons against Russian strategic nuclear forces, but on the whole they are unanimous that it would not be possible for such a scenario to be carried out at present.¹² Still, it must be noted that the following trends will work to increase apprehensions in Russia.

As has been the case for the past twenty years, the rate of reductions in Russian strategic nuclear forces will continue to exceed the rate of new missiles brought into service. Although the procurement program for the armed forces to the year 2020 anticipates the production of new ICBMs and SLBMs as well as construction of eight new strategic submarines, there are reasonable grounds to doubt that these targets will be fulfilled.¹³

Notwithstanding the organizational decision to establish the ASD Force and to ensure its rearmament, new surface-to-air missile complexes will also be purchased in more limited numbers than provided for in the government program; for this reason, no reversal of the trend toward degradation of the air defense forces is expected any time soon. In addition, major problems continue to exist in conducting surface and underwater surveillance in waters from which sea-based cruise missiles could be launched.

The precision-guided weapons that the U.S. armed forces have today could be used against a wide range of targets, including hardened

fixed sites and well-armored mobile targets. Potential weapons, including those under development under the framework of the Prompt Global Strike program, would have significantly greater capabilities.

The development of precision-guided weapons and their relevant information technologies and infrastructure figures prominently in U.S. Defense Department program documents. New doctrinal approaches are emerging in which the missions that would have previously been assigned to nuclear weapons are gradually being shifted to precisionguided non-nuclear weapons.

In light of these trends, attempts by the United States to remove START Treaty restrictions and controls from its strategic non-nuclear delivery systems¹⁴ and the plans to deploy a BMD system in Europe appear to Russia to be steps that could potentially be used to accomplish the scenario of a disarming strike carried out with precision-guided nonnuclear weapons.

What is the actual extent to which Russian strategic nuclear forces are protected from the threat of an air-space attack?

The defense of the strategic forces from threats of conventionally armed air-space attack has been among the most important missions of the Soviet Armed Forces since at least the early 1980s. According to data published by Lieutenant General Vadim Volkovitskiy, at the peak of AD development in the mid-1980s, the Soviet Air Defense Force had 200 anti-aircraft regiments and brigades equipped with the S-200, S-125, S-75, and S-300 missile systems, and counting the Air Force's fighters, there were more than 80 regiments flying the MiG-23, 25, and 31, and the Su-27 aircraft. Still, such forces were even then unable to carry out the mission of ensuring the survival of a "necessary level" of Strategic Nuclear Forces (SNFs) systems (which for the Strategic Missile Force was 95 percent) under various scenarios of air-space attack. According to estimates by Soviet military research institutes, the desire to achieve formal parity with the United States in defending strategic nuclear forces would in some cases have required the use of an unsustainable number of air defense units. Although estimated losses among the Strategic Missile Force's assets would have been rather high, the adversary's attacking air-space forces would also suffer high losses while penetrating site defenses, significantly exceeding accepted levels stipulated for piloted aircraft. This

made the likelihood of such an enemy attack doubtful, which rendered it impossible to draw any reasonable conclusions about feasible actions that could be taken to defend strategic missile sites.¹⁵

Based on Vadim Volkovitskiy's estimates, in the mid-1980s, about 95 percent of Soviet strategic nuclear assets were directly covered by air defense missile forces: the Strategic Missile Force was 96 percent covered; sea-based strategic forces were 100 percent covered; and air-based strategic forces were 88 percent covered. Subsequently, mainly as a result of reductions in the air defense forces, these rates began to decline, reaching a low at the end of 2001 and beginning of 2002, by which time only about 36 percent of the strategic nuclear systems were covered (the Strategic Missile Force was 23 percent covered; sea-based SNFs were 100 percent covered; and air-based SNFs were 13 percent covered). By 2005 the situation had improved somewhat, but the number of strategic nuclear systems covered still remained below 40 percent.¹⁶

It should be noted that the mission of defending SNFs against attack by the air-space forces of an adversary is a complex one, for the solution of which anti-aircraft missile forces represent only one link. Judging by published information, other defensive measures (both active and passive) could be employed during periods of threat.¹⁷ However, how well prepared these measures are and whether they could be used in practice in the future remains unclear. Therefore, considering the continued reductions in the available air defense forces and their increasingly more outdated and obsolescent weaponry, which is being replaced by new systems at rates slower than called for in the official planning,¹⁸ President Medvedev's order to the ASD Force to give priority to reinforcing the defensive coverage of strategic nuclear facilities seems to be a logical step, despite the extremely low probability these days of a disarming strike scenario.

The U.S. operational non-nuclear precision-guided weapons that may have counterforce capabilities have been examined in detail in previous works by the author of the present chapter.¹⁹ These can be said to include a wide range of weapons from guided air bombs to sea-launched and airlaunched long-range cruise missiles. Such weapons would be delivered either by strategic carriers (heavy bombers, nuclear submarines) or nonstrategic carriers (tactical aircraft, combat ships). At the present time,

the United States is carrying out a program not only to thoroughly modernize its existing strike systems and their infrastructure to give them qualitatively new capabilities but also to develop promising precisionguided weapons.

In the scenarios of a disarming strike that have been presented by Russian experts, long-range cruise missiles have been viewed as representing the greatest potential threat for Russian SNFs. Although flight times for the sea-launched and air-launched cruise missiles currently operated by the U.S. Armed Forces can reach two or three hours, such missiles can be launched stealthily. In addition, a low-flying cruise missile is a difficult object to detect quickly enough to allow time for interception. Experts admit that to build a robust defense system that would guarantee the defense of national territory from cruise missile attack would be problematic even for the United States.²⁰

An analysis of the state of development of long-range cruise missiles in the U.S, their delivery systems, and programs for developing advanced non-nuclear strike weapons that may have counterforce capabilities is presented below.

Sea-launched cruise missiles

U.S. Navy attack submarines and ballistic missile nuclear-powered submarines, as well as several types of U.S. Navy warships, have been armed with the Tomahawk sea-launched cruise missiles (SLCMs).

The Tomahawk is a subsonic SLCM that has a low radar cross section and can fly at altitudes as low as ten meters above the surface. It has a combination guidance system that includes the Inertial Navigation System (INS) and the Terrain Control Matching (TERCOM) and Digital Scene Matching Area Correlation (DSMAC) systems, and its flight path can also be adjusted by GPS signal. Over the course of its development, the Tomahawk has undergone several modifications (Blocks I– IV). The latest modification (Block IV, the Tactical Tomahawk) differs from previous models principally in greater range (up to 1,600 km) and in-flight retargeting capabilities.²¹ The SLCM's operational range is heavily dependent on the mass of its payload and on its flight mode, although Russian experts estimate the maximum operational range of the potential Tactical Tomahawk missiles at 2,400 km.²² As the estimates of the operational range for the Tomahawk SLCM in its nuclear configuration that had been made as far back as the early 1990s indicate, it can be much greater.²³

Tomahawk SLCMs can carry either a nuclear or a conventional payload.²⁴ The Block III SLCMs,²⁵ which make up the bulk of the U.S. long-range SLCMs in service, are equipped with a WDU-36/B high-explosive fragmentary type warhead or Combined Effects Bombs (CEBs) with self-targeting BLU-97/B bomblet submunitions. Reports say that some of the Block IV SLCMs will carry a WDU-36/B warhead,²⁶ while others will carry a WDU-43/B penetrating warhead.²⁷ The U.S. Navy is currently conducting research on the MEWS (Multi Effects Warhead System) program, aimed at developing a shaped charge tandem warhead for the Tomahawk-type SLCMs.²⁸ In addition, the missile's guidance and navigation systems are being improved. In order to improve the Tomahawk's accuracy in hitting land targets, it is planned to replace the TERCOM navigation system with a new PTAN (Precision Terrain Aided Navigation) one. Its interferometric altimeter will allow not only the relative altitudes of points on the surface to be determined, but also angles of inclination of the terrain.

As of 2006, Raytheon had produced about 4,200 Block I–III Tomahawks, of which about 2,000 were used in U.S. military operations in 1991-2011.²⁹ Serial production of the Block IV Tactical Tomahawk began in 2002;³⁰ by 2010 and 2011, purchases of this version were minimal (196 units per year) and were made for the primary purpose of maintaining the production infrastructure.³¹ Similar purchase volumes are planned up to 2015. As of 2011, the average cost per unit has been around 1.5 million dollars. The current inventory of Tomahawk SLCMs of all modifications is estimated at more than 3,000 units.

Air-launched cruise missiles

The Boeing Company originally built about 1,700 long-range AGM-86 air-launched cruise missiles (ALCMs) that were to be used only

in nuclear mode. However, beginning in 1988, about 500 of them were refit to carry conventional warheads.³² The non-nuclear modification of the missile was designated the Conventional Air-Launched Cruise Missile (CALCM), or AGM-86C/D. The CALCM can deliver blast/fragmentation or penetrating warheads over a range of up to 1,500 km.³³ The equivalent yield of blast/fragmentation payloads is about 1,300 kg of TNT. The AUP-3(M) penetrating warhead has a weight of about 540 kg.³⁴ The CALCM uses an inertial GPS-adjusted navigation system.

It would be rather difficult to estimate the number of long-range nonnuclear ALCMs in the U.S. inventory. The CALCM-type missiles were widely used in military conflicts between 1991 and 2003, with a total of about 360 missiles fired.³⁵ However, according to published data, by 2006 the United States still had 289 CALCMs.³⁶ In 2007, the U.S. Air Force announced plans to substantially reduce its nuclear ALCMs, which would leave about 528 ALCMs in operational readiness out of 1,142 available at the time.³⁷ It cannot be ruled out that by now a portion of these missiles may have been converted into conventional ALCMs. It is also possible that the 394 nuclear-armed ALCMs (AGM-129) that had been planned for withdrawal from service may also have been converted to carry non-nuclear warheads.³⁸ Nevertheless, existing plans provide for nuclear-armed ALCMs to remain in service until 2030. Funding for research and development of a new ALCM to replace the current modifications is planned to be increased drastically in 2013, 2014, and 2015 (the 2011 budget allocated \$3.6 million for this purpose); serial production is to begin in 2025.³⁹

The U.S. Air Force is also armed with the little noticed JASSM (AGM-158 A) guided missile (GM), having an operational range of 400 km and accuracy of up to three meters. It is equipped with the J-1000 450 kg blast/fragmentation or penetrating warhead. This missile is carried by strategic bombers of all types and F-16C/D fighters, and in the future the F-15E aircraft will also be equipped with them. Serial production of the missile began in fiscal year 2002. In parallel, Lockheed-Martin, the company that developed the JASSM GM, is also finishing work on the new JASSM-ER (AGM-158B) modification that will have increased operating range (800-1000 km) and in-flight retargeting capabilities. These missiles are planned to enter service in 2012. Serial production

of both modifications was resumed in 2011, after an interruption in 2010 due to low missile reliability. In fiscal years 2011 and 2012, respectively, 171 and 142 GMs were planned for purchase,⁴⁰ along with a total of 2,400 JASSM and 2,500 JASSM-ER missiles.⁴¹

Sea-launched cruise missile carriers

The long-range Tomahawk SLCMs can be launched from the torpedo tubes and vertical launch systems found on essentially all U.S. Navy attack submarines. The Ohio-class ballistic missile submarines that by 2008 had been converted to carry SLCMs have the greatest attack potential.⁴² Each of these submarines is capable of carrying up to 154 Tomahawk cruise missiles. The Los Angeles-class submarines, which were built before 1985, can launch SLCMs only from reloadable torpedo launchers. However, beginning with the Providence SSN-719 submarine, all submarines of this class have been equipped with twelve vertical launchers specifically designed to hold SLCMs. Virginia-class submarines have a similar capability. The newly-constructed Block-III Virginia-type submarines will carry twelve SLCMs in two launchers (Virginia Payload Tubes) installed in the nose section. The U.S. Navy has also been considering the option of equipping Virginia-class submarines with four universal launchers (Virginia Payload Modules) that would be able to carry seven Tomahawk SLCMs each, or other payloads.⁴³ Thus, the maximum number of SLCMs that could be carried aboard each new submarine built starting in 2019 will increase to 28. Although Seawolf-class submarines do not have vertical launchers, their number of torpedo launchers has been doubled and they can carry up to 50 missiles.

In 2012, the U.S. Navy had 53 attack submarines, including eight Virginia-class, three Seawolf-class, and 42 Los Angeles-class submarines with SLCM vertical launchers.⁴⁴ By 2020, plans call for a fleet of 50 attack submarines to be maintained, including 22 Virginia-class submarines that will have become operational by that time. In the longer term, the total number of multi-purpose submarines may decrease to 44.⁴⁵

Navy surface ships usually operate as part of aircraft carrier strike groups and, unlike submarines, cannot launch stealth attacks against

land targets. Among the U.S. Navy ships that are capable of launching Tomahawk SLCMs from vertical launchers are the DDG-51 (Arleigh Burke-class) destroyers and CG-47 (Ticonderoga-class) cruisers, which are equipped with the Aegis multi-functional combat control system and can carry anti-missile, anti-aircraft, and anti-submarine weapons.

As of the end of 2010, the U.S. Navy had 59 destroyers and 22 cruisers.⁴⁶ The construction of DDG-51 continues and existing plans provide for the total number of combat ready ships of this type to reach 72 by 2020.⁴⁷ Apart from that, three new-generation DDG-1000 (Zumwalt-type) destroyers for conducting missile strikes against land targets are planned to be built between 2016 and 2018, which will also be armed with Tomahawk SLCMs.

The CG-47 can carry a maximum of 122 SLCMs, while the DDG-51 and DDG-1000 can hold 90 and 80 SLCMs respectively.⁴⁸ Since the vertical launchers aboard these ships can be used not only for attacking land targets, but also for anti-submarine and anti-aircraft warfare, the number of SLCMs they actually carry is usually from one third to a half of the maximum.

Table 1Potential Numbers of Tomahawk SLCM Carriersand Their Payload Capacities

Type of SLCM carrier	Potential numbers of carriers	Maximum number of SLCM launchers
Providence-class submarine (SSN-719)	24	480
Seawolf-class submarine	3	60
Virginia-class submarine (SSN-774)	22	440
Ohio-class ballistic missile submarine	4	616
CG-47 (Ticonderoga)	22	1,320
DDG-51 (Arleigh Burke)	72	3,240
DDG-1000 (Zumwalt)	3	120
Total		6,276

Note. In estimating the maximum number of missiles a ship would carry, it was assumed that only half of their vertical launchers would be used for SLCMs

In the context of this chapter it is important to note that current U.S. plans to deploy BMD in Europe do not rule out the potential appearance of cruisers or destroyers armed with Aegis systems in the Black, Barents, or North seas.⁴⁹ Were events to follow such a scenario, these ships would also be armed with long-range SLCMs in addition to the Standard SM-3 Block II interceptor missiles, which would mean that the threat posed to Russia's strategic nuclear forces by cruise missiles would be much greater than that posed by interceptor missiles. This threat will become even more pronounced if the ArcLight program (discussed below) is continued.

Also capable of making precision strikes against an adversary's territory would be carrier-based U.S. Navy aircraft. The U.S. Navy currently has eleven nuclear-powered aircraft carriers and plans to retain this number until 2020, by which time the CVN-77 George H. W. Bush and CVN-78 Gerald R. Ford nuclear-powered aircraft carriers are to become operational. The attack function of carrier-based aircraft is served by the F/A-18C/D (Hornet) and F/A-18 E/F (Super Hornet) fighters, of which type there are typically 36 aircraft in a carrier air wing.⁵⁰

Air-launched cruise missile carriers

The backbone of the U.S. Air Force's strategic attack capability is the B-52H, B-1B, and B-2 heavy bombers. Until the beginning of the 1990s, strategic bombers were capable of delivering only nuclear weapons and gravity bombs. Modernization programs over the past decade have made it possible to arm these bombers with precision-guided bombs, guided missiles, or ALCMs with GPS-adjusted targeting. The U.S. Air Force currently has 76 B-52H, 65 B-1B, and 20 B-2 heavy bombers.⁵¹

Only the B-52H-class heavy bombers (HB) are currently armed with long-range CALCMs. This bomber can carry a maximum of 20 cruise missiles.

Although the B-1B HB had been counted under the START Treaty as a bomber not designed to carry ALCMs, and there are no plans to convert it into a carrier of this type of ALCMs, this option would still be technically feasible. In particular, the CRSL launchers with eight CALCMs

that are carried by the B-52H strategic bomber can also be placed into the forward weapons bay of the B-1B HB. Moreover, the aircraft is designed to allow for up to fourteen ALCMs to be installed on six dual and two single mounts under the fuselage.⁵² The existence of this capability makes it clear why the Russian side is concerned and opposes converting the B-1B heavy bomber into a non-nuclear bomber, which the United States had proposed under the framework of the New Start Treaty implementation.⁵³ Heavy bombers armed with non-nuclear weapons are not included in the limitations on carriers and payloads stipulated by the Treaty, and control measures covering such bombers are rather limited in nature.⁵⁴ Moreover, under the New START Treaty, the United States would be able to convert all of its B-1Bs into "non-nuclear" heavy bombers, which means that this class of bombers is becoming no longer subject to the Treaty or its deployment restrictions.⁵⁵ Interestingly, the data published by the U.S State Department on the composition of Strategic Offensive Arms as of September 1, 2011, do not list the B-1B heavy bombers.⁵⁶ This may indicate that the United States is planning on reducing Treaty procedures and restrictions to a minimum for this type of heavy bomber.

According to U.S. Air Force plans, the existing types of heavy bomber will be in operation at least until 2030. If the B-52, B-1B, and B-2 heavy bombers are modernized, they could remain operational until 2044, 2047, and 2058 respectively.⁵⁷ The amount requested in the 2012 budget for developing the next generation of U.S. Air Force bomber was \$200 million, and \$3.7 billion is planned to be spent for that purpose over the next five years. Production of the new bomber is expected to begin in the late 2020s.⁵⁸

Precision-guided weapons can also be used by U.S. Air Force tactical fighters (F-15E, F-16C/D, F-22, F-117, and F-111) that are primarily designed to conduct strikes against land targets. Although their range and payload capacity is substantially less than those of the strategic bombers, their short flight time to target since they are based at the air force bases of U.S. NATO allies in Europe, in the Transcaucasus, and in the countries of Central Asia makes them appear a significant threat to Russian SNFs.

Potential supersonic cruise missiles

The main disadvantage of the cruise missiles currently in service with the U.S. Armed Forces is their relatively low speed, which limits the number of situations when such weapons could be used. For this reason, concurrently with the modernization of operational cruise missiles, the United States has also been working to develop new supersonic missiles.

The U.S. Navy has completed research and development for the RATTLRS program (Revolutionary Approach to Time Critical Long Range Strike), which would use a missile flying at 4.5 M (where M [Mach] is the speed of sound) to attack coastal targets at ranges of up to 1,000 km. The cruise time at maximum range would be 15 minutes, and the firing accuracy (circular error probable – CEP) would be about 9 meters. The missile could be equipped with a penetrating warhead or with cluster warheads consisting of self-guiding combined-effect elements.⁵⁹ Demonstration testing of the missile is expected to be completed by 2015, and a decision will be made with regard to its serial production and deployment based on the results.

The U.S. Navy has joined with Boeing to pursue the HyFly program, aimed at building a hypersonic missile having an operational range of at least 1,100 km and a speed of $M \ge 6$. A full-scale model of the missile has undergone static aerodynamic testing. Several launches have been made from an F-15E fighter-bomber aircraft. The selection of the main versions and the conceptual design of a future sea-launched and air-launched hypersonic missile is expected to be completed in the near future.⁶⁰

The ArcLight project carried out by the DARPA agency seeks to create a long-range sea-based strike weapons system based on the Standard SM-3 interceptor missile equipped with a hypersonic engine and carrying a payload. This new delivery system is to have an operational range of over 3,300 km and carry a 40-90 kg payload. The missiles would be loaded into vertical launchers aboard surface ships and submarines. In order to develop this concept, two and five million dollars were allocated in 2010 and 2011, respectively. However, the Defense Department did not request any additional funding for 2012.⁶¹

The Boeing Company is working with the U.S. Air Force to develop the X-51A WaveRider hypersonic aircraft equipped with a directflow scramjet engine. The vehicle is planned to serve as the prototype of an air-launched missile that would have an operational range of up to 1,200 km and a speed of at least 6 M.⁶² During flight testing of the missile prototypes attached to a B-52 bomber in May 2010 and June 2011, the goals were not fully met. Still, the developers noted that during controlled flight of the hypersonic vehicle they had collected data that gave some reason to hope for success.⁶³ Two additional tests have been planned for the future.

Weapons developed under the framework of the Prompt Global Strike Program

In the early 2000s, the U.S. Strategic Command (STRATCOM), which had been previously charged with planning nuclear operations, was assigned a broader role. One of these new functions was to maintain the ability to make rapid, remote precision kinetic (using both conventional and nuclear arms) and non-contact (using space-based and information weapons) strikes on any target anywhere in the world.⁶⁴ In order to meet this goal, the Prompt Global Strike (PGS) strategic concept was developed, entailing the use of a broad range of strategic weapons.

According to the concept, the United States could face the urgent need to make a prompt preemptive strike in order to destroy a limited number of fixed or mobile targets located beyond the operational range of its forward-based forces (Naval or Air Force tactical aviation deployed in the particular region). In fact, the goal would be to deliver a payload to any target around the world within one hour, a capability which only ICBMs and SLBMs currently possess. The ballistic missiles currently in operation in the U.S. armed forces are capable of delivering only nuclear weapons, which significantly limits the possible scenarios for using them to conduct a prompt global strike to those in which the politicians can venture the use of nuclear weapons. For this reason, the Strategic Command has for many years been insisting on the need to press for accelerated development of conventional warheads that could be accurately delivered to distant targets by SLBMs, ICBMs, or hypersonic air vehicles.

The conceptual development of systems for the PGS program has undergone significant change due to research and development delays and to the reluctance of Congress to fund the large-scale production and deployment of these systems. On the whole, Congress shares the opinion that the military command needs to have the appropriate means to carry out prompt non-nuclear strikes against distant targets around the world. Still, the intention to arm ballistic missiles with non-nuclear warheads has encountered strong opposition. The main argument made by opponents of these programs has been that it is difficult to distinguish the launch of a nuclear missile from that of a non-nuclear missile, which could provoke other countries to make a retaliatory nuclear strike. This would be particularly true with respect to SLBMs, which are planned for deployment aboard strategic submarines that would also be armed with nuclear-tipped missiles. Thus, Congress has to the present day adopted spending bills to continue funding the research and development aspect, while cutting allocations for making preparations for deployment.

Once the new U.S. president's administration had declared that it intended to pursue the elimination of nuclear weapons from the planet, the PGS concept was given new life. The new Quadrennial Defense Review Report⁶⁵ published in February 2010 underlined the importance of this program area. The research and development plans presented by the Department of Defense in February 2010 featured a nearly threefold increase in allocations for the PGS program relative to the expenditures that had been provided by the Bush Administration in 2008. Under the new plans, funding for the PGS program accounted for \$239.9 million in 2011, \$238.5 million in 2012, \$274 million in 2013, \$374 million in 2014, and \$574.6 million in 2015.⁶⁶ However, the need for budget sequestration might significantly impact the program. Despite the \$204.8 million Department of Defense allocation request for this program for 2012, the Appropriations Committee recommended allocating only half of this amount.⁶⁷

Another important factor that influenced priorities under the framework of the PGS program was the New START Treaty. Although the United States had recognized the influence of ICBMs and SLBMs with conventional warheads on strategic stability when it signed the Treaty, and had agreed to introduce limitations for such weapons, it did not believe it

necessary to make the PGS weapons an issue for discussion at future negotiations. While referring the New START to Congress, the U.S. Administration declared that the Treaty would not present any obstacle to the development, testing, or deployment of PGS systems. In addition, the American side noted that it would not regard every new kind of weapon with strategic range as a "new kind of strategic offensive arms" that would thus be subject to restriction under the new Treaty. In particular, it emphasized that it would no longer regard future non-nuclear strategic range armaments as being strategic offensive arms for the purposes of the Treaty, if they had not been so defined by its provisions.⁶⁸ A similar interpretation was also reflected in a U.S. Senate Committee on Foreign Relations resolution adopted in relation to the New START Treaty.⁶⁹ For this reason, the main emphasis of the PGS program shifted to the development of hypersonic vehicles,⁷⁰ although the projects using ICBMs and SLBMs with ballistic flight trajectory payloads were still considered to be possible alternative options.⁷¹ The date for deploying elements of the system has been postponed repeatedly and is not expected before 2020.72

In 2011, PGS development centered on three main options, all aimed to test hypersonic vehicles: the Hypersonic Technology Vehicle (HTV-2), the Advanced Hypersonic Vehicle (AHW), and the Conventional Strategic Missile (CSM).⁷³

The HTV-2 vehicle is the experimental prototype of a highly maneuverable guided gliding (with no engine) vehicle that began under the framework of the Force Application and Launch from Continental U.S. (FALCON) program in 2002. The U.S. Air Force is pursuing this project jointly with the DARPA agency and the Lockheed-Martin company. The vehicle being developed was previously named the Common Air Vehicle (CAV), intended to be able to deviate from a standard ballistic trajectory by up to 5,500 km and to carry a payload of about 450 kg. In particular, the CAV was designed to carry a cluster warhead with guided smart submunitions (i.e. BLU-108) or a penetrating warhead that would be able to destroy a target deep underground thanks to its extremely high impact velocity (up to 1.2 km/sec).⁷⁴

The first two flight tests of the HTV-2 were carried out in April 2010 and August 2011. They both followed a similar scenario. The vehicle was boosted by Minotaur IV Lite rocket (three-stage "lite" version of the MX ICBM) from the Vandenberg launch facility. During the flight testing, the vehicles were successfully launched on boosters and then performed a controlled reentry at a speed of about 20 M, but then prematurely (the flight time had been planned for 30 minutes) lost control and self-destructed.⁷⁵ Still, DARPA intends to continue the project and to test the HTV-2 vehicle with a payload.

The goal of the Advanced Hypersonic Weapon (AHW) program is to create a hypersonic glide vehicle that would be able to deliver payloads of up to 450 kg over intercontinental distances.⁷⁶ This is a joint project of the U.S. Army and the Sandia National Laboratory and is considered as a fallback to the FALCON project. Plans call for a vehicle with a shorter range than the FALCON to be launched from forward bases (Guam or Diego Garcia islands) by the booster system manufactured by Orbital Sciences Corporation for the GBI interceptor missiles. Since the mass of the ICBM together with its hypersonic vehicle will be about 20 tons, it is expected that the system will be transportable by air.⁷⁷

The first flight test of the AHW demonstrator was conducted in November 2011 and was considered a success. The hypersonic vehicle was launched from the Pacific Missile Range Facility, Kauai Atoll, Hawaii. After a three-minute flight, the vehicle struck the impact location at the Reagan test site (Kwajalein, Marshall Islands).⁷⁸ According to analysts, the speed of the vehicle during the experiment reached 8 M.⁷⁹

The concept of using ICBMs in conventional configuration that had received the name Conventional Strike Missile (CSM) had been under development for a number of years and by mid-2008 had come to the forefront.⁸⁰

The potential carrier is currently seen to be the Minotaur IV missile. It will combine three stages from the MX ICBM and a fourth stage developed by Orbital Sciences Corporation.⁸¹ Initially, a number of different payloads had been considered for the CSM system, but recently developers have been inclined to use hypersonic vehicles as payload, which would make a significant portion of the flight path of the reentry vehicle differ from a ballistic trajectory, and thus the new weapon type would not be subject to the New START Treaty.⁸² The potential vehicle for delivering the weapon to its target came to be known as the Payload Delivery Vehicle (PDV). The HTV-2 hypersonic vehicle equipped with

a Kinetic Energy Projectile (KEP) warhead developed by the Lawrence Livermore National Laboratory is planned for use as the PDV during testing. The warhead will consist of a charge to produce a directed explosion and several thousand cube-shaped metal elements. The warhead would detonate at a set altitude above the target, and the fragments would inflict damage on the target from their high kinetic energy. In the future, various types of warheads can be considered under the framework of the CSM program.⁸³

The Conventional Trident Missile (CTM) project that planned to equip a portion of the Trident II SLBMs deployed on strategic submarines with conventional warheads had also been undertaken before under the framework of the PGS program. However, Congress has consistently refused to finance the project, and has funded only the research and development portion. Although the Defense Department budget for 2011 and 2012 did not include funding for the CTM program, the U.S. military leadership plans to continue the development of a non-nuclear tipped SLBM.⁸⁴

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