The Motivations Behind the Nuclear Modernization Programs of the P5

Francisco Galamas

Francisco Galamas is a WMD nonproliferation researcher at the National Defense Institute (IDN), Lisbon, Portugal. He is also a member of the Young Atlanticist NATO Working Group of the U.S. Atlantic Council as well as of the George C. Marshall European Center for Security Studies.

Abstract

Over the last years, the Nuclear Nonproliferation Treaty (NPT) recognized nuclear powers (P5) have substantially invested in modernizing their nuclear arsenals. Even considering the need for replacement of some of the nuclear platforms, analysis demonstrates that the development and deployment of new military systems – like the missile shield or hypersonic systems – has created a strategic domino effect on other nuclear powers, namely Russia and China. This article intends not only to describe some of the nuclear modernizations programs currently being implemented by the P5 but also the strategic motivations behind the latter.

Resumo

Motivações dos Programas de Modernização Nuclear dos P5

Nos últimos anos, as potências nucleares reconhecidas pelo Tratado de Não-Proliferação Nuclear (P5) têm investido substancialmente na modernização do seu arsenal nuclear. Mesmo tendo presente a necessidade de substituir algumas das plataformas nucleares, é percetível que o desenvolvimento e a operacionalização de novos sistemas militares – como o escudo antimíssil ou sistemas hipersónicos – criaram um efeito dominó estratégico sob outras potências nucleares, como a Rússia e a China. Este artigo almeja não só descrever alguns dos programas de modernização nuclear em fase de implementação, por parte dos P5, mas também aborda as motivações estratégicas por detrás dos mesmos.

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Introduction

In 2010, the United States (US) and Russia signed the New START, with the purpose of diminishing the number of nuclear warheads and launchers until February 2018. Although the two countries with biggest nuclear arsenals have been making significant reductions over the past decades, recent data demonstrates another trend related to nuclear weapons. Both Washington and Moscow are modernizing their arsenal and the other permanent members of the Security Council are following suit. More importantly, all of these countries have publically mentioned the importance of their nuclear arsenals for their current day threats and Defense strategies.

As most publications describe the modernization process, it should also be seen as paramount an analysis focusing on the strategic drivers behind the latter. Additionally, a Review Conference of the Nuclear Nonproliferation Treaty (NPT) is scheduled for 2015 and such modernization programs are suitable topics for debate. Other countries are also in the midst of upgrading processes on their nuclear delivery vectors – such as North Korea, Pakistan and India – but for the purposes of narrowing the scope of this article no mention will be made to the latter.

US Nuclear Modernization Program

Over the last 20 years, the US has significantly decrease the number of nuclear warheads, an effort that had its biggest reductions under the George H. Bush and George W. Bush Administrations (Kristensen, 2014a). The redundancy of a high number of nuclear weapons as Russia no longer has been able to keep up with a nuclear arms race and the need to uphold nuclear arms control agreements also made with this former superpower were some of the pointed reasons supporting Washington's decision. Notwithstanding such efforts, the US has – at the same time that continues to decrease the quantity of nuclear weapons – initiated substantial investments on its strategic nuclear triad.

The US nuclear modernization plan seeks to extensively upgrade all the nuclear systems, namely strategic missiles, nuclear ballistic missile submarines (known as SSBN), strategic bombers, warheads and support industrial infrastructures. As planned, this program is set to endure for 30 years and to cost $200 billion in just the first 10 years of its duration as the overall costs may rise to $1 trillion (Kristensen and Norris, 2014a: 88). Some analysts have questioned the US financial capability to support such expensive modernization program considering other identified priorities by the military apparatus (Wolfsthal *et al*, 2014). Notwithstanding such criticisms, the objectives of the modernization programs have been clearly outlined: increase the precision of the weapons, expand the options against underground facilities, diminish the released radioactivity and create interoperable warheads so to enable the use of the latter by a wider range ballistic vectors.

In order to achieve these programs, investments are being made in two separate ways: life-extension programs (LEP) and developing new nuclear delivery platforms. As the LEP intends to modernize existing nuclear weapons platforms and grant additional years for its operational use, the second program aims to develop new nuclear weapons platforms to permanently substitute the currently used vectors.

For intercontinental ballistic missiles (ICBM), the US will at the short/medium term modernize elements of the Minuteman III. Since 1998, for example, several programs have been undertaken to replace the propulsion systems (including the missile's solid fuel), the rocket engine, the target REACT system, the warhead and the navigation system (Woolf, 2014: 12-14). In fact, over the last years, the Minuteman III has received US$ 7 billion in LEP so to keep these strategic vectors operational until 2030 (Arms Control Association, 2014).

As these ballistic platforms receive their upgrades, opinions have gathered to address the need to outline the post-2030 ICBM forces. Different options were identified. One of the options entails the maintenance of the Minuteman III ICBM until 2075 without any upgrades. Another possibility envisions the maintenance of this ICBM until 2075 but including necessary upgrades. Finally, a third option looks at the possibility of producing a silo-based Minuteman III substitute. Different variations of this last option were also considered either in a road-mobile and rail-mobile based versions (Woolf, 2014: 16).

The replacement for the current ICBM model is already being contemplated by the US Air Force, which is likely to be named Ground-Based Strategic Deterrent (GBSD) but whose major details are yet unknown. While no final decision is taken, a hybrid vector merging a new design with some already used elements of the Minuteman III is also seen as a credible hypothesis. More specifically, the team may maintain the basic structure of the presently used ICBM while inserting a new rocket motors and target-guidance systems. A major feature of the new ICBM may be its mobility as the design team will try to make it mobile platforms compatible, especially for trucks or especially designed trains. If confirmed, such option would strengthen the US second strike capabilities as it increase the odds of survivability of this nuclear platform against a hypothetical first strike. Still, one of the most anticipated upgrades for the GBSD ICBM is its accuracy as it would allow US forces to destroy the highly protected targets (such as underground facilities or heavily reinforced ICBM silos) with just one warhead instead of using a multitude of them (Grossman, 2014). Furthermore, by opting with just one warhead the US would be, at the same time, abiding to the New START agreed limitations.

Recently, an analysis by the RAND Corporation on the US's ICBM forces concluded that the financial efforts to produce a new ICBM will double or triple the costs compared to other options that rely on the progressive modernization of the currently used systems (Caston *et al*, 2014). Albeit the putative financial burden behind the development a new nuclear intercontinental delivery platform, the head of U.S. Strategic Command, Admiral Haney, has stated that a new ICBM is needed as continuous upgrades of the Minuteman III capabilities are unlikely to meet future security needs (Grossman, 2014). In order to address those security requirements, the US Air Force planning aims to replace 450 Minuteman III ICBM with 420 GBSD ICBM by 2030.

The maritime vector of the nuclear triad will also be modernized. The Ohio-class submarines operational use has been extended until 2027, after which the US Navy will begin the replacement of these vessels for new nuclear ballistic missile capable submarines (SSBN)at a rate of one per year. Known as the SSBN(X) or the Ohio Replacement Program, the new SSBN development project has already begun but the production will only begin in 2019 so to begin entering the fleet in 2029. The total cost of the SSBN(X) is expected to stay between $97 and $102 billion for twelve new submarines that will replace the current fleet of fourteen Ohio-class SSBN (Woolf, 2014: 22). The SSBN(X) is likely to have a 40-42 years of service life and will possess 16 submarine-launched ballistic missile (SLBM) launch tubes (O'Rourke, 2014).

Another objective of the US Navy is to upgrade the currently used Trident IID-5 SLBM. Efforts were led to modernize this ballistic missile with the purpose of extending the Trident IID-5 use until 2042. The modernization process will not focus solely on electronics as it aims to upgrade the D-5 warhead as well. Additionally, the warhead used in the D-5 SLBM has been also subjected to a LEP in order prolong its lifetime for an additional 25 years (Osborn, 2014a).

Nuclear bombers will undergo improvements as well. The US Air Force has decided to invest $10 billion on needed modifications for the B-2 bomber over the next few years so to keep it in service until 2058. Upgrades in this stealth bomber, for instance, include a new receiver to withstand the electromagnetic pulse of a nuclear explosion (Campbell, 2014). In September 2011, it was decided that the B-52H – another US nuclear bomber – would also receive upgrades, including advanced satellite links so to prolong its service life until 2044. To arm these bombers, a new nuclear cruise missile is also under development albeit the currently used AGM-86 Air-Launched Cruise Missile (ALCM) is also being improved to last until 2030. With the new Long Range Stand-Off (LRSO) cruise missile these bombers are intended to be able to deliver their nuclear weapons without having to expose themselves to modern air defenses (Freedberg Jr., 2014). Other purposes surrounding the development of the LRSO include the ability to penetrate and evade modern integrated air defense systems while targeting "strategic targets in support of the USAF's global attack capability and strategic deterrence core function"(Hemmerdinger, 2014). Additionally, by using lower yield warheads, the LRSO permits the US political and military decision-makers a higher degree of flexibility in case of nuclear response necessity (Kristensen, 2014b).

Modernization work will be done in the B61 gravity bomb as well. According to the US National Nuclear Security Administration, the B61-12 bomb upgrades are aimed to extend the service life of this nuclear weapon for an additional 20 years, in a project that had a cost of around $8 billion (Robinson-Avila, 2014). The integration of the B61-12 nuclear bomb in NATO's arsenal will begin in 2015 and will likely endure until 2018. F-16, Tornado and F-25A aircrafts will be some of the chosen platforms for this weapon when delivered to the "Dutch, Italian, Turkish, and possibly Belgian air forces" (Kristensen, 2014c). This upgraded model of the B61 will be more accurate which in turn will enable the use of lower yield warheads, a similar posture permitted by the nuclear cruise missiles. The downside of resorting to nuclear bombs is the required proximity to the target that may jeopardize the aircraft's physical security.
Finally, the US Air Force intends to develop a new strategic bomber, the Long-Range Strike Bomber (LRS-B), to replace the B-2 bombers. Although much of the details surrounding this new bomber are yet unavailable, it is anticipated that it will include features such as stealth manned and unmanned flight, nuclear capability, the ability to fly across the globe in hours and to carry emerging or future weapons. Initial plans predict the acquisition of 80 to 100 LRS-B at a price tag of $550 million per unit (Osborn, 2014b).

Russian Nuclear Modernization Program

Similar to the US efforts, Russia already began the nuclear modernization of its strategic triad mostly to offset the US and NATO conventional military superiority. Although the most significant steps have been taken since 2013, Moscow has initiated the replacement and upgrade of its nuclear weapons platforms years earlier while keeping a simultaneous development process for new ones.
On the ICBM front, the Russian Strategic Missile Force (SMF) will replace older vectors like the SS-18, SS-19 and the SS-19 with the post-Cold War Topol-M SS-27 and RS-24 Yars (also known as SS-27 Mod 2) until 2022. But Russia is developing new ICBMs as well. For instance, a new and lighter version of the RS-24 Yars, known as RS-26 Rubezh, has already been tested and is expect to be deployed over the next years with a modified warhead and improved accuracy. The Rubezh ICBM is expected to replace the Topol-M SS-27 and the RS-24 Yars in the future. Russia also plans on producing a new ICBM, named Sarmat, to substitute the aging SS-18 Satan. According to the information available, the Sarmat ICBM will be a silo-based liquid-fueled missile capable of carrying MIRV warheads over 10 thousand kilometers and likely to be deployed around 2020 (Global Security, 2014) (Kristensen, 2014d). Before any deployment, the Sarmat ICBM will need to undergo a series of tests as the Russian liquid-fueled missiles were traditionally built in Ukraine and the Russian ability to develop these sort of missiles needs additional validation (Kristensen and Norris, 2014: 78-79).

Considering the modifications currently taking place in the Russian strategic missile forces, analysts predict that its ICBM structure is likely to be comprised by five variants of the solid-fuel SS-27 (silo and mobile-based SS-27 Mod 1, the silo and mobile-based SS-27 Mod 2 and the RS-24 Yars) as well as with the new liquid-fuel Sarmat ICBM. Although there will be less ICBMs in the new missile structure, it is predicted that – until 2024 – 70% of them will have MIRV warheads installed which will represent a substantial increase from the current 36% of ICBMs with MIRV capability (Kristensen, 2014d). This modification may have an impact on the strategic balance with other nuclear powers – such as the US – mostly because by adding warheads to a single vector, Russia increases the incentives to a first nuclear strike.

The maritime branch of the Russian nuclear triad will also be modernized. Over the last years, Russia has relied on SSBNs as a strategic platform for a naval second strike capability. The SSBN fleet has consisted of eight submarines, out of which six are Delta-IV class and two are Delta-III class. As Moscow intends to upgrade the Delta-IV SSBN, so they can endure an additional 10-15 years, the Delta-III SSBN is scheduled for decommission. Considering the need to replace these naval platforms, Russia has been developing the fourth generation Borey-class SSBN. In 2013, two have already been deployed to the Russian Navy SSBN force with a capacity for 16 SLBM each. With the anticipated addition of six more Borey-class SSBN to the Russian Navy, this configuration for a sea-based nuclear deterrence is planned to last until 2040 (Weitz, 2014).

In terms of naval platforms' ballistic missiles, in 2007, the Russian Navy has deployed the liquid-fuel Sineva SLBM to Delta-IV SSBN. The Sineva is capable of carrying between 6 to 12 warheads of 150 kilotons yield each or 4 warheads of strategic yield and has a range of over 11 thousand kilometers. Four years later, this particular SLBM was renamed Liner and heavily modified in order to include MIRV capability and other missile defenses evading technologies (NTI, 2011). Another SLBM currently under development by the Russian Armed Forces is the Bulava. Weighting 37 tones, this vector has suffered eight test failures over the past years, making it necessary for additional sea trials in 2015. The Bulava is a three stage solid-fuel SLBM with a range of 8 000 kilometers and capable of carrying 6 to 10 hypersonic 100-150 kiloton nuclear warheads (Jordan, 2014).

Finally, Russia is modernizing its Air Force ability to deliver nuclear weapons. Currently, the Russian Air Force has three different nuclear bombers: the Tu-22M3, Tu-160 and the Tu-95. Both of them are capable of using ALCM like the Kh-55 or gravity bombs. But Moscow has decided to develop a new nuclear capable ALCM, the Kh-102. Capable of delivering a single 250 Kilotons nuclear warhead this particular vector is being developed in order to replace the currently used Kh-55 in the near future. Although shrouded with uncertainty, some information claims that this missile will have a range between 2000 to 3500 kilometers (Missile Threat, 2013).

Efforts are also being carried in the development of a new strategic long range bomber known as PAK-DA. Scheduled to enter service in 2023, this new sub-sonic bomber will include stealth features and is anticipated to replace the currently used nuclear bombers (de Larrinaga, 2014).

Considering the two thousand "non-strategic" nuclear weapons possessed by Russia, the modernization of their delivery means is also being under consideration. A new fighter-bomber, the Su-34 "Fullback" with tactical nuclear weapons capability, has been delivered to the Russian Ministry of Defense to substitute the currently used Su-24M Fencer. Other platforms for tactical nuclear weapons have been recently deployed, namely the Severodvinsk-class submarine with a new cruise missile, Kalibr, that may be nuclear capable. Finally, the SS-26 Iskander-M tactical missiles, also a viable mean to deliver a tactical nuclear warhead, were developed to replace the SS-21 tactical missiles (Kristensen, 2014e).

Similar to what happened in the US, questions have emerged about the Russian economy capability to support the large investments required by the military modernization process, including the costs on nuclear modernization and development. Moscow aims to spend $500 billion until 2020 and an additional similar program has been announced for 2016-2025. In the light of these numbers, the Russian Minister of Finance has claimed that the country's economy cannot support investments of such dimension. Furthermore, the currently-enforced Western countries sanctions coupled with the inflation and declining oil prices have further hampered the Russian economy growth perspectives and raised eyebrows on the financial feasibility of the ongoing nuclear modernization efforts (Bodner, 2014).

Chinese Nuclear Modernization Program

Parallel to the ongoing military modernization led by the USA and Russia, China's military apparatus is also modernizing its nuclear arsenal. The two decade old nuclear renewal process aims at not only improving land, sea and air nuclear platforms but to increase (although marginally) the size of the nuclear arsenal as well. In fact, China is the only country of the P5 to expand the number of its nuclear weapons.

In terms of ICBM, Beijing is pursuing solid-fuel and mobile strategic missiles so to reinforce its second strike capability and credibility. Over the last years China has relied on DF-31 and DF-31A ICBM to support the already existing silo-based liquid-fuel ICBMs. The development of the DF-31 began in 1970 but operational requirements made it necessary design modifications in the 90's. While it is seldom to find reliable information about this vector, some accounts suggest that it is MIRV capable although Chinese authorities will prefer the single warhead version with penetration support mechanisms. The DF-31A is an upgrade version with an extended range that varies between 10 000 - 14 000 kilometers (depending on the payload) which puts the US territory within the range of these vectors (Missile Threat, 2014). Notwithstanding the declared operational status in 1999-2000, China might produce a new ICBM, with MIRV capability, as a reinforcement of the Chinese deterrence capability (Office of the Secretary of Defense, 2013: 6).

In 2014, the Pentagon confirmed that China is developing a new ICBM which had another flight test in December of 2014. Already acknowledged by the Chinese authorities, the DF-41 will likely be a solid-fuel road-mobile ICBM with 12 000 kilometers range and MIRV capability, to a maximum of ten warheads per missile (AFP, 2014; Gertz, 2014a).

Another unconfirmed hypothesis encompasses the development of a new intermediate-range ballistic missile (IRBM). Known as the DF-26C, this mobile and solid-fuel IRBM could be the future substitute of the DF-21 (Gertz, 2014b). Beijing is also believed to be developing hypersonic nuclear capable delivery means. In August of 2014, news emerged on a (allegedly unsuccessful) second flight test of WU-14, a hypersonic glide vehicle, to be later linked with strategic nuclear weapons systems (US-China Economic and Security Review Commission, 2014: 291; Gertz, 2014c).

When considering maritime-based nuclear assets, the Chinese leadership has been spending substantial resources in sea-deterrence capabilities in order to develop a naval credible second strike capability for the first time in the country's History. For that matter, the Chinese Navy has been developing the Jing-class SSBN, including the three already operational Jing-class (type 094) with the purpose of adding one or two Type 094 SSBN to the SSBN fleet until 2020. Although recent, sources claim the latter to have poor SSBN standards, detectability issues and nuclear propulsion problems placing their effectiveness well below the currently used US and Russian SSBN. To solve those complications, including noise reduction devices to better prevent detection, China has started to plan a next-generation SSBN, the type 096 Tang-class submarine.

SSBN capabilities only matter if there are vectors that can reach the opponents territory and the development of the JL-2 SLBM by the Chinese military apparatus aims to do so. Although lacking reliable information, US estimates that the JL-2 range varies between 7 000 to 7 400 kilometers, which prevents it from reaching the continental US (8 400 kilometers) or Washington DC (11 000 kilometers) if launched inside Chinese territorial waters. Like other nuclear capable missiles, MIRV capability has also been another analyzed possibility for the JL-2 SLBM. Experts have expressed different opinions on the number of warheads that a "MIRVed" JL-2 might possess but they all agree that China already has the sufficient know-how to implement such technology (Skypek, 2010).

Still, the lack of any known joint JL-2 SLBM in a Type 094 SSBN test makes it unlikely that both systems are yet operational. Furthermore, even if operational, to reach the US, these Chinese submarines would need to sail deep into the Pacific where the US has substantial anti-submarine capabilities. Due to the current noise levels derived from the Chinese SSBN, this would allow an easy detection by the US naval forces which in the end would prove to be a very fragile strategic option (Kristensen, 2013). China is also believed to be planning a new SLBM, JL-3, presumably to have an 11 000 kilometers range, MIRV warheads and achieve operational status by 2020 (Skypek, 2010: 118).

Nuclear platforms capabilities have been targeted for modernization by the Chinese Air Force as well. The People's Liberation Army received in June 2013, 15 new nuclear-capable bombers (Xian H-6K) deriving from the H-6 bomber but with upgraded engines allowing it to reach 3 500 kilometers. The elimination of the bomb bay from this nuclear bomber was another factor behind the extension of this bomber's range. Moreover, the H-6K are capable of launching the new nuclear long-range cruise missile (CJ-10k), the first long-range LACM produced by China. By uniting the range of the new Chinese bomber and the CJ-10K (1500 and 2000 kilometers), China may be able to have a combined 5 000 kilometers nuclear strike range allowing it to reach Guam, Alaska or Hawaii from Chinese territory(Keck, 2013). Furthermore, according to the US Air Force Global Strike Command, Beijing may be also testing a new nuclear capable cruise missile, the CJ-20, a variant of the already existing CJ-10 (US-China Economic and Security Review Commission, 2014: 312; Barnes, 2013).

Additional efforts are being taken in the development of a new long-range bomber capable of reaching 12 000 kilometers and will likely be based on the US B-2 Spirit bomber. Such endeavor may be undertaken in collaboration with Russia, according to the director of the aviation industry department at the Russian Ministry of Industry and Trade (Want China Times, 2014; Gertz, 2013).

The Chinese People's Liberation Army has also invested in the command and control and communications capabilities of its more dispersed nuclear forces, mostly due to increasing reliance on ICBM mobile platforms and the likely initiation of SSBN deterrence patrols (Office of the Secretary of Defense, 2013: 31-32). Yet, China's nuclear doctrine has not shifted from the traditional "No-First Use" policy – a doctrine that envisages the use of nuclear weapons solely as a response against a previous nuclear attack– whose foundations still rely on the survivability of its nuclear arsenal against a first strike. With this purpose in mind, it is perceptible that the Chinese nuclear modernization process is aimed at improving its command and control, delivery capabilities and credibility with the purpose of assuring nuclear retaliation (Kulacki, 2011).

French Nuclear Modernization Program

Like the three previous countries, France also has an ongoing process of nuclear forces modernization, including submarines, airplanes, missiles and warheads so to extend their service life until 2050. With a 300 nuclear weapons stockpile and an yearly budget of $4.5 billion, Paris currently lies the foundations of its *force du frappe* in two main components: sea-based nuclear forces and aircrafts with nuclear weapons capability. Both components are going through a decade long modernization process. The sea-based deterrence forces are based on the four operational SSBN with the 5 000 kilometer range SLBM, the M45. Yet, since 1992 that the French authorities felt the need to develop a new SLBM model, named M51 (Federation of American Scientists, 2000).

With penetration aids and a range of 6 000 kilometers – that can be extended to 8 000 kilometers if a lighter payload is chosen – the M51 will suffer continuous design modifications until its final version which will be deployed in 2020 (Freedman and Tertrais, 2009: 10). The first version of this SLBM (M51.1) relies on the TN75 warheads, with a 100Kt yield, and was placed in the *Le Terrible* SSBN. Other M51 versions are still in the development phase (whose versions will be named M51.2 and M51.3) and will likely replace the previous M51 version over the next few years. Both models are planned to be operational in 2015-2018 and 2020, respectively. One of the most significant changes in these two latter models will be the introduction of the new Tête Nucléaire Océanique (TNO) warhead. In the meantime, as the latest upgraded models of the M51 are yet to be deployed, France has already began developing the concept for the M6 SLBM (Collin, 2013).

Regarding the air nuclear delivery platforms, the French Air Force operates two nuclear-capable aircrafts: the Mirage 2000N K3 and the Rafale F3. For nuclear-type missions, the former will be continuously replaced by the Rafale F3, until the end of the decade. In 2010, the Rafale F3 was upgraded in order to carry the new Air-Sol Moyenne Portée Amélioré (ASMP-A) nuclear cruise missile. The ASMPA is solid fuel missile with a range of over 500 kilometers and will carry the new Tête Nucleaire Aéroportée (TNA) warhead (Air Force Technology, 2013).

United Kingdom Nuclear Modernization Program

Though in the midst of a nuclear weapons stockpile reduction process, the United Kingdom (UK) is also undergoing a process of nuclear modernization. From the current 225 nuclear weapons, the British leadership aims to reduce this stockpile to 180 nuclear devices until the first half of the next decade (Kristensen, 2014e). Out of these 180 warheads, around 120 will be operationally available until 2030 (Russia Times, 2014b). In terms of LEP, the warheads used in these ballistic missiles are likely to have been upgraded in order to extend their service life until 2040. This process was supported by the US based on the 1958 US-UK Mutual Defence Agreement that permits the transfer of technology for nuclear weapons between both countries (Kristensen, 2011). Still, the UK nuclear arsenal currently relies solely on four Vanguard-class SSBN each one carrying 16 Trident

II D5 SLBM, as the WE.177 nuclear bomb was retired from the British military arsenal in 1998.

A 2006 White Paper from the British Ministry of Defence (MoD) recommended the maintenance of nuclear weapons with the purpose of maintaining a sea-based minimum nuclear deterrence capability (The Secretary of State for Defence and The Secretary of State for Foreign and Commonwealth Affairs, 2006). To do so, the UK began to plan for a nuclear weapons and platforms modernization initiative, named the successor programme that, if fully implemented, will include the replacement of the Vanguard-class SSBN for new nuclear weapons capable submarines. With an anticipated cost around £15-20 billion, the programme will envisage a new submarine (named Successor), new warheads for the Trident II D5 SLBM warheads and support infrastructure (Mills and Brooke-Holland, 2014). But although this modernization process is likely to be implemented, it is improbable that any structural decision affecting the British nuclear arsenal is made prior to 2016 (Grossman, 2014b).

Nuclear Modernization Motivations

The most likely reason behind these modernization efforts is linked to the expiration of these vectors' service life, or in some cases to their technological redundancy, as most of them are Cold War remnants. In the case of the US, the LEP are badly needed to maintain the efficiency of the delivery platforms and prevent them from becoming outdated. For example, the Minuteman III ICBM was initially deployed in 1970 and is expected to last until 2030. Even considering all the upgrades made, it still is a 40-year old design with decades old command and control infrastructure (Vanderschuere, 2013). Russia's Nuclear Forces suffer from the same problem. The Russian ICBM have a 30-40 year service life period which has already expired and some missiles have initiated its decommissioning process, like the SS-18, SS-19 and the SS-25. Similar actions will be taken for the Russian Delta-III SSBN. The Delta-IV SSBN is likely to be modernized so to endure an additional 10 to 15 years, while the new Borey-class SSBN fleet does not come into fruition (Weitz, 2014a). Furthermore, the Tu-95 MS nuclear bombers, built in 1950's, are expected to be replaced by the new Russian nuclear capable aircraft, named PAK-DA.

Other nuclear weapons countries face analogous challenges. The UK, for instance, will need to make a decision on its SSBN fleet as they were built between 1986 and 1999 and the end of their service lives will begin shortly after 2020 (Klotz, 2013). Both China's need to replace some of its older DF-5 ICBM versions for newer models, such as the DF-31A or the still under test DF-41, as well as France's modernization efforts, to maintain its nuclear arsenal credibility until 2050, are strong examples on the need substitute older platforms of nuclear forces (Rover, 2014).

Another important factor behind nuclear modernization programs is the US purpose of maintaining nuclear superiority over its two main nuclear opponents –

China and Russia. Although we have been witnessing a 20 year hiatus from any Great-power enmity, the reality has bluntly showed that nuclear weapons are the most powerful weapons in the planet and an equivalent of enormous geostrategic value (Kroenig, 2013). As China power projection capabilities improve significantly, especially in terms of second strike capability, and Russia devotes substantial financial resources to its nuclear forces, US political and military stakeholders see it necessary to maintain a nuclear capabilities gap with its opponents, even if solely in qualitative terms. A quick look into the 2014 Quadrennial Defense Review tells us that the US Nuclear Forces need to have the "ability to project power by communicating to potential nuclear-armed adversaries that they cannot escalate their way out of failed conventional aggression" (Department of Defense, 2014: V). To achieve this purpose, maintaining a nuclear capability superiority is paramount.

Furthermore, if the US wishes to maintain a global presence, including scenarios with other nuclear weapons powers, preserving Alliances with non-nuclear countries will inevitably imply extended deterrence commitments to the latter for stability maintenance purposes. Such strategy will only be seen as viable if the US nuclear capabilities are understood as capable to not only protect its Allies - resorting to, for instance, to missile defenses – but also to deter and retaliate against an attacker. As the 2010 Nuclear Posture Review clearly states "U.S. nuclear weapons have played an essential role in extending deterrence to U.S. allies and partners against nuclear attacks or nuclear-backed coercion by states in their region that possess or are seeking nuclear weapons" (Department of Defense, 2010: 31). Any failure in doing so, will eventually not only undermine the US's credibility towards its Allies but risks igniting a regional nuclear arms race.

Also pointed out as catalyst for some of the nuclear weapons platforms' modernization is the deployment of antimissile interceptors systems. Washington and Moscow, in 1972, signed the Anti-Ballistic Missile (ABM) Treaty that limited the placement of missile interceptors to just one location. This agreement was based upon the notion that the available systems were too expensive and technologically unsophisticated to pursue considering the countermeasures available, such as MIRV warheads and other decoys. Additionally, the lack of missile defense systems coupled with mutual assured destruction permitted by both nuclear arsenals allowed for a strategic stability between both States as well as prevented a quantitative and qualitative nuclear arms race. As the development of "deterrence by denial" systems was seen as detrimental for the stability, the ABM Treaty provided an important tool to further guarantee stability between both superpowers (Schaffer, 2014).

In December of 2001, the Bush Administration announced that the US would unilaterally withdraw from the ABM Treaty due to the menace of "terrorist or rogue-state missile attacks" and to protect the US and its allies from the latter

(Bush, 2001). At the time, President Bush also announced the need to implement a ballistic missile shield in Europe (known as European Interceptor Site) and, in 2007, the placement of the missile interceptors systems began to be formally negotiated with Poland and Czech Republic. A year later, in 2009, the then recently elected President Obama abandoned the Bush Administration missile defense plans for Europe and revealed an altered version, named European Phased Adaptive Approach (EPAA).

Regardless of the modifications made in the EPAA version of the missile shield structure, Russia continued to demand legal binding guarantees stating that the interceptors placed in Europe are not aimed at the Russian nuclear weapons. Furthermore, Moscow also requested to be present in a future joint missile shield structure as a partner. Other requests included, for instance, a limitation on the number of interceptors placed in Europe and missile defense sites as well as restrictions on the speed of the deployed interceptors (Péczeli, 2013).

In this particular aspect, Moscow believes that interceptors, like the ones placed in the Aegis-equipped (the SM-3 IIA or the SM-3 Block IIB) can undermine the Russian second strike capability due to their capability to interrupt an ICBM trajectory. Notwithstanding such claims, a model developed by a researcher at RAND calculates that interceptors placed in the Polish site cannot eliminate the Russian strategic nuclear vectors. Still, the Obama Administration decided to cancel the placement of the SM-3 Block IIB in Europe as well as the Precision Tracking Space System sensors program that could reduce the response time of Aegis-ship placed SM-3 Block IIA interceptors so to hit ICBM for the sake of preserving a stable US-Russia strategic relationship (Sankaran, 2013).

Albeit these decisions, Russia has decided to pursue an upgrade of its nuclear arsenal so to allow its strategic vectors to overcome any NATO missile defense capability. In fact, both the Russian 2010 National Security Strategy and the 2014 revised National Military Doctrine clearly state that the deployment of "strategic missile defence systems" is considered one of the main threats that Russia is currently faced with (Russian Federation, 2010) (Weitz, 2014b).

When looking at all the nuclear modernization efforts made so far, it is perceptible that much of these endeavors aim to diminish any impact the missile interceptors may have on the Russian strategic arsenal. For instance, Maneuverable Reentry Vehicle (MARV) warheads were added to the Topol SS-27 ICBM to decrease the interception capabilities of any placed missile defense systems. Similar options were made for the Liner SLBM which was already tested with MIRV warheads and other missile defense countermeasures, such as electronic jammers. Additionally, the recent RS-26 Rubezh test has been announced by the Russian authorities to have the capability to surpass the "*modern (…) prospective American missile defenses*" (emphasis added) (Russia Times, 2014a). With analogous purposes, Russian hypersonic delivery vehicles are currently in the development stage (US National Air and Space Intelligence Center, 2013).

Efforts are also being devoted by Russia in the realm of missile defense. Since 1999, that Russia is developing a land "highly mobile fifth-generation air-defense and anti-ballistic missile defense system"(S-500 Prometheus) planned for deployment in 2016 (Russia Times, 2014c). This latter system will be capable of intercepting missiles at an altitude of 200 kilometers while sea-based ballistic missile defense endeavors have also been undertaken as a naval version of the S-500 is expected to be ready for deployment in 2016 (Honkova, 2013).

Looking at the development of missile defense systems through the Chinese point of view shows that this system also had an impact on the military leadership. Over the last years, a number of missile defense systems have been deployed in East Asia due to the fears linked to the North Korean ballistic missile development and testing. Seven Aegis-equipped destroyers with SM-3 interceptors are already supporting Japan's missile defense efforts that include Patriot Advanced Capability-2 (PAC-2) missile defense systems as well. Due to some limitations of the PAC-2 systems, Tokyo will look into the possibility of resorting to a Terminal High Altitude Area Defense (THAAD) and land version of the Aegis system so to create a four-layer missile defense structure (Japan Times, 2014). For similar reasons, South Korea has already acquired PAC-2 interceptors and is currently developing the Korean Air and Missile Defense (KAMD) which will include several missile intercepting equipment (Galamas, 2014).

As regional efforts gather to counter the ballistic missile threat from Pyongyang, China has the clear perception that any regional missile defense structure aimed at North Korean missiles could affect China's strategic arsenal as well (Entous and Barnes, 2012). For example, over the last months of 2014, Beijing criticized the USA for placing X-band early warning radars and other missile defense equipment in East Asian countries. Such capabilities could be, according to Chinese officials, highly detrimental for the stability and mutual trust in the Asia-Pacific region (Rajagopalan, 2014).

To address such situation, some of the nuclear modernization options taken by China have been though to counter the current and future regionally deployed interceptors. The Chinese military apparatus have been working on MARV and MIRV warheads, decoys, chaff, jamming and other types missile defense countermeasures (Office of the Secretary of Defense, 2013: 31). The development of the new DF-41 ICBM with MIRV warheads serves as another example, among others, of missile defense countermeasures development by the Chinese Armed Forces.

Another important factor driving both the Russian and Chinese nuclear modernization processes is the Counterforce Revolution of the US military capabilities, particularly the Prompt Global Strike (PGS) system. If the PGS is fully developed, including its hypersonic platforms, it will give the possibility to the US military planners to strike any target on the planet in one hour with high levels of precision. Because these weapons travel at such velocity, it is very difficult to track or eliminate them with the current defense systems. In fact, the US nuclear forces improvement of counterforce capabilities is clearly outlined in the objectives behind the nuclear modernization as previously mentioned. Besides, when high velocity and precision delivery platforms enter the nuclear deterrence formula it is important to bear in mind that the stability of the latter is highly permeable to any nuclear policy shifts that imply increased emphasis on counterforce targeting.

Fearing that a preemptive hypersonic weapon attack can eliminate nuclear weapons platforms – such as silo-based ICBM – both Moscow and Beijing are making some modifications to their nuclear forces so to better tackle this possibility. Taking advantage of its enormous strategic depth, Russia, for example, announced that it will re-implement rail-mounted ICBM in order to guarantee the survivability of the nuclear forces and reinforce its second strike capability (Panda, 2013). The announcement came directly from the Russian news agency declaring that this system, named Barguzin, will remain operational from 2018-19 to 2040 and will be able to carry six Yars or Yars-M ICBM (Russian News Agency «TASS», 2014). The S-500 Prometheus anti-ballistic missile defense system is another good example as it was announced to resort to two new missiles (the 77N6-N and the 77N6-N1) capable of hitting targets flying at hypersonic speeds (around seven kilometers per second) (Missile Threat, 2013).

Going on a similar path, China also decided to reinforce its second strike capability. The recently tested DF-41 ICBM is predicted to be road-mobile so to evade any preemptive strike attempt while a hypersonic missile, the Wu-14, is already in the test phase. US officials claim that the purpose of this vector is to allow China to have US defenses penetration capability (Lau, 2014). Finally, reports sustain that China is developing tunneling technology in order to expand its underground strategic nuclear facilities. Such technology will not only permit the underground use of mobile ICBM but also the installation of rail-mobile ICBM (Gertz, 2014d).

These options clearly demonstrate that both Russia and China feel that missile defense and PGS technology and capabilities may undermine their nuclear second strike capabilities. As mentioned earlier, the Chinese nuclear doctrine is based on a "No-First Use" policy that solely relies on second strike capabilities. Any technologies that may undermine the assurance of nuclear retaliation or the survivability of the nuclear forces to a preemptive nuclear strike will be met – without surprise – with nuclear weapons and vectors upgrades and modernization.

In the specific case of Russia, the issue of international prestige must also be taken into consideration. Throughout the years, the national pride and strategic culture of Russia has been closely linked to its great power status. Thus, the ability to be at the forefront of military technological developments is important for Russia in a time that the US is significantly upgrading its nuclear arsenal.

Final Remarks

In a year that the State Parties of the Nuclear Nonproliferation Treaty (NPT) will meet to evaluate its implementation, it is important to look at the nuclear arsenals of the NPT recognized nuclear weapons States. Although the number of nuclear weapons has significantly decrease over the last 30 years, the destabilizing effects of nuclear weapons risk being felt if additional measures for transparency are not taken.

The US, albeit its decision withdraw from the ABM Treaty, has taken some nuclear doctrine stabilizing decisions. For instance, by diminishing the number of warheads on its ICBM and choosing road-mobile ICBM for its future arsenal, the US are decreasing any incentives for a first strike option. On the other hand, the worldwide implementation of missile defenses – regardless of their actual technical necessity – and its focus on counterforce doctrines had the detrimental effect of creating a qualitative nuclear arms race in other nuclear powers, namely Russia and China.

The main issue behind the qualitative improvements that both Moscow and Beijing are doing in their arsenal is that it was reverse effects than those that are desirable. By placing MIRV warheads on several of their delivery means they are actually creating incentives for a preemptive strike which is the opposite of what is desirable for a strategic stability dynamic between nuclear powers. Furthermore, the nuclear proliferation phenomenon – either in its horizontal or vertical aspect – "feeds" on itself. Any shifts on the nuclear arsenals or related defense capabilities will automatically have repercussions on other nuclear powers arsenals, risking creating a nuclear arms race.

The main difference between the current nuclear arms race we are currently witnessing and the one occurred during the Cold War lies on the fact that the number of vectors is no longer the main focus of the nuclear powers. In fact, they are demonstrating a deeper concern with second strike capabilities and defense systems countermeasures, which can be more dangerous as this particular competition is only limited by technological innovation capabilities. For instance, even though the new US nuclear capabilities have not yet materialized, Lockheed Martin is already anticipating and researching – partly funded by the US Department of Defense – methods to address the threat of hypersonic missiles, which are already under development in Russia and China. Moreover, it has been upgrading the range of the THAAD missile interceptor system so to increase nine to twelve times the current coverage as well as it is devoting efforts to augment the velocity of THAAD's interceptors (Weisgerber, 2015).

But the World must face the harsh reality that nuclear weapons – due to its strategic importance – are here to stay and nuclear arsenals improvements will continue to be sought by the States as an important factor to gain military advantage. Situation will only get worse as the number of countries possessing such weapons increase and the world community cannot address the regional security reasons behind those nuclear weapons programs. Bearing in mind the detrimental effects that such can provoke it is paramount that the NPT's recognized nuclear powers address the security concerns behind the quantitative and qualitative improvements of nuclear weapons programs, preferably within diplomatic multilateral *fora.* Any other courses of action are unlike to produce better outcomes than the latter solution.

References

AFP (2014). "China 'confirms new generation long range missiles'". *The Telegraph*, August 1. Available at http://www.telegraph.co.uk/news/worldnews/asia/china/11005061/China-confirms-new-generation-long-range-missiles.html.

Air Force Technology (2013). "French Air Force evaluates ASMPA enhanced stand-off missile". *Air Force Technology*, September 25. Available at http://www.airforce-technology.com/news/newsfrench-air-force-evaluates-asmpa-enhanced-stand-off-missile.

Arms Control Association (2014). "U.S. Nuclear Modernization Programs". *Arms Control Association*, January. Available at http://www.armscontrol.org/factsheets/USNuclear-Modernization.

Barnes, Diane (2013). "North Korea, China Pursuing Nuke-Ready Cruise Missiles: Air Force". *Global Security Newswire*, May 30. Available at http://www.nti.org/gsn/article/north-korea-and-china-pursuing-nuke-ready-cruise-missiles-air-force/.

Bodner, Matthew (2014). "Finance Minister Says Russia's Grand Rearmament Plans are Unaffordable". *The Moscow Times*, October 7. Available at http://www.themoscowtimes.com/business/article/finance-minister-urges-defense-budget-rethink-amid-bleak-economic-forecast/508569.html

Bush, George (2001). *President Bush's Remarks on U.S. Withdrawal From the ABM Treaty*, December 13. Available at http://www.armscontrol.org/act/2002_01-02/docjanfeb02.

Caston, Lauren; Robert S. Leonard; Christopher A. Mouton, Chad J. R. Ohlandt, Craig S. Moore, Raymond E. Conley, and Glenn Buchan (2014). *The Future of the U.S. Intercontinental Ballistic Missile Force*. RAND Corporation. Available at http://www.rand.org/content/dam/rand/pubs/monographs/MG1200/MG1210/RAND_MG1210.pdf.

Campbell, Matt (2014). "B-2 stealth bomber, at age 25, to get major upgrades from Air Force". *The Kansas City Star*, July 14. Available at http://www.kansascity.com/news/government-politics/article728437.html#storylink=cpy.

Collin, Jean-Marie (2013). "The M51 Missile Failure: Where Does This Leave French Nuclear Modernization?". *British American Security Information Council*, June 27. Available at http://www.basicint.org/blogs/2013/06/m51-missile-failure-where-does-leave-french-nuclear-modernization.

Department of Defense (2014). *Quadrennial Defense Review 2014*. US Government, March 4. Available at http://www.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf.

Department of Defense (2010). *Nuclear Posture Review*. US Government, April. Available at http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20 Report.pdf.

de Larrinaga, Nicholas (2014). "Russia's PAK-DA bomber to fly in 2019". *Jane's Defence Weekly*, May 22. Available at http://www.janes.com/article/38268/russia-s-pak-da-bomber-to-fly-in-2019.

Entous, Adam and Barnes, Julian E. (2012). "U.S. Plans New Asia Missile Defenses". *The Wall Street Journal*, August 23. Available at http://www.wsj.com/articles/SB100008723963904448127045776055916290394 00.

Federation of American Scientists (2000). "M-4 / M-45". *Federation of American Scientists*, August 11. Available at http://fas.org/nuke/guide/france/slbm/m-4.htm.

Freedberg Jr., Sydney (2014). "New Nuke Cruise Missile As Crucial As New Bomber: Haney". *Breaking Defense*, September 18. Available at http://breakingdefense.com/2014/09/new-nuke-cruise-missile-as-crucial-as-new-bomber-haney/.

Freedman, Lawrence and Bruno Tertrais (2009). "France and the United Kingdom". *The Henry L. Stimson Center*, February. Available at http://www.stimson.org/images/uploads/research-pdfs/Nuclear_Security_FINAL_Complete_UK_France.pdf.

Galamas, Francisco (2014). "2014: A Year in North Korean Security". *The Diplomat*, December 16. Available at http://thediplomat.com/2014/12/2014-a-year-in-north-korean-security/.

Gertz Bill (2013). "China Deploys New Bomber with Long-Range Land Attack Missile". *The Washington Free Beacon*, November 7. Available at http://freebeacon.com/national-security/china-deploys-new-bomber-with-long-range-land-attack-missile/.

Gertz, Bill (2014a). "Pentagon Confirms New Chinese Long-Range ICBM Development". *The Washington Free Beacon*, June 6. Available at http://freebeacon.com/national-security/pentagon-confirms-new-chinese-long-range-icbm-development/.

Gertz, Bill (2014b). "China Fields New Intermediate-Range Nuclear Missile". *The Washington Free Beacon*, March 3. Available at http://freebeacon.com/national-security/china-fields-new-intermediate-range-nuclear-missile/.

Gertz, Bill (2014c). "China Secretly Conducts Second Flight Test Of New Ultra High-Speed Missile". *The Washington Free Beacon*, August 19. Available at http://freebeacon.com/national-security/china-secretly-conducts-second-flight-test-of-new-ultra-high-speed-missile/.

Gertz, Bill (2014d). "Chinese Military Confirms DF-41 Flight Test". *The Washington Free Beacon*, December 26. Available at http://freebeacon.com/national-security/chinese-military-confirms-df-41-flight-test/.

Global Security (2014). "SS-30 ?? / R-X-? Sarmat New Heavy ICBM". *Global Security*. Available at http://www.globalsecurity.org/wmd/world/russia/ss-30.htm.

Grossman, Elaine (2014a). "Key targeting tech for future U.S. nuclear missile has gone unfunded". *NextGov*, August 19. Available at http://www.nextgov.com/defense/2014/08/key-targeting-tech-future-us-nuclear-missile-has-gone-unfunded/91790/.

Grossman, Elaine (2014b). "U.K. Independent Panel: Retain Trident Subs, But Explore Delay Options". *Global Security Newswire*, July 1. Available at http://www.nti.org/gsn/article/uk-independent-panel-retain-trident-subs-explore-delay-options/.

Hemmerdinger, Jon (2014). "USAF's LRSO missile may reach IOC around 2030". *Flight Global*, January 7. Available at http://www.flightglobal.com/news/articles/usaf39s-lrso-missile-may-reach-ioc-around-2030-394622/.

Honkova, Jana (2013). "Current Developments in Russia's Ballistic Missile Defense". *Policy Outlook*, George C. Marshall Institute, April. Available at http://marshall.org/wp-content/uploads/2013/08/Honkova-Current-Developments-in-Russias-Ballistic-Missile-Defense.pdf.

Japan Times (2014). "Defense Ministry to study new missile defense systems". *Japan Times*, June 21. Available at http://www.japantimes.co.jp/news/2014/06/21/national/defense-ministry-to-study-new-missile-defense-systems/#.VKLu_sjn0.

Jordan, Bryant (2014). "Russia Successful in Test Launches of Bulava missile". *Defense Tech*, October 31. Available at http://defensetech.org/2014/10/31/russia-successful-in-test-launches-of-bulava-missile/.

Keck, Zachary (2013). "Can China's New Strategic Bomber Reach Hawaii?". *The Diplomat*, August 13. Available at http://thediplomat.com/2013/08/can-chinas-new-strategic-bomber-reach-hawaii/.

Klotz, Frank (2013). "The Future of Britain's Nuclear Deterrent". *The National Interest*, July 24. Available at http://nationalinterest.org/commentary/the-future-britains-nuclear-deterrent-8768.

Kristensen, Hans (2011). "British Submarines to Receive Upgraded US Nuclear Warhead". *Federation of American Scientists*, April 1. Available at http://fas.org/blogs/security/2011/04/britishw76-1/.

Kristensen, Hans (2013). "New Nuclear Notebook: Chinese Nuclear Force Modernization". *Federation of American Scientists*, November 13. Available at http://fas.org/blogs/security/2013/11/chinanukes2013/.

Kristensen, Hans (2014a). "How Presidents Arm and Disarm". *Federation of American Scientists*, October 15. Available at http://fas.org/blogs/security/2014/10/stockpilereductions/.

Kristensen, Hans (2014b). "W80-1 Warhead Selected For New Nuclear Cruise Missile". *Federation of American Scientists*, October 10. Available at http://fas.org/blogs/security/2014/10/w80-1_lrso/.

Kristensen, Hans (2014c). "B61-12 Nuclear Bomb Integration On NATO Aircraft To Start In 2015". *Federation of American Scientists*, March 13. Available at http://fas.org/blogs/security/2014/03/b61-12integration/.

Kristensen, Hans (2014d). "Russian ICBM Force Modernization: Arms Control Please!". *Federation of American Scientists,* May 7. Available at http://fas.org/blogs/security/2014/05/russianmodernization/.

Kristensen, Hans (2014e). "Nuclear Weapons Modernization: A Threat to the NPT?". *Arms Control Today,* May. Available at http://www.armscontrol.org/act/2014_05/Nuclear-Weapons-Modernization-A-Threat-to-the-NPT.

Kristensen, Hans and Robert S. Norris (2014). "US nuclear forces, 2014". *Bulletin of the Atomic Scientists*, Vol. 70 (1). Available at http://thebulletin.org/2014/january/us-nuclear-forces-2014.

Kroening, Matthew (2013). "Think Again: American Nuclear Disarmament". *Foreign Policy*, September 3. Available at http://foreignpolicy.com/2013/09/03/think-again-american-nuclear-disarmament/.

Kulacki, Gregory (2011). "China's Nuclear Arsenal: Status and Evolution". *Union of Concerned Scientists*, October. Available at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/UCS-Chinese-nuclear-modernization.pdf.

Lau, Mimi (2014). "China mounts third hypersonic 'Wu-14' missile test, US report says". *South China Morning Post*, December 6. Available at http://www.scmp.com/news/china/article/1656748/china-mounts-third-hypersonic-wu-14-missile-test-us-report-says.

Mills, Claire and Brooke-Holland, Louisa (2014). "The Trident Successor Programme: an Update". *United Kingdom Parliament*, July 4. Available at http://www.parliament.uk/business/publications/research/briefing-papers/SN06526/the-trident-successor-programme-an-update.

Missile Threat (2013a). "Kh101/102". *George C. Marshall Institute and Claremont Institute*. Available at http://missilethreat.com/missiles/kh-101-102/.

Missile Threat (2013b). "S-500 Prometheus". *George C. Marshall Institute and Claremont Institute*, April 26. Available at http://missilethreat.com/defense-systems/s-500/.

Missile Threat (2014). "DF-31/-31A (CSS-9)". *George C. Marshall Institute and Claremont Institute*. Available at http://missilethreat.com/missiles/df-31-31a-css-9/.

No Author(2014). "Russia's future railway-based system Barguzin to carry 6 ballistic missiles — source". *Russian News Agency "TASS".* December 26. Available at http://itar-tass.com/en/russia/769357.

NTI (2014). "Russia Announces New Sub-Fired Ballistic Missile". *Global Security Newswire*, August 10. Available at http://www.nti.org/gsn/article/russia-announces-new-sub-fired-ballistic-missile/.

Office of the Secretary of Defense (2013). *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2013*, US Department of Defense. Available at http://www.defense.gov/pubs/2013_China_Report_FINAL.pdf.

Osborn, Kris (2014a). "Navy Extends Trident II D5 Nuclear Missile Service Life". *Defense Tech*, April 11. Available at http://defensetech.org/2014/04/11/navy-extends-trident-ii-d5-nuclear-missile-service-life/#ixzz3NxkeIxkb.

Osborn, Kris (2014b). "Air Force Plans Major Step in Long Range Strike Bomber Program". *Defense Tech*, September 15. Available at http://defensetech.org/2014/09/15/air-force-plans-major-step-in-long-range-strike-bomber-program/#ixzz3NxxncgAf .

O'Rourke, Ronald (2014). "Navy Ohio Replacement (SSBN[X]) Ballistic Missile Submarine Program: Background and Issues for Congress". *Congressional Research Service*, July 31. Available at http://fas.org/sgp/crs/weapons/R41129.pdf

Panda, Ankit (2013). "US Prompt Global Strike Missiles Prompt Russian Rail-Mounted ICBMs". *The Diplomat*, December 19. Available at http://thediplomat.com/2013/12/us-prompt-global-strike-missiles-prompt-russian-rail-mounted-icbms/.

Péczeli, Anna (2013). "Phased Adaptive Approach – Prospects for US-Russian Cooperation in the Framework of the Ballistic Missile Defense System in Europe". *Centre for European and North Atlantic Affairs*, February. Available at http://cenaa.org/analysis/phased-adaptive-approach-prospects-for-us-russian-cooperation-in-the-framework-of-the-ballistic-missile-defense-system-in-europe/.

Rajagopalan, Megha (2014). "China criticizes U.S. missile defense radar in Japan". *Reuters*, October 23. Available at http://www.reuters.com/article/2014/10/23/us-china-japan-usa-idUSKCN0IC16P20141023.

Robinson-Avila, Kevin (2014). "Overhauling the Nation's Nuclear Arsenal: Sandia National Labs achieves B61 milestone". *Albuquerque Journal*, May 18. Available at http://www.abqjournal.com/402297/news/sandia-national-labs-achieves-b61-milestone.html.

Rover, Jay (2014). "Nuclear Weapons Modernization Threatens NPT?". *Viewsweek*, May 25. Available at http://viewsweek.com/viewsweek-exclusive/nuclear-weapons-modernization-a-threat-to-the-npt/.

Russian Federation (2010). "The Military Doctrine of the Russian Federation". *Russian Presidency*, available at http://carnegieendowment.org/files/2010russia_military_doctrine.pdf.

Russia Times (2014a). "Russian 'ABM killer' intercontinental missile to enter service in 2016". *Russia Times*, December 25. Available at http://rt.com/news/217695-abm-killer-missile-russia/.

Russia Times (2014b). "Young Brits say nuke arsenal upgrade not a priority". *Russia Times*, April 8. Available at http://rt.com/uk/151053-uktrident-modernization-untrusted/.

Russia Times (2014c). "Russia to deploy fifth-gen fighters, S-500 missiles in 2016". *Russia Times*, August 11. Available at http://rt.com/news/179256-russia-deploy-s500-missiles/.

Sankaran, Jaganath (2013). "Missile Defense Against Iran Without Threatening Russia". *Arms Control Today*, November. Available at http://www.armscontrol.org/act/2013_11/Missile-Defense-Against-Iran-Without-Threatening-Russia.

Schaffer, Marvin Baker (2014). "Time to Revive Debate About Space-Based Missile Defense". *National Defense Magazine*, October. Available at http://www.nationaldefensemagazine.org/archive/2014/October/Pages/TimetoReviveDebateAboutSpaceBasedMissileDefense.aspx.

Skypek, Thomas (2010). "China's Sea-Based Nuclear Deterrent in 2020: Four Alternative Futures for China's SSBN Fleet" in Mark Jansson (ed.), *A Collection of Papers from the 2010 Nuclear Scholars Initiative*, pp. 105-122. Washington, DC: Center for Strategic and International Studies. Available at http://csis.org/images/stories/poni/101015_2010_NSI_Collection_of_Papers.pdf.

The Secretary of State for Defence and The Secretary of State for Foreign and Commonwealth Affairs (2006). "The Future of the United Kingdom's Nuclear Deterrent". *United Kingdom Government*, December. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/27378/DefenceWhitePaper2006_Cm6994.pdf.

US-China Economic and Security Review Commission (2014). *2014 Report To Congress*, November. Available at http://www.uscc.gov/sites/default/files/annual_reports/Complete%20Report.PDF.

US National Air and Space Intelligence Center (2013). *Ballistic and Cruise Missile Threat*. Available at http://fas.org/programs/ssp/nukes/nuclearweapons/NASIC2013_050813.pdf.

Vanderschuere, Matthew (2013). "The Nation's ICBM Force: Increasingly Creaky Broken Missiles". *Time*, January 23. Available at http://nation.time.com/2013/01/23/the-nations-icbm-force-increasingly-creaky-broken-missiles/.

Weisgerber, Marcus (2015). "Lockheed Working To Extend Range of U.S. Missile Interceptors". *Defense One*, January 7. Available at http://www.defenseone.com/threats/2015/01/pentagon-wants-extend-range-one-its-missile-interceptors/102444/.

Weitz, Richard (2014a), "Russia's Nuclear Revival and Its Challenges", *Hudson Institute*, [online] August 22. Available at http://www.hudson.org/research/10564-russia-s-nuclear-revival-and-its-challenges.

Weitz, Richard (2014b). "Russia's New Military Doctrine Hypes NATO Threat". *World Politics Review*, December 30. Available at http://www.worldpoliticsreview.com/articles/14758/russia-s-new-military-doctrine-hypes-nato-threat.

Want China Times (2014). "Russia and China can jointly develop bomber: Voice of Russia". *Want China Times*, February 17. Available at http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20140217000019&cid=1101.

Wolfsthal, Jon B.; Jeffrey Lewis, and Marc Quint (2014). "The Trillion Dollar Nuclear Triad". *James Martin Center for Nonproliferation Studies*, January. Available at http://cns.miis.edu/opapers/pdfs/140107_trillion_dollar_nuclear_triad.pdf.

Woolf, Amy (2014). "U.S. Strategic Nuclear Forces: Background, Developments, and Issues". *Congressional Research Service*, September 5. Available at http://www.fas.org/sgp/crs/nuke/RL33640.pdf.