WHITE PAPER

Missile Defense

Challenges and Opportunities for the Trump Administration

Henry F. Cooper, Malcolm R. O'Neill,
Robert L. Pfaltzgraff, Jr., and Rowland H. Worrell

The Institute for Foreign Policy Analysis, Inc.

The Institute for Foreign Policy Analysis, Inc. (IFPA) develops innovative strategies for new security challenges. IFPA conducts studies and produces reports, briefings, and publications. IFPA also organizes workshops, seminars, and international conferences in Washington, D.C., elsewhere in the United States, and overseas that address a wide variety of national and international security issues. IFPA's products and services help government policymakers, military and industry leaders, and the broader public policy communities make informed decisions in a complex and dynamic global environment. In addition to its core staff in Cambridge, Massachusetts, and Washington, D.C., the Institute maintains a global network of research advisors and consultants. To find out more about IFPA's work and publications, visit www.IFPA.org.

The Independent Working Group

The Independent Working Group (IWG) on Missile Defense was formed in 2002. Its goals are several: (1) to identify the evolving threats to the United States, its overseas forces, allies, and coalition partners from the proliferation of ballistic missiles; (2) to examine missile defense requirements in the twenty-first century security setting; (3) to assess current missile defense programs in light of technological opportunities in the post-ABM Treaty world; and (4) to set forth general and specific recommendations for a robust, layered missile defense for the United States to meet these proliferation challenges. The IWG includes members with technical and policy expertise on missile defense and related national security issues. Information about IWG reports, studies, White Papers, and meetings are available at www.IFPA.org.

WHITE PAPER

Missile Defense

Challenges and Opportunities for the Trump Administration

Henry F. Cooper, Malcolm R. O'Neill,
Robert L. Pfaltzgraff, Jr., and Rowland H. Worrell

Published by the Institute for Foreign Policy Analysis

IFPA

Independent Working Group

Executive Summary

Growing terrorist attacks, deteriorating U.S. military capability, and the consequences of U.S. withdrawal from its global leadership role will confront the Trump Administration with a more dangerous and complex national security environment. The nuclear armed ballistic missile threat will intensify as hostile actors such as North Korea and Iran—and even terrorists—gain more capabilities and both Russia and China modernize their existing nuclear and ballistic missile forces. The immediate effect of a ground or low altitude burst of a nuclear weapon can be catastrophic and subsequent radiation aftereffects can extend many miles.

However, one of the most serious—but least acknowledged—threats is that rogue states or terrorists have/or may soon gain the ability to conduct a high-altitude electromagnetic pulse (EMP) attack that could destroy vital electronic infrastructure with catastrophic consequences for the United States including the deaths of most Americans within a year, from starvation, disease and societal collapse according to 2008 congressional testimony by the Congressionally-appointed EMP Commission.

Central to an effective strategy to counter these growing threats is to return to key elements of the Strategic Defensive Initiative (SDI) era, particularly to deploy space-based ballistic missile defense (BMD) systems. Such a capability would help us secure the United States, its forward-deployed forces, and allies/partners against the accelerating ballistic missile threat. The current—and projected—U.S. ground- and sea-based BMD architecture is not sufficient to counter this threat.

Challenges and Threats Facing the United States

North Korea can today execute an EMP attack and Iran will have that capability, if it does not already. Both launch satellites to their South, posing an EMP threat to the United States which lacks robust early-warning radar coverage in the southern hemisphere, positions its ground-based interceptors to counter intercontinental-range ballistic missiles (ICBMs) approaching from the North, and normally does not position/prepare its sea-based BMD systems to counter this threat. Even terrorist groups could acquire nuclear weapons, mate them to easily-purchased ballistic missiles and launch an EMP strike from vessels cruising near our coasts, especially from the Gulf of Mexico.

Such threats are exacerbated by Russia's nuclear modernization and missile programs, first use nuclear strategy, and belligerent actions in East Europe and elsewhere; and by China's nuclear and space system modernization, aggressive activities in the South China Sea, expanding global economic power, and threats to the U.S. homeland. Both nations are also developing hypersonic glide vehicles, maneuverable warheads, and more sophisticated decoys that could defeat current U.S. ground- and sea-based interceptors. Moreover, both are sources for enabling rogue states/terrorists to develop asymmetrical strategies and capabilities to conduct cyber and EMP attacks on a variety of critical U.S. civilian, commercial, and military targets.

The United States has focused development of limited missile defenses to counter smaller nuclear states such as North Korea and potentially Iran and chosen not to defend against the larger nuclear forces of China or Russia. The legacy of this strategic choice makes little sense given the challenges the United States now faces from Russia and China and the fact that the advanced technologies/weapons being developed and deployed by these two nations will become increasingly available to other nations and even terrorists. The result will be a heightened requirement for advanced U.S. missile defenses to counter these challenges.

These defenses must correct the cost-exchange ratio that favors nuclear weapons delivered by ballistic missiles over BMD interceptors. Currently, it costs the United States much more to shoot down an attacking nuclear weapon than it does an adversary to develop, purchase or replace that threat. This means that as ballistic and cruise missiles proliferate and their unit costs decrease, maintaining the needed defenses could become unaffordable, undermining U.S. deterrence policy and limiting U.S. escalatory options in a crisis.

A Twenty-first Century *Brilliant Pebbles* Program

Former Commander of U.S. Northern Command Admiral William Gortney observed that to counter these threats the United States needs to destroy ballistic missiles in their boost phase, not rely solely on midcourse- and terminal-phase interception, as is the focus of current U.S. BMD systems. Such boost-phase missile defense is most effectively provided from space, as was judged feasible in 1990, based on then maturing technology.

Most cost-effective was the *Brilliant Pebbles* (BP) constellation of small interceptors combining early-warning and tracking capability with high maneuverability to engage attacking ballistic missiles in all phases of their flight trajectory and provide multiple opportunities for interception. *Brilliant Pebbles* underwent numerous scientific and engineering peer reviews and was approved by the Pentagon's acquisition authorities in 1991. Moreover, subsequent space missions have space qualified that technology—but not for BMD missions.

Supporters of the Clinton candidacy saw *Brilliant Pebbles* as a major threat to his administration's national security strategy, which was based on international treaties vice missile defense. So, political rather than technology constraints led to cancelation of the *Brilliant Pebbles* program in 1993. Since then, U.S. BMD architectures and technologies have excluded space-based interceptors and ignored the benefits of space-based boost-phase defenses to counter escalating proliferation threats and to stay ahead of the unfavorable defense-offense cost exchange ratio.

Since the cancellation of *Brilliant Pebbles*, substantial advances in the commercial, civil, and defense sectors enable lighter mass, lower cost, higher performance technologies, and very high reliability. Less-costly fabrication techniques, best-practices management, on-orbit servicing, and reduced launch costs could provide even more cost-effective BP interceptors, surpassing capabilities of the 1990 *Brilliant Pebbles*, which was estimated to cost $10 billion in 1988 dollars (about $20 billion in 2016 dollars) over its twenty-year life-cycle. A new BP program could cost even less while providing vastly greater protection than all current U.S. land- and sea-based missile defenses.

A twenty-first-century BP system would contribute to deterrence policy, particularly as a central element of deterrence by denial, i.e., the ability to defend and protect vitally important targets. This essential component of twenty-first-century escalation control would provide U.S. decision makers with escalatory and deterrence options in addition to those based solely on retaliation. It could defend against missile attacks in each phase of a ballistic missile's flight—particularly in the boost phase when a ballistic missile is most vulnerable and has not released its warheads and decoys—enabling an alternative to retaliation-in-kind nuclear responses. In addition, a BP system would support other vital national security missions such as space situational awareness, detection and interdiction of direct-ascent anti-satellite weapons, and tactical intelligence, as well as enhance the survivability of critical space assets on which practically all U.S. military operations depend.

Conclusions/Recommendations

To address the range of challenges confronting our nation, including growing nuclear weapon and ballistic missile proliferation and the EMP threat, the United States should undertake the following:

- Develop and deploy BMD systems to counter the ballistic missile and EMP threat from North Korea, Iran, and terrorist groups. Included should be *Aegis* BMD ships, *Aegis* Ashore deployed along the U.S. Gulf Coast to counter southern trajectory threats, and development of unmanned aerial vehicles (UAVs) to provide early warning and boost-phase intercept as a short-term response to these threats. The National Missile Defense Act of 1999 should also be amended to remove its limit on missile defense development to defend only against "limited" attacks.
- Move beyond the "limited" attack mission and confront the increasing threat posed by Russia and China's belligerent behavior and growing military capabilities which may become available to their surrogate states—and even terrorist groups.
- Develop and deploy twenty-first-century cost-effective space-based defense systems to address the rapidly evolving security setting described in this White Paper. They would protect the U.S. homeland, our overseas troops, and friends and allies against ballistic missiles in all phases of their flight. Their boost-phase intercept capability would provide the most effective way to defeat ballistic missiles carrying multiple warheads and/or decoys, including against high altitude EMP attacks that might be launched from anywhere on earth to be detonated over the United States. It would also support other vital national security missions.
- In particular, initiate a crash program to deploy a twenty-first-century *Brilliant Pebbles* space-based interceptor system building on technologies of the SDI era that were sufficiently mature to be approved in 1991 by the Pentagon's acquisition authorities to enter a demonstration-validation (DemVal) phase. Such a system would enhance deterrence (by denial) and escalation control for assured survival in a security environment marked by the growing availability of nuclear weapons and delivery systems to a variety of actors.
- Harden the electric power grid and prepare to reconstitute quickly key portions to restore essential services if the grid is lost from a natural or manmade EMP event and/or a cyber attack. Top priority should be to protect our nuclear reactors to avoid radiation hazards and help reinstate the grid after a major blackout.

Missile Defense: Challenges and Opportunities for the Trump Administration

Growing terrorist attacks, atrophying U.S. military capability and the consequences of U.S. withdrawal from its previously recognized leadership roles around the world will confront the Trump Administration with a much more dangerous global security setting. In particular, the threat posed by ballistic missiles and nuclear weapons will intensify as nuclear-armed missile capabilities become more widely available to hostile actors. Most ominous among the plausible threat scenarios is that rogue states or even terrorists may gain—if they do not already have—the ability to carry out an electromagnetic pulse (EMP) attack that could kill most Americans within a year. The fact that Russia and China have long had this capability and could provide it to others only adds to the national security challenges facing the Trump Administration.

Central to an effective strategy to counter these growing threats is to return to key elements of the Strategic Defensive Initiative (SDI) era (1983 through 1992; abandoned in 1993). In particular, the aggressive development, deployment and operation of twenty-first-century space-based missile defenses can rapidly and credibly achieve impressive security for the United States, its forward-deployed forces, and allies/partners against the accelerating ballistic missile threat. The current—and projected—U.S. ground- and sea-based ballistic missile defense (BMD) architecture is not sufficient to counter this threat.

Key Challenges: Rapidly Emerging Threats and Delinquent Responses

North Korea has an EMP attack capability and Iran will have it—if it does not already.[1] North Korea and Iran have for many years

1 See the February 14, 2016 *National Review* article, "Underestimating Nuclear Missile Threats from North Korea and Iran," by Former CIA Director Ambassador. R. James Woolsey; Chairman of the EMP Commission Dr. William R. Graham; Former Strategic Defense Initiative Director Ambassador Henry F. Cooper; Former Chairman of the National Intelligence Council Fritz Ermarth; and EMP Commission Executive Director Dr. Peter Vincent Pry (http://www.nationalreview.com/article/431206/) and a February 1, 2015 *Newsmax* article, "Experts: Iran Now a Nuclear-Ready State, Missiles Capable of Hitting US," by the same authors (except Woolsey who was out of the country—otherwise he would have surely been a coauthor). (http://www.newsmax.com/Headline/iran-nuclear-ready-missiles/2015/02/01/id/621982/?ns_mail_uid=1561463&ns_mail_job=1606083_02022015&s=al&dkt_nbr=3pbjgpfl).

tested ballistic missiles and launched satellites—and could place nuclear warheads on either. North Korea is reported to have tested nuclear weapons especially designed to enhance EMP effects.[2] They likely have shared this knowledge with Iranian scientists who have been present at North Korean nuclear and ballistic missile/satellite launcher tests. Both nations include EMP as part of their military doctrine.[3] Even knowledgeable experts who are silent on the EMP consequences of North Korea's persistent nuclear tests—its latest took place on September 9, 2016—acknowledge that its program to develop nuclear weapons is unstoppable, but suggest its development of intercontinental range ballistic missiles (ICBMs) may be.[4]

Such a scenario seems unlikely because both North Korea and Iran have tested ballistic missiles since the late 1990s—and both have launched satellites with space launchers that could easily morph into ICBMs. Also, then Commander of U.S. Northern Command (USNORTHCOM), Admiral William Gortney, warned in 2015 that North Korea has tested the KN-08, a mobile ICBM capable of striking the continental United States.[5] North Korea's

These articles, among other things, explain why a prudent planner should assume Iran already could deliver an EMP attack on the entire United States.

2 "North Korea Poses EMP Threat, by Daniel John Sobieski, *The American Thinker*, May 2, 2016, http://www.americanthinker.com/articles/2016/04/north_korea_poses_emp_threat.html.

3 For example, Rep. Trent Franks (R-AZ) numerous times in 2014, including on the House floor, reported: "The National Intelligence University of the United States recently translated an Iranian military doctrine called 'Passive Defense' which referenced the use of nuclear EMP as a weapon more than 20 times. This doctrine stresses that electrical grids are vital to national existence. It includes a formula for calculating the value of electric power plants and for prioritizing the targeting of electric grid components and other infrastructures."

4 For example, the *New York Times'* article by David Sanger et al the morning after the regime's fifth underground nuclear test and second in 2016, "A Big Blast in North Korea and Big Questions on U.S. Policy," quotes former Defense Secretary Bill Perry as recently saying "It's too late on the nuclear weapons program — that is not going to be reversed." He argued the only choice is to stop its development of ballistic missiles. See http://www.nytimes.com/2016/09/10/world/asia/north-korea-nuclear-test.html?emc=edit_th_20160910&nl=todaysheadlines&nlid=21300290 .

5 See Pentagon Press Briefing by Admiral Gortney, April 7, 2015 (http://www.defense.gov/News/Transcripts/Transcript-View/Article/607034/department-of-defense-press-briefing-by-admiral-gortney-in-the-pentagon-briefin). In this briefing, he also acknowledged the electromagnetic pulse (EMP) threat and noted the efforts to harden the systems within Cheyenne Mountain. North Korea continues to test its ballistic missiles, note the flurry in September 2016, perhaps

submarine developments[6] could be followed by Iran—so both ultimately may be able to launch ballistic missiles from submarines near our coasts. Both already have the ability to launch them from container ships or other vessels near our ports—they can buy this launch capability from their ally Russia,[7] which grows increasingly belligerent as Russian President Vladimir Putin shows little regard for U.S. interests.

Both North Korea and Iran launch satellites to their south; they approach the United States from our mostly undefended south—and on-board nuclear weapons could be detonated over the United States to produce EMP with devastating consequences.[8] No technology beyond that needed to place nuclear weapons on satellites is required because detonation above the atmosphere would not require hardened reentry vehicles needed to strike a target on the ground such as a city.

Since the United States currently lacks robust early-warning radar coverage in the southern hemisphere, postures its ground-based interceptors to counter ballistic missiles approaching from the north, and normally does not have its sea-based defenses appropriately prepared to counter this threat, a satellite harboring a nuclear weapon following a southern trajectory could blindside the

---

intended to counter nearby deployment of THAAD interceptors. (See http://www.cnn.com/2016/09/06/asia/north-korea-missiles-thaad/).

6 See "North Korea fires submarine launched missile toward Japan," by Ju-min Park and Jack Kim, *Reuters*, August 24, 2016, http://www.reuters.com/article/us-northkorea-missiles-idUSKCN10Y2B0.

7 Russia's Club-K offers container ship launchers for cruise missiles for sale—it is not a major leap of imagination to provide a SCUD launch version. See https://www.youtube.com/watch?v=mbUU_9bOcnM for a video of the cruise missile version. See also "A cruise missile in a shipping box on sale to rogue bidders," Thomas Harding, *The Telegraph*, April 25, 2010, for earlier press accounts. See http://www.telegraph.co.uk/news/worldnews/europe/russia/7632543/A-cruise-missile-in-a-shipping-box-on-sale-to-rogue-bidders.html.

8 North Korea again demonstrated this capability on February 7, 2016. See https://www.csis.org/analysis/north-korea%E2%80%99s-february-2016-satellite-launch for a discussion of the implications of this test for ballistic missile applications. On August 31, 2016, Adam Kredo reported in http://freebeacon.com/national-security/iran-satellite-launch-prompts-fear-long-range-ballistic-missile-attack/ that, according to Iranian officials, Iran was preparing multiple satellite launches in 2016. See http://iran-times.com/russia-signs-deal-to-build-launch-iran-satellites/ for an *Iran Times* report of related Russian support to Iran for such satellite launches as well as in developing ballistic missiles—an issue discussed in the following section.

United States. Given the existential stakes for the United States, this is a danger that must be addressed; it cannot be underestimated, let alone ignored. If such unpredictable nations—or jihadi terrorists—cannot be deterred by the threat of devastating counterstrikes, the United States must deploy robust missile defenses to deny such adversaries the perception that a missile attack will succeed—i.e., provide "deterrence by denial."[9]

Whether current U.S. defenses are directed against such an attack is not certain, but in recent years we have deployed *Aegis* ships with capable missile defense interceptors—many in the Pacific with the inherent ability to help counter this threat. For example, our success against a North Korean nuclear EMP attack today would depend on the positioning of existing *Aegis* ships to enable them to conduct the intercept—and their being prepared to execute such a defense. Since North Korea already has the ability to launch an EMP strike, we need to assure that well positioned *Aegis* crews have necessary advance warning and are trained and authorized to perform the needed timely intercept. We should augment that capability as rapidly as possible, coupled with the development and deployment of even more robust missile defenses.[10]

We should also as quickly as possible provide effective defenses against ballistic missiles and satellite launches from Iran. The Joint

---

9 Although deterrence has usually been associated with the prevention of undesirable behavior by the threat of punishment, deterrence can also be based on denial of access to a desired target. What level of retaliation or punishment will be sufficient to deter bad behavior? What level of defense or protection will be sufficient to deter by denial? Deterrence may include a combination of punishment and denial. For example, we seek to deter criminal behavior by the threat of punishment that may include incarceration as well as by efforts to deny access or to defend targets by means that may include locks on doors and windows, perimeter fences, alarm systems, and airline security checks to deter criminal and terrorist acts. In strategic military context, deterrence by denial includes, among other components, missile defenses designed to reduce or eliminate prospects for executing a successful attack on a highly valued target. The authors of this White Paper believe that twenty-first-century deterrence should be based not only on the threat of punishment but also the ability through effective missile defenses to provide deterrence by denial.

10 *Aegis* ships have four other missions in addition to their BMD responsibilities: air defense, cruise missile defense, anti-submarine warfare, and naval gunfire. The *Aegis* fire control system cannot perform all five missions simultaneously. And in many situations the priority of the *Aegis* ship is defense of an aircraft carrier which does not maneuver to maintain an optimal position for BMD operations. Interceptors with greater range would give *Aegis* BMD ships increased flexibility.

Comprehensive Plan of Action (JCPOA), commonly known as the "Iran nuclear deal" concluded in 2015, provides little if any reason to believe Tehran will not develop nuclear weapons covertly, along with plans to mate them to the Middle East's largest inventory of ballistic missiles[11] or to place them on satellites to be launched to their south. Indeed, as noted above, some believe they may already have such a capability—and that competent planners would assume that they do.[12] The flawed JCPOA agreement:

- Granted sanction relief upfront (i.e., the release of more than $100 billion in frozen assets) that squandered U.S. leverage over Iran if it does not fulfill provisions of the agreement—and Iranian compliance shortcomings do not augur well for the future.
- Does not address Iran's robust ballistic missile programs, and we cannot discount the possibility that Iran retains associated clandestine military nuclear programs that continue beyond international purview.
- Likely deceived the Obama Administration to get international sanctions removed and forestall military action while maintaining a covert military nuclear program with breakout capability.[13]

---

11 *Statement for the Record, Worldwide Threat Assessment of the US Intelligence Community*, to the House Appropriations Subcommittee on Defense by James R. Clapper, Director of National Intelligence, March 25, 2015, p.6. http://docs.house.gov/meetings/AP/AP02/20150325/103200/HHRG-114-AP02-Wstate-ClapperJ-20150325.pdf.

12 Moreover, the JCPOA at best legitimizes an Iranian path to nuclear weapons after it expires in 2030.

13 International Atomic Energy Agency (IAEA) reports issued after inspections over many years reveal that Iran has manufactured nuclear weapon components, conducted experiments of a nuclear implosion device, and worked on the design of a nuclear warhead that could be deployed on its extensive ballistic missile inventory that remains outside the nuclear agreement. More recently, there have been reports that Iran's Atomic Energy Organization has been surreptitiously seeking to purchase carbon fiber, a material required to construct advanced uranium centrifuges. See "The nuclear deal with Iran: Teething pains or trouble ahead?" *The Economist*, June 25, 2016, http://www.economist.com/news/middle-east-and-africa/21701121-agreement-curb-irans-nuclear-activities-working-it-may-be-more.

- Left open pathways for Iran to buy nuclear weapons and supplement their existing means to build and/or deliver them—e.g., from their ally North Korea or China.[14]
- Was complemented and supplemented with "side deals," some of which were recently recognized with the exposure of a "ransom for hostage" exchange.[15]

Terrorist groups, possibly acting as surrogates to Iran in particular, could gain nuclear weapons and mate them to ballistic missiles they can easily purchase—to launch from vessels near our coasts[16]—also with warheads to produce EMP without reentering the atmosphere. The EMP Commission[17] almost a decade ago identified such a launch as a very troubling way credibly to threaten the

14 North Korea and China have financial and political incentives to supply nuclear-related materials and missile technologies to Iran. Russia has also made advanced technologies available to Tehran (see footnote 7). The international nuclear network of Pakistan's A. Q. Khan that facilitated the proliferation of nuclear knowhow and hardware to several states (e.g., Iran, North Korea, and Libya) more than a decade ago was never fully disrupted. It provides another potential source of expertise—and possibly nuclear-related materials/components—that Iran could access.

15 See "U.S., others agreed 'secret' exemptions for Iran after nuclear deal: think tank," by Jonathan Landay, *Reuters*, September 1, 2016, http://www.reuters.com/article/us-iran-nuclear-exemptions-exclusive-idUSKCN1173LA and Mark A. Thiessen, "Another Secret Iran Deal Exposed," AEIdeas, September 2, 2016, http://www.aei.org/publication/another-secret-iran-deal-exposed/?utm_source=paramount&utm_medium=email&utm_content=AEITODAY&utm_campaign=090716.

16 Iran's tests of ballistic missiles and satellites and expanding inventory of missiles help destabilize the Middle East, increasing massive refugee crises produced by the continuing conflict and posing associated threats from Islamic terrorism. Threat scenarios involving terrorists who purchase nuclear weapons are conceivable. The nuclear weapons could be smuggled into the United States though our porous borders or launched on missiles from vessels off our coasts. According to Australia's Air Power Studies Centre Working Paper 55 linked to by the Federation of American Scientists (http://fas.org/irp/threat/missile/paper55.htm), North Korean Scud C missiles were sold to Syria for only around $3-million-per-copy. So, getting the means for ballistic missile delivery is not a challenge for terrorists—if they can obtain a nuclear weapon.

17 The most authoritative discussion of the EMP threat and how to protect against it is found in the 2004 and 2008 reports of *The Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack*—or EMP Commission for short (http://www.empcommission.org/). Commissioners have testified that up to 90 percent of the American population could die from starvation, disease, and societal collapse within a year after losing the U.S. electric grid for an indefinite duration.

American people with EMP attack.[18] Commissioners testified that EMP from a high altitude nuclear weapon detonation would cause massive voltage spikes that could destroy vital electronic infrastructure with catastrophic and indefinitely irreparable consequences for the United States.[19]

We remain highly vulnerable to these potentially existential threats today because we have not employed effective countermeasures, even though we could. For example, we could exploit our sea-based BMD systems—now operational on about 35 *Aegis* BMD ships deployed around the world, supplemented by *Aegis* Ashore sites, such as is now operational in Romania and planned to be operational in Poland by 2018. As of July 28, 2016, the *Aegis* BMD system tests since January 2002 had 33 intercepts[20] of ballistic missiles of different ranges in their "ascent" and remaining exo-atmospheric phases—plus an impressive 2008 intercept in space of a dying satellite travelling at ICBM speeds, which could have spread toxic fuel on population centers.[21]

Almost two years ago, complementary initiatives were recommended to: 1) fully exploit our existing operational ground-based and sea-based BMD systems against the EMP threat and 2) harden our critical infrastructure—especially the electric power grid—against

---

18 In July 2008, EMP Commission Chairman Dr. William R. Graham testified to the House Armed Services Committee that Iran had launched missiles from vessels in the Caspian Sea and "detonated the warhead near apogee, not over the target area where the thing would eventually land, but at altitude" … exactly the profile of an EMP attack. He added that the commission examined the Iranian tests (dating back to 1998) and "connected the dots," even though the U.S. intelligence community previously had failed to do so. Graham noted, "The only plausible explanation we can find is that the Iranians are figuring out how to launch a missile from a ship and get it up to altitude and then detonate it." See "U.S. Intel: Iran Plans Strike on U.S." by Kenneth R. Timmerman, July 29, 2008, http://www.newsmax.com/Newsfront/iran-nuclear-plan/2008/07/29/id/324724/.

19 The inconveniences from electricity power outages in major floods, hurricanes, heatwaves or snowstorms would pale by comparison with an EMP attack (or a major solar storm, to be discussed later) that could destroy both our economy and our defenses with fatalities numbering in the millions and possibly hundreds of millions, as concluded by the EMP Commission over a decade ago.

20 See the July 28, 2016 Missile Defense Agency Fact Sheet https://www.mda.mil/global/documents/pdf/aegis_tests.pdf.

21 The 2008 "Burnt Frost" event demonstrated with the first generation *Aegis* interceptor this impressive capability, provided the needed cueing information is available. See https://www.mda.mil/system/aegis_one_time_mission.html and summary and descriptive video at https://www.youtube.com/watch?v=pDqNjnUNUl8. Today's interceptors and sensors are inherently more capable.

EMP effects.[22] Little has changed since then to alter our continuing vulnerability or our recommendations. These readily available countermeasures should be employed immediately. These proposed initiatives should be extended with an increased sense of urgency to address the growing geopolitical challenges.

Some Emerging Geopolitical and Technological Challenges

The threats to us and our allies by rogue states and terrorists are exacerbated by: 1) Russia's nuclear modernization and missile programs, first use nuclear strategy, and belligerent actions in the Ukraine and elsewhere—while filling the U.S. leadership vacuum in the Black Sea Region, Europe and the Middle East; and 2) China's modernization of its nuclear and space systems, together with its aggressive behavior in the South China Sea, extensions of economic power globally and threats to the U.S. homeland. Both nuclear-armed nations are developing hypersonic glide vehicles (HGV) that cannot be countered with existing BMD systems.[23] Again, we are delinquent in fully developing technology available two decades ago to block the HGV threat, which no doubt will also find its way to rogue states and terrorists via the cacophony of proliferation.[24]

U.S. modernization programs do not match the pace of those of Russia and China.[25] Moreover, these potentially peer strategic com-

---

22 Henry F. Cooper and Robert L. Pfaltzgraff, Jr., "How to Protect A Vulnerable America From EMP Threat," *Investor's Business Daily*, October 3, 2014, http://www.investors.com/politics/perspective/countering-an-emp-attack-on-america/.

23 For example, see Bill Gertz, "Russia to field hypersonic missiles by 2020," *The Washington Free Beacon*, August 25, 2016, (http://freebeacon.com/national-security/russia-field-hypersonic-missiles-2020/?utm_source=Freedom+Mail&utm_campaign=51d1c19f1c-WFB_Morning_Beacon_08_25_168_24_2016&utm_medium=email&utm_term=0_b5e6e0e9ea-51d1c19f1c-45645521) and Staff Writers Moscow (Sputnik), "Russia's 'US-Missile Defense Killing' Hypersonic Rockets Arriving Soon," *Space Daily*, Aug 23, 2016, http://www.spacewar.com/reports/Russias_US_Missile_Defense_Killing_Hypersonic_Rockets_Arriving_Soon_999.html.

24 These issues are discussed in detail by two knowledgeable "insiders" in *The Nuclear Express: A Political History of the Bomb and Its Proliferation,* Thomas C. Reed and Danny B. Stillman, Zenith Press, 2009.

25 See for example, "The 40-Year Procurement Holiday," by Peter Huessy in *RealClear Defense*, October 12, 2016, http://www.realcleardefense.com/articles/2016/10/12/the_40_year_nuclear_procurement_holiday_110195.html.

petitors are "root sources" for enabling rogue states and non-state armed groups that are developing asymmetrical strategies and capabilities to employ cyber and EMP attacks to disrupt or destroy critically important space systems and essential civil infrastructure, such as electric power grids, communication, financial, transportation, and food distribution systems—as well as key military systems. Such an attack would represent the ultimate asymmetrical act by a smaller state or terrorists against the United States.

In recent years the hopeful post-Soviet era has given way to rising tensions with Russia. Although Russia faces domestic economic troubles that have resulted in reduced wages and living standards,[26] President Putin's foreign policy is clearly designed to reassert Russian dominance on its periphery and beyond—in an effort to reduce losses following the dissolution of the Soviet Union—and to modernize Russia's nuclear forces with which he can intimidate NATO and the United States. His obvious "expansionist" interests have been demonstrated by Russia's incursions into Georgia, invasion of Ukraine with its annexation of Crimea—and its threats to the Baltic States and an explicit threat to NATO. These trends have been aided by U.S. withdrawal from its post-World War II leadership role around the world.

This trend toward U.S. policy impotence exacerbated by atrophying U.S. military capabilities—including its strategic nuclear forces, adds to associated dangers around the world. Dr. Mark B. Schneider recently discussed in considerable detail the growing buildup of Russian strategic nuclear forces and noncompliance with the INF and New START Treaties.[27]

Consequent "negative effects" also have led to important shifting political conditions that bode ill for U.S. interests in the Middle East and East Asia where the growing dangers of a nuclear Iran encourage neighboring Sunni Arab states and others to seek nuclear weapons and to strengthen alternate alliances (particularly with Russia) rather than to depend on U.S. leadership and diplomacy for their protection. Putin is extending Russia's long-time alliances with

26 Western sanctions, together with the drop in oil prices, have forced Moscow to prop up the ruble leading to sharply diminished foreign exchange reserves. Russia's GDP contracted by 3.7% in 2015 and is expected to drop by another 1.8% this year.

27 See Dr. Mark B. Schneider, "Russia's Growing Strategic Nuclear Forces and New Start Treaty Compliance," NIPP Information Series, No. 407, June 21, 2016 and "Russian Violations of the INF and New START Treaties" NIPP Information Series, No. 410, August 15, 2106.

Iran and Syria to others, including Iraq and those that have long depended on U.S. leadership—e.g., Egypt, Saudi Arabia, our NATO ally Turkey, and even our longtime friend and the only democracy in the Middle East Israel. The conjunction of the "buzzing" of U.S. warships by Russian jet fighters and Iranian speedboats is hard to miss.

Lack of U.S. leadership and commitment in dealing with the Islamic State also creates dangers. With the possible proliferation of nuclear weapons from Iran or Pakistan (which reportedly has more than one hundred nuclear weapons),[28] the Islamic State might obtain nuclear weapons and as discussed above mate them to ballistic missiles and launch them from vessels off our coasts in an EMP attack. The possible death of most Americans within a year would fit with Iran's leaders announced objective of destroying the "Great Satan" America—perhaps after also destroying the "Little Satan" Israel, our most reliable ally in the Middle East.[29]

Whatever its efforts in influencing the Middle East and elsewhere in pursuing its economic interests—e.g., with its vast petroleum reserves, a resource-constrained Russia will no doubt seek to achieve the broad goals of its ambitious military modernization plan. Nuclear weapons will retain their priority at the expense of still impressive conventional forces because of their perceived greater strategic military value as well as the prestige they confer on a superpower status-conscious Russia. Given the need for strategic choices, resulting from economic constraints, Russia will continue to pursue nuclear modernization including advanced missile delivery systems at the expense of conventional forces. The result is that, by its own strategic decisions, the United States will remain vulnerable to nuclear weapons launched from Russia.[30]

28 *Nuclear Weapons, Who Has What, At a Glance*, The Arms Control Association, August 2016, https://www.armscontrol.org/factsheets/Nuclearweaponswhohaswhat.

29 Iran's Supreme Leader Ayatollah Ali Khamenei and his followers have repeatedly chanted "Death to America" and "Death to Israel." Over a year ago, four days after President Obama's vaunted "nuclear deal" was signed, Khamenei told the world it would not change Iran's course—see for example "Iran's Khamenei hails his people for demanding death to America and Israel," *The Times of Israel*, July 18, 2015, http://www.timesofisrael.com/irans-khamenei-hails-his-people-for-demanding-death-to-america-and-israel/.

30 This situation leaves the United States heavily dependent upon the Cold War's deterrent strategy of threatening retaliation following a massive Russian nuclear attack. However, U.S. missile defenses could and should provide protection against a limited accidental or unauthorized launch, which also remains a serious concern.

China also is modernizing its nuclear and ballistic missile forces. It is developing and testing several new classes of ballistic missiles (e.g., the road-mobile DF-41 ICBM capable of carrying multiple independently targetable reentry vehicles [MIRVs], and the DF-26 intermediate-range ballistic missile). These efforts include the formation of additional missile units, the upgrade of existing missile systems, the development of methods to counter ballistic missile defenses, and the testing of a hypersonic glide vehicle.

In addition, China is continuing to build the JIN-class ballistic missile submarine and the JL-2 submarine-launched ballistic missile (SLBM) with an estimated range of about 4,500 miles, which represents Beijing's "first credible, sea-based nuclear deterrent." China also continues to build long-range bombers and publications suggest that Beijing may develop a "long-range 'strategic' stealth bomber" which, together with its land- and sea-based systems, would represent a Chinese nuclear triad. This diverse nuclear/ballistic missile arsenal gives China the ability to attack U.S. regional forces and allies, as well as targets across the U.S. homeland.[31]

China's links to the Middle East are also a concern, at least given North Korea-Iran linkages which exemplify the nature of proliferation to rogue states. China has long aided North Korea in its nuclear and ballistic missile development programs—and North Korea inevitably shares its knowledge with Iran—no doubt for a price now further aided by the infusion of cash via the JCPOA discussed above and recent U.S. ransom payments in exchange for release of U.S. hostages. Recent reports of China aiding its long-time ally North Korea with SLBMs are no great surprise,[32] and likely are only a forerunner for Iran to follow suit in such a deployment.

The emerging security setting also contains important technological challenges to our existing defenses. As noted previously, both China and Russia are developing new-generation technologies/weapons that include hypersonic glide vehicles, maneuverable warheads, and more sophisticated decoys against which our current Ground-based Missile Defense (GMD) interceptors and *Aegis* BMD ships and *Aegis* Ashore would be inadequate, especially given

31 See *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2016*, Office of the Secretary of Defense, April 26, 2016, pp.25-26 and p.38, http://www.defense.gov/Portals/1/Documents/pubs/2016%20China%20Military%20Power%20Report.pdf.

32 "China may have given SLBM to NK: US expert," Jun Ji-hye, *The Korea Times*, September 2, 2016, http://www.koreatimes.co.kr/www/news/nation/2016/09/116_213328.html.

an HGV's capability to maneuver, outrun interceptors, and fly at low, radar-evading altitudes.[33] In time, these capabilities will also no doubt find their way to rogue states.

Despite these twenty-first-century security challenges, the United States has focused its BMD efforts primarily on countering a threat by smaller nuclear states, notably North Korea and potentially Iran. We have consciously chosen not to design a missile defense against the larger nuclear forces of China or Russia even though both Beijing and Moscow have stridently opposed even the limited U.S. BMD programs and deployments while pursuing their own major nuclear modernization programs.

Such a strategic choice makes little sense in an era in which the United States and its allies face geostrategic challenges from Russia in Europe and the Middle East and from China in the Asia-Pacific area. Such technologies/weapons are likely to be deployed by China and Russia by the middle of the next decade—if not sooner, and they will become increasingly available to others as well. The result will be an intensification of the need to develop more advanced missile defenses to remain ahead of these challenges.

These challenges also were recently addressed in a Hudson Institute study[34] led by Rebeccah Heinrichs and supported by an impressive review panel of national security policy, intelligence and technology experts and summarized in her *Space News* article.[35] A brief summary of key findings follows:

- The debate about whether "space is weaponized" is over—adversaries are exploiting U.S. vulnerabilities.
- Antisatellite (ASAT) systems, particularly direct ascent ASATs, threaten our space systems that are important to our military operations and critical civil infrastructure (e.g., the electric power grid, communications, transportation, etc.)—and those of our allies.

33 The United States is also developing hypersonic-glide and scramjet-powered vehicles such as the X-51 unmanned scramjet hypersonic aircraft. X-51 technology will be used in the High Speed Strike Weapon, a Mach 5 missile projected to enter service in the mid-2020s.

34 See *Space and the Right to Self Defense*, the Hudson Institute, June 2016, http://www.hudson.org/content/researchattachments/attachment/1499/20160627heinrichsspaceandtherighttoselfdefense.pdf.

35 "Commentary—Space-Based Interceptors: Realistic, Affordable, Necessary," Rebeccah Heinrichs, *Space News*, August 16, 2016, http://spacenews.com/commentary-space-based-interceptors-realistic-affordable-and-necessary/.

- Hypersonic missiles being developed can defeat our existing ballistic missile defense systems.
- The list of adversaries and associated capabilities is growing (e.g., North Korea and Iran are gaining "greater ranges, mobility, increased accuracy and the technical ability to use more challenging counter-measures, all while amassing great numbers of missiles to enable salvo launches." And both have successfully launched satellites into space).
- For many years such threatening space systems were both beyond the capability and reach of potential U.S. adversaries. No longer ... and our adversaries recognize the asymmetric nature of U.S. space dominance together with space assets' fragility and vulnerability to attack, and are taking advantage of this U.S. Achilles' heel by developing weapons to target our space assets.
- Our space defense posture is primarily passive and reactive, an anachronism of the Cold War era during which we had a single superpower adversary and the uneasy deterrence construct relying on the Mutual Assured Destruction (MAD) doctrine. The Pentagon has begun to build needed resiliency into our space architectures and is requesting funds from Congress to improve space situational awareness—but we cannot prevail in space merely by passively defending against hostile forces; we must have active defenses as well.
- The most effective, and currently missing, way to meet these needs is "to deploy a satellite constellation in space that provides sensor coverage as well as a kinetic kill capability."[36]
- Notably, we know such a space-based interceptor (SBI) system is "affordable" and development efforts should begin immediately.

This welcome study mirrors Independent Working Group (IWG) on Ballistic Missile Defense studies conducted and reported during the last decade.[37] These studies discussed: 1) The growing ballistic missile threat; 2) The lessons learned from the Strategic Defense Initiative era, during which research and development were in

36 This defensive satellite constellation could also protect other critical U.S. satellites in various orbits from antisatellite (ASAT) attack. In the future, it could be supplemented by a space-based "directed energy" system to minimize the "space debris" following such intercept operations.

37 See *Missile Defense, the Space Relationship, and the Twenty-First Century,* Independent Working Group on Missile Defense (Cambridge, MA: Institute for Foreign Policy Analysis, 2009), http://www.ifpa.org/pdf/IWG2009.pdf .

keeping with President Ronald Reagan's original guidance and intent to achieve an effective defense to protect the American people and our friends and allies around the world; 3) The political constraints that so sharply curtailed those efforts in 1993 and subsequently limited defenses of the U.S. homeland to Ground Based Interceptor (GBI) concepts; and 4) The sound technical and policy basis for developing and deploying much more cost-effective ballistic missile defense systems deployed at sea and in space; and 5) Specific recommended cost-effective BMD system concepts for development, testing and deployment.

In particular was the IWG detailed documentation, drawing from the SDI era from 1984 through 1992, that 1) Given explicit Congressional direction, the United States had chosen, for political rather than technical, engineering or programmatic reasons, to cancel those most cost-effective programs and to focus sharply curtailed homeland defense development programs on fixed GBI system concepts; 2) This selection had led the Pentagon to invest in developing the most expensive, least effective defense concept to defend the U.S. homeland—to the exclusion of all others; and 3) The United States should give its top priority to developing Theater Missile Defense (TMD) for U.S. overseas forces, friends, and allies.[38]

The IWG reviewed the then maturing development of the sea-based *Aegis* BMD for TMD applications and, based on previous detailed studies by the U.S. Navy, concluded that those sea-based systems would be more cost-effective in defending the U.S. homeland than the GBI systems. And finally, the IWG reviewed in detail the SDI development of SBI concepts—the *Brilliant Pebbles* concept in particular—and concluded that space-based defense would be the most cost-effective approach for defending the United States and U.S. overseas forces, friends, and allies. Directed Energy systems, including space-based lasers, were also considered and continued research, development and eventual deployment was recommended.

38 The SBI programs were completely scuttled and the associated technologists dispersed; the fully-approved GBI demonstration and validation (DemVal) program was cancelled and the Army was instructed to return the contractor proposals, unopened, to the bidders in the private sector; and even the funding for the so-called "top priority" TMD programs was cut by about 25 percent. The politically directed emphasis on TMD systems came at the expense of the then-Ballistic Missile Defense Organization's preferred expenditures on high-payoff BMD system developments, previously a primary SDI focus.

Key Economic and U.S. Political Challenges

Recent trends only underscore the urgent need to heed these IWG recommendations to meet a foreseen but thus far unaddressed challenge. As Ms. Heinrichs and her panel of experts noted and as should have been anticipated, the U.S. military and the broader national security policy community are finally becoming concerned that the cost-exchange ratio between offensive missiles and missile defense interceptors currently favor the offense. This means that the United States must pay more to shoot down a ballistic missile than it costs an adversary to develop, purchase or replace that ballistic missile—especially if the likely proliferation of potential Chinese and Russian (and shortly, if not already deployed, North Korean and Iranian) defense penetration aids is considered.

Against an adversary possessing a very small number of ballistic missiles such an adverse missile-to-defense expense ratio might be acceptable. However, as ballistic and cruise missiles proliferate and their unit costs decrease, maintaining the needed defenses could become unaffordable. Such an eventuality would undermine U.S. deterrence policy and greatly limit our escalatory options during a crisis.

This technological challenge was foreseen and accounted for in President Reagan's Strategic Defense Initiative—30 years ago. That challenge was explicit among those involved in his SDI program. Congressional leaders, primarily to constrain progress toward prematurely building ineffective BMD systems, passed legislation imposing the so-called "Nitze criteria" by which, as a matter of law, no BMD system could be built unless it would cost more for an enemy to build offensive countermeasures than for the United States to build defensive responses.[39] This required precondition became known as requiring defenses to be "cost-effective at the margin."

39 Named after Paul H. Nitze, who served in high-ranking positions in several administrations from Truman to Reagan, the Nitze criteria were adopted under the Reagan Administration to help determine whether or not a missile defense system, once developed, should be fielded. Under these criteria, any missile defense system deployed must be survivable and cost-effective at the margin. Notably, this cost comparison took no note of the value of the defended equities nor attributed any value to the lives saved. Even so, requiring this capability for space-based defenses was far more effective in limiting the Soviet development of multiple independent reentry vehicles (MIRVs) than arms control agreements since a cost-effective boost-phase intercept capability greatly shifts the cost exchange balance to advantage the defense. During those START negotiations with the Soviets, a

And President Reagan's negotiators referred often to the requirement that our SDI deployments would be "cost effective at the margin and survivable against direct attack"—the latter constraint being intended to avoid defense suppression attacks. We further shorthanded this condition in our negotiations with the Soviets to simply "effective defenses."

With the passage of the Missile Defense Act of 1999,[40] this precondition was abandoned when it became "the policy of the United States to deploy as soon as is technologically possible an effective National Missile Defense system capable of defending the territory of the United States against limited ballistic missile attack (whether accidental, unauthorized, or deliberate)." This new status, which gained unanimous congressional approval, was an immediate response to North Korea's 1998 tests demonstrating a budding intercontinental ballistic missile capability.[41]

At the time, this initiative was welcomed by missile defense advocates because previous congressional restraints had blocked building any homeland defense. But in time, it led to the idea that all that made sense was a "limited" BMD system rather than defending against a "limited" attack. Consequently, the focus of these development programs became ground-based defenses—and that constraint can be traced to the fact that the anti-ballistic missile (ABM) Treaty permitted only ground-based interceptors for a limited homeland defense. As discussed in the IWG reports, ground-based defenses should have been recognized as the most expensive, least effective BMD systems—no doubt the objective of those who originally negotiated the ABM Treaty, which was intended to support the Cold War Mutual Assured Destruction (MAD) doctrine that made a virtue out of keeping Soviet and U.S. citizens vulnerable to an existential threat of a nuclear exchange.

Under the ABM Treaty, development, testing, and deployment of all basing modes other than GBIs were banned—with a small opening for defenses based on undefined "other physical principles," or OPP. Lasers were clearly included as being based on OPP—and agreement on such systems was required to be negotiated before deployment. A thorough review of the ABM Treaty negotiating

key objective was to reduce MIRVed ICBMs—an objective largely abandoned in New START as well as in developing space based defenses.

40 See https://www.congress.gov/bill/106th-congress/senate-bill/269/text .

41 For example, see http://www.nytimes.com/1998/09/01/world/north-korea-fires-missile-over-japanese-territory.html , "North Korea Fires Missile Over Japanese Territory' by Sheryl WuDunn, *New York Times*, September 1, 1998.

record led to the Reagan Administration's view (called the Broad Interpretation) that would permit development and testing of mobile "hit-to-kill" interceptor systems—including in space. However, this view was overruled by the U.S. Senate—with the consequent constraints intended to limit all interceptor programs to a so-called "Narrow Interpretation" of the Treaty. Only "research" was to be permitted on all homeland defense interceptor systems except those fixed ground based ABM systems employing ground based interceptors.

TMD programs were treated somewhat differently—since the primary objective of the ABM Treaty was to limit ABM systems against ICBMs. Without defining what constituted a TMD system, the Treaty focused on blocking covert development of ABM systems, including under the guise of developing TMD systems—which were little different than air defense systems, which were not supposed to be limited. This ambiguous arrangement led to much confusion that constrained the development and testing of our air defense systems.

For example, when the Senate advocated giving the *Patriot* air defense system a capability against short-range ballistic missiles, former Strategic Arms Limitation Talks (SALT) Chief Negotiator Paul Warnke argued repeatedly that such a capability would violate the ABM Treaty—a view that the U.S. Senate just as regularly rejected.[42] The Senate funded giving *Patriot* a limited BMD capability, the House zeroed the Senate-proposed funding and the Joint Conference settled at half-funding. Consequently, a very limited *Patriot* ballistic missile defense was barely entering its testing phase when Iraq invaded Kuwait in 1991 and was prematurely produced[43] to become a hero in the 1991 Gulf War.

As a consequence of the 1991 Gulf War, TMD systems were accepted, recognized as being necessary and indeed strongly supported by Congress—even though other perceived ABM Treaty constraints continued to influence SDI efforts. With strong support from Congress, U.S. Navy efforts to develop *Aegis* sea-based defenses as a TMD system proceeded—but constrained to avoid perceived ABM capability. Under the terms of the ABM Treaty, even the development and testing of sea-based defenses of the U.S. homeland were

---

42 A technically competent engineer can prove that the *Patriot* keep out range, sensors, timelines, velocities, etc. were inadequate for shooting down ICBMs.

43 Only four *Patriot* interceptors were available for testing when Saddam Hussein went into Kuwait—and the Martin Marietta and Raytheon production lines were prematurely turned on to produce every untested *Patriot* employed in the Gulf War.

banned—which is why *Aegis* BMD development began as a TMD system—remarkable because of previous constraints resulting from perceived ABM Treaty limitations.[44]

These ABM Treaty constraints should have been dropped when President George W. Bush withdrew from the ABM Treaty in 2002, but the impressive inherent "cost-effective" capability of the *Aegis* BMD system inexplicably is still not included in the architecture for our homeland defense. For example, *Aegis* BMD ships normally off our coasts could provide significant homeland defense capability but do not operate to support that mission. At a time taken at random in 2013, there were 4-6 *Aegis* BMD ships off the East Coast or in port that could have provided this capability, but they were not prepared to do so—and, to our understanding, this is still the case. Such a capability could help defend against Iranian ICBMs and employed to intercept missiles launched from vessels off our coasts, ending this current vulnerability.

Moreover, even research and experimental activities associated with SBIs have not been restored since they were cancelled in early 1993, without any evaluation whatsoever of the consequences. Nevertheless, almost all the key technology system components were space qualified in the joint DoD-NASA Clementine mission that, for the first time in a quarter century, returned to the Moon in 1994 and space-qualified the technologies that underpinned the *Brilliant Pebbles* program that was pioneered by SDI.[45] This evident blindness was not only a consequence of ABM Treaty constraints, but also the political aversion to so-called "weapons in space" that continues to hamper our current missile defense efforts, even in the absence of the ABM Treaty.

44 Because of perceived ABM Treaty limitations, development of the *Aegis* BMD system had been restrained by limiting the air defense system such that it could not track and intercept ballistic missiles—even though it was inherently capable of doing so.

45 See the IWG report for discussion of Clementine and its implications for SBI viability, at least from a technology perspective. See http://nssdc.gsfc.nasa.gov/planetary/clementine.html for Clementine project information from NASA. The Clementine Project team was presented with awards from NASA and the National Academy of Sciences. Clementine space-qualified sensors that mapped the Lunar surface in 13 spectral bands producing more frames of data than obtained by the entire Apollo Program. It also discovered water in the polar regions, confirmed in subsequent NASA missions to the Moon. The only *Brilliant Pebbles* component not demonstrated on the Clementine mission was miniature rocket thrusters, which were space-qualified on a companion Astrid launch.

During the Reagan and George H.W. Bush Administrations, the programs were pursued in the face of these political concerns of the arms control community—because of the clear benefits of space-based defenses if they could meet the "Nitze" criteria. As discussed below, meeting this condition was not only possible but the *Brilliant Pebbles* SBI concept passed a number of critical reviews demonstrating its potential viability, then judged to justify serious study and evaluation—even within the confines of the ABM Treaty.

Back to the Future: The Goals and Programs of a Resurrected Strategic Defense Initiative

It is past time to re-examine these previous decisions, especially since, as former USNORTHCOM Commander Admiral Gortney,[46] among others, has observed, that the United States is on the "wrong side of the ballistic missile defense 'cost curve'." As a result, we risk "shooting down not very expensive rockets with very expensive rockets." He added: "We need to start knocking them down during the boost-phase and not just relying on the mid-course where we are today."[47] To the extent that sequestration and other constraints slow defense spending and much-needed technological advances, it will become more difficult to outpace the threat.

These recent revelations were the same ones that drove the SDI studies from their inception in 1983-4 through 1992 when the program was cancelled at the outset of the Clinton Administration, as discussed above. Furthermore, SDI demonstrated that the solution to anticipated threats lies in space-based defense development and deployment to accomplish boost-phase intercept.

A boost-phase missile defense is best provided from space, not a new idea since its history dates back long before SDI in the 1980s. It was considered in the 1960s by Defense Advanced Research Agency

46 See footnote 5.

47 A ballistic missile flight path encompasses four phases: boost, ascent, midcourse, and terminal. The boost phase begins immediately after launch while the ballistic missile is emitting exhaust gases that are relatively easy for sensors to detect and track. The ascent phase is the period immediately following boost phase and ends when the missile reaches apogee prior to discharge of its warhead(s) and decoys. During the ensuing midcourse phase in space the ballistic missile warhead(s) and decoys/countermeasures are released; this is followed by the terminal phase when the warhead(s) renters the atmosphere and descends to the target(s). Interception in the boost and ascent phases is optimal because the missile is moving relatively slowly and it has not yet discharged its warheads and decoys.

(DARPA) studies that concluded that the technology then available could not accomplish the desired objective. The SDI re-examination of the issues and the then developing technology concluded that it was a feasible concept by 1990—based on the then maturing technology in the private sector, as well as within SDI.[48]

The United States had at least conceptually developed technologies for lightweight propulsion units, sensors, computers, and other components of an advanced kinetic kill vehicle. The most advanced SDI concept, *Brilliant Pebbles*, consisted of a constellation of small interceptors that combined their own early-warning and tracking capability with high maneuverability to engage attacking ballistic missiles in all phases of their flight trajectory. The then cutting edge technology enabled lightweight onboard computers with sufficient capability to fully manage the entire constellation of thousands of lightweight "*Pebbles*," each autonomous and networked with its near- and far-neighboring *Pebbles* sensors, to provide a comprehensive overall defensive system that could be managed by a relatively small operations cadre.

Each interceptor, or "*Pebble*," was designed to identify the nature of the attack, which might include thousands of ballistic missile warheads, based on a defense that included thousands of "*Brilliant Pebbles*;" and since it knew its own location and that of all other *Pebbles*, each could calculate an optimum attack strategy from its own perspective and execute an interception, while simultaneously informing the other *Pebbles* of its action. The basic idea was to exploit the then-cutting-edge computational power of small handheld computers (and miniaturized sensors)—now several generations more mature—to enable a large constellation of small low-earth-orbit satellites to perform the primary elements of battle management to maneuver into the path of ballistic missiles/warheads beginning in their boost phase and continuing throughout their midcourse trajectory in space until sometime after they began to reenter the Earth's atmosphere in the terminal phase.

48 SDI eventually gave space-based interceptors top priority because the needed kinetic kill and associated technology was judged in extensive 1989-90 technical reviews, and approved in 1991 by the Pentagon's acquisition authorities, to be sufficiently mature to enter a formal demonstration and validation (DemVal) phase. SDI also continued research and development on directed energy (DE) defenses as a future missile defense option. In the late 1970s, DARPA demonstrated "brassboard" optics, laser, and pointing/tracking technology for eventual space-based high energy laser missions—and even designed a system concept compatible with being launched by the Space Shuttle.

This operational concept was based on a robust, viable, testable capability that survived numerous scientific and engineering peer reviews in the 1989-90 timeframe, including by some groups that were hostile to the idea of missile defense in general, and space-based defenses in particular. And it was incorporated into the leading "global" role of the Global Protection Against Limited Strikes (GPALS) concept endorsed by President George H.W. Bush in 1991.[49] In this role it not only had impressive autonomous capabilities, it also played a major role in providing tracking and discrimination capabilities to support BMD systems based on the ground, at sea and potentially in the air. It was by far the most cost-effective component of GPALS[50] that also included both TMD and national missile defense ground-based components.

Still, because of persistent policy preferences, the opposition eventually gained the upper hand politically, and the program, which had been formally approved by the Pentagon's acquisition authorities, was curtailed by Congress in 1991 and 1992 and then cancelled by the Clinton Administration in early 1993.[51] As a result, in the decades that have followed, the United States pursued missile defense architectures and technologies that excluded space-based interceptors and restricted our ability to develop the benefits of space-based boost-phase missile defenses. And overall system effectiveness has suffered as other more expensive, less effective components have proliferated to gain global coverage—which obviously is better provided by SBIs with the capabilities embedded in the *Brilliant Pebbles* system, a concept which should be reinstated.

As envisioned, *Brilliant Pebbles* autonomy in detecting launch and dispatching interceptors would have complicated the use of

49 "Global" meant defenses against ballistic missiles launched from anywhere against targets anywhere else more than a few hundred miles away; "Protection" meant a very high probability of kill to provide actual protection rather than a partial defense to "deter" attack; and "Limited" meant up to 200 attacking warheads—what was then under the command of a Soviet submarine commander.

50 See http://highfrontier.org/wp-content/uploads/2012/09/GPALS-Briefing-to-Press-12-February-1991.pdf for the annotated Pentagon Press Briefing (rotate clockwise for easy reading) that formally introduced the presidentially-approved program.

51 For the record of this important program as recorded by the Missile Defense Agency's historian, Donald R. Baucom see "The Rise and Fall of Brilliant Pebbles," International Flight Symposium, October 23, 2001, http://highfrontier.org/oldarchive/Archive/hf/The%20Rise%20and%20Fall%20of%20Brilliant%20Pebbles%20-Baucom.pdf. This piece was subsequently published in the *Journal of Social, Political and Economic Studies* 29, no. 2, (September 2004).

countermeasures against their command and control system. And because of the number of interceptors deployed in space, these defenses would have multiple opportunities for interception, thus increasing their chances of a successful intercept in the boost and midcourse phases, or even high in the Earth's atmosphere during the terminal phase. These characteristics stand in contrast to current-generation interceptors, which are hard pressed to provide more than one independent intercept opportunity because they lack redundancy and depend on proper positioning to intercept missiles in their midcourse and terminal phases.

Although the BP program was terminated in early 1993, major advances in the commercial, civil, and other defense sectors since that time should now permit even lighter mass, lower cost, and higher performance technologies, components, and systems than would have been achieved by the 1990-era technology base. Thus, lighter weight and smarter components building on twenty-first-century robotic technologies could now empower SBIs with greater acceleration/velocity, enabling boost-phase intercept of even short- and medium-range ballistic missiles as well as high-acceleration ICBMs, thus surpassing the capabilities of the 1990 *Brilliant Pebbles*. For example, boost-phase interception will be essential to counter the hypersonic missiles of the next decade in their boost phase before they reach maximum speed and maneuverability.[52]

In addition, the capabilities of a twenty-first century BP system would support other vital national security missions and enhance the survivability of critical space assets on which all U.S. military operations depend. Such additional missions include early warning, space domain awareness, ASAT detection and interdiction, detecting nuclear-test detonations, tactical intelligence, monitoring treaty compliance, and tracking the activities of potential proliferators.

Cost Effectiveness Considerations

In the budget-constrained environment facing the Trump Administration, *Brilliant Pebbles* has an additional advantage that addresses the offense/defense cost-effectiveness problem. As indicated

52 Swarm robotic technologies could support a twenty-first century *Brilliant Pebbles.* There are numerous similar characteristics, including low-cost systems that could be deployed in large quantities, in this case, to overwhelm *offensive* systems, namely ballistic missiles by their sheer numbers. As in today's robotic swarming, *Brilliant Pebbles* operated as networked, cooperative systems.

in the 1991 GPALS briefing,[53] *Brilliant Pebbles* then thought by the Pentagon's best cost estimators to be $10 billion in 1988 dollars, or about $20 billion in 2016 dollars,[54] which would have been spread over BP's twenty-year life-cycle.

With the progress made in the past 25 years—including miniaturization, reduced computing, sensor, and launch costs, etc.—the price tag for a new *Brilliant Pebbles* program should be even lower while providing substantially greater intercept capabilities and cost effective adjuncts to the overall missile defense system now operating around the world. A $20 billion—or lower—price tag for an updated BP effort represents an extremely low and manageable cost given its vitally important mission to protect the U.S. homeland coupled with the fact that other DOD acquisition programs such as the F-35 and B-21 bomber *far* exceed this cost.[55] The breakdown in 2016 dollars for the various costs of the 1989 *Brilliant Pebbles* program is approximately:

- $14 billion for research, development, test and evaluation;
- $1.6 billion for production of 2000 BPs (or $830,000) based on replacing each of the 1000 BPs once during the system's 20-year life cycle;
- $1.5 billion for launching 2000 BPs; and
- $3.9 billion for the 20-year operating cost.

---

53 Reference 50 provides the best then-available (in 1991) cost estimate for research, development, deployment and 20-year operations of a global constellation of approximately 1000 *Brilliant Pebbles* ($10 Billion in 1988 dollars). That program was publicly introduced as a presidentially approved refocused SDI program, and its estimated costs were based on several independent analyses including by the Secretary of Defense Cost Analysis Improvement Group (CAIG) and other independent studies discussed by the SDI historian in Reference 51. Many of these cost studies were performed for a larger constellation of about 4000 *Brilliant Pebbles* and adapted by the *Brilliant Pebbles* Task Force for President Bush's GPALS effort. Subsequently, further independent cost estimates were to be produced by the two independent contractor teams (down-selected from a competition of six)—all of which were exposed to the previous "season of studies" and associated cost-estimates discussed in Reference 50. Most of these cost analyses were done on Lt. General George Monahan's watch as SDI Director, and are still the best available 20-year life cycle cost estimates—corresponding to about $20 billion in 2016 dollars. More recent cost estimates have been based on far less information and technical scrutiny.

54 The Bureau of Labor Statistics Consumer Price Index (CPI) Calculator was used for all 2016 cost figures.

55 Compare the huge Obama Administration stimulus spending, with the proposed cost of *Brilliant Pebbles* that pales by comparison.

The costs for space launch and on-orbit sustainment and operations have also decreased. Additional cost savings should also materialize as we develop robotic on-orbit autonomous servicing of satellites.[56] Moreover, advances in miniaturization will allow more components to be packed into smaller packages and thus increase capabilities while simultaneously lowering launch costs. The availability and use of low cost, commercial off-the-shelf products and components will further reduce costs.

For example, SpaceX, a private company founded in 2002 by Elon Musk that designs, manufactures, and launches rockets and satellites, offers the prospect to lower the cost of access to space. On April 8, 2016, the first stage of the SpaceX Falcon 9 rocket—which boosted a Dragon cargo capsule into orbit that docked two days later with the International Space Station—successfully landed on a barge in the Atlantic Ocean. Successful first-stage landings back on earth have been repeated several times since then. The first-stage boosters are the most expensive element of a launch vehicle.

Their reuse, as the successful landings in the Atlantic and at Cape Canaveral have proved feasible, will help reduce launch costs making travel to space a routine freight operation, including rocket launches for the deployment of the various elements of a space-based BP missile defense. Competition for launch services from other commercial companies like Blue Origin, a privately-funded space-launch company created by Amazon co-founder Jeff Bezos, hold the possibility for further reducing the cost of accessing space.

Furthermore, DARPA is developing an experimental, re-usable space vehicle (the XS-1) to demonstrate the capability of launching a 3,000- to 5,000-pound satellite into orbit on a near-daily basis. An operational XS-1 system would dramatically reduce launch costs with each flight to space projected to cost no more than $5 million.[57]

In addition, commercial ventures such as OneWeb, a private company that plans to launch a constellation of approximately 700 satellites to provide affordable Internet access worldwide, will utilize

56 For example, DARPA is developing a capability for autonomous, on-orbit servicing/maintenance and repair of satellites reaching up to geosynchronous orbit. See http://www.darpa.mil/news-events/2016-03-25.

57 This budding "reusable launch" capability is the legacy of SDI's Delta Clipper-Experimental, or DC-X, pioneering efforts that were first demonstrated on August 18, 1993 and later repeated launches in New Mexico. See http://www.space.com/22391-reusable-rocket-nasa-dc-x-anniversary.html for discussions of it and subsequent programs. SDI's Program Manager that led this historic effort now pursues even more advanced efforts to further reduce launch costs at DARPA.

mass-production techniques to create a high volume of low-cost, low-weight satellites—as was the plan for *Brilliant Pebbles*. Such manufacturing techniques would reduce production costs for today's *Brilliant Pebbles'* components.

Significant cost reductions could also be achieved if a twenty-first-century *Brilliant Pebbles* program employed a top-down management approach, similar to that formed in response to President Reagan's March 23, 1983 visionary speech that launched SDI—and in particular employed by the *Brilliant Pebbles* Task Force. Moreover, making the position of Director of the Missile Defense Agency (MDA) a four-star-equivalent billet would give the director "a seat at the table" with warfighters and budgeteers providing him/her with greater say in funding and system acquisition priorities and decisions.

Given the accelerating current threat, the MDA Director should be given a charter similar to that employed in the expedited development of our ground- and sea-based ballistic missile programs of the late 1950s and early 1960s. In particular, the MDA Director should pursue an expedited new *Brilliant Pebbles* program framework that includes leveraging technologies, products, and innovative manufacturing and management processes spearheaded in the commercial sector—again as was pioneered with *Brilliant Pebbles* in the SDI era. Key programs also should restore active development of directed energy BMD systems.

Competition in the commercial sector to provide reusable rocket boosters and engines, commercial off-the-shelf products and components such as computers, software, sensors, lightweight materials, etc., and the utilization of low-cost fabrication techniques and streamlined, best-practices management should be employed. Such a framework would restrain cost growth and reduce the time necessary to develop and deploy the *Brilliant Pebble* constellation. It would leverage new technologies as well as private sector expertise and know-how, as discussed in an earlier section of this White Paper.

Finally, BP's ability to support other crucial missions as outlined above would allow multi-mission data sharing to serve numerous national security stakeholders, such as MDA, Air Force Space Command, the combatant commands, and intelligence community, resulting in operational efficiencies and cost savings.

Because of all these factors, if needed, additional BP systems could be cost-effectively deployed in response to a proliferated threat.

Brilliant Pebbles, Deterrence, Denial, and Escalation Control

Increasingly, the focus of deterrence has included denial, an essential element of which is the ability to defend and protect vitally important targets. No U.S. president should be left only with the option of retaliating against the civilian population of another country. It would be preferable to be able to defend against such an attack and thus to protect the U.S. population. Furthermore, as the difficulty of problems inherent in identifying the perpetrator of an attack grows, the greater is the need for a form of deterrence that raises the cost of attacking those targets or preferably, renders them as fully as possible invulnerable to an enemy strike. In place of mutual assured destruction as a basis for deterrence, such a concept of deterrence by denial must be based on assured survival.

To the extent that technologies are already available, or could become available for this purpose, the importance of deterrence by denial becomes integral to twenty-first-century escalation control. Because missile defense technologies have proven capabilities to intercept a broad spectrum of missiles, they form an essential component of deterrence by denial. Ideally, the national command authority should be given a series of escalatory and deterrence options in addition to those based on retaliation. The ability to defend or protect key targets in itself contributes to such options. Hence the importance of missile defense for twenty-first-century deterrence and escalation control.

Since the 1980s, the United States has developed layered missile defense architectures and deployments designed to protect the U.S. homeland, deployed military forces, and allies/partners from ballistic missiles especially in the midcourse and terminal phases of their flight. We have also worked closely with allies in Europe and with Japan to develop and deploy defenses against missiles.[58] We have collaborated with Israel to develop a layered missile defense that includes the *Arrow* system against ballistic missiles as well as the *Iron Dome* system against Hamas and Hezbollah short-range rockets armed with conventional warheads.

Although the focus of U.S. missile defense systems has been against countries such as North Korea and Iran, both China and

58 In particular, Japan has played a critically important role in the development of our *Aegis* BMD capability, now deployed around the world—including several now operated by Japanese sailors to protect their homeland.

Russia possess nuclear forces capable of targeting the United States either by themselves or as part of a future nuclear coalition against the United States and its allies. This might include, for example, Russia and China allied with each other, or either Russia or China aligned with a nuclear Iran or North Korea. Thus, a missile defense system that specifically excluded defenses against China and Russia would be inadequate for this purpose. It would leave both the United States and its allies and coalition partners exposed in a condition of greater vulnerability with a range of possible negative consequences for deterrence and escalation control.

As the number of nations with ballistic missiles and nuclear weapons grows and if the United States faces nuclear armed coalitions of states, we will need to consider how many missile defense interceptors are needed to deter escalation. The limited number of interceptors available in the U.S. arsenal—what the U.S. Navy refers to as "magazine depth"—will limit our ability to intercept missiles before our interceptor inventory is depleted. The smaller the size of this interceptor inventory, the greater may be the incentive of an adversary to launch a saturation attack, or enough missiles to deplete our missile defense stockpile, with major consequences for U.S. deterrence and escalation control. The deployment of a modern SBI system patterned after *Brilliant Pebbles* would provide a cost-effective solution to this problem. It would give the United States a capability to defend against a missile strike and provide an alternative to a retaliation-in-kind nuclear response.

The Reagan-Bush-41 Administrations developed a missile defense architecture that could have begun deployment in the mid-1990s. It included not only *Brilliant Pebbles* as the space-based interceptor component, but also ground- and sea-based national and theater defenses designed to intercept missiles launched from any point against the United States or its forces, allies, and friends overseas. This would have defended against ballistic missile launches and limited ballistic missile strikes initiated from anywhere on the globe. In marked contrast to the more limited missile defenses thus far evolved, this architecture could still provide a multi-tiered defense beginning in boost phase against missiles just after their launch and extending through midcourse and into the terminal phase. By 1990, as a result of the technology investments of the preceding decade, the space-based elements were technically mature and ready for rapid development. That system was not deployed because of conscious political choices that do not serve our national security needs.

Today, space-based interceptors would provide the greatest leverage against ballistic missiles of all ranges in a world of proliferating capabilities, with interdiction in each phase of a ballistic missile's flight—particularly in the boost phase when a ballistic missile is most vulnerable and has not released its warheads and decoys. This capability will be far more effective in limiting the development of multiple independent reentry vehicles than arms control agreements since a boost-phase intercept capability will greatly shift the cost exchange balance to advantage the defense.

EMP and Missile Defense

As indicated in our opening section, EMP looms large as a major threat, which could be countered with such a boost-phase intercept capability. This option should be included in the response to the 2016 National Defense Authorization Act, which directed the Department of Defense to initiate a concept development study for a space-based boost-phase defense interception capability. An important consequence of such a strategy would be a counter to the EMP threat. In our *Investor's Business Daily* article (see Footnote 22) we recommended the following strategy:

- First, develop and deploy missile defense systems to address the ballistic missile and EMP threat from North Korea, Iran, and terrorist groups. Included should be *Aegis* BMD ships, *Aegis* Ashore (deployed along the Gulf Coast to counter southern trajectory threats), and the development of unmanned aerial vehicles (UAVs) with capabilities for early warning and boost-phase intercept as a short-term response to this threat.
- Beyond that immediate fix, allocate resources to initiate immediately the development and test of a BP prototype and the rapid acquisition and deployment of an initial BP missile defense constellation which would enable us to counter the EMP threat and to remain ahead of the rapidly evolving security setting described in this White Paper.
- Finally, take immediate steps to harden the electric power grid and prepare to reconstitute key portions of the grid quickly to restore essential services if the grid is lost from a natural event such as a solar storm, or because of an EMP strike and/or a cyber attack. In addition, it is vital to protect our nuclear reactors to eliminate the possibility of the type of reactor meltdowns that occurred in Japan following the 2011 earthquake and tsunami resulting in electric power

generation shortfalls and nuclear contamination. The electric grid is the U.S. Achilles' Heel, as former ABC *Nightline* anchor Ted Koppel has stated in his book[59] emphasizing its vulnerability to cyber warfare and cyber hackers.

To support hardening the power grid, note that approximately 2% of our electricity from the power grid is lost each year due to the effects of solar radiation on associated infrastructure—a revenue loss of about $8 billion annually. Aside from the important national security considerations, it would pay the power companies to harden the electric power grid to negate this $8 billion annual loss and over time, return the savings to consumers in the form of lower electric bills. Since our electronic infrastructure, especially the electric power grid, is vulnerable to a major solar storm that will one day occur,[60] we should protect the grid now.

Conclusions

Such considerations as discussed in the previous sections led former Directors of the nation's BMD acquisition programs since the formation of the Strategic Defense Initiative Organization (SDIO) in 1984 to write to the Chairmen and Ranking Members of the Senate and House Armed Services, recommending that the Conference Committee for the National Defense Authorization Act for 2017—NDAA (2017)—replace the language of the National Missile Defense Act of 1999 that restricted the nation's missile defense development activities to defending against "limited" attacks. Their brief summary of the current situation is entirely consistent with ours—which reflects more recent events since their September 1, 2016 letter:[61]

> *"You are no doubt aware that, recently, North Korea demonstrated a submarine-launched intermediate range ballistic missile capability—this capability was apparently developed in near record time by one of the most economically sanctioned regimes on Earth. The Islamic Republic of Iran continues to develop its ballistic missile capability and adds to what is estimated to be the largest ballistic missile inventory in the world. What's more, Russia and China are actively testing new hypersonic boost-glide based weapons that may*

59 *Lights Out: A Cyberattack, A Nation Unprepared, Surviving the Aftermath*, by Ted Koppel, Penguin Random House, 2015.

60 We missed such a debilitating solar emission by less than a week in 2013, when it passed through the Earth's orbit.

61 See http://highfrontier.org/wp-content/uploads/2016/09/Former-MDA-Directors-NDAA-Letter-160901.pdf.

have both conventional and nuclear warheads and against which it is believed the U.S. has no defensive capability.

If ever it was the case, there is no longer a "limited" ballistic missile threat to the homeland. Unfortunately, our foundational policies have not kept pace with the threat. Indeed, the National Missile Defense Act of 1999 has not been updated in 17 years, since before the United States withdrew from the Anti-Ballistic Missile Treaty of 1972, before the United States demonstrated the Ground-based Midcourse Defense system, and certainly before our relationship with Russia and China collapsed.

As former directors of the Missile Defense Agency, and its predecessors, we feel obliged to share our view that the language in the House and Senate National Defense Authorization Acts for FY17 is a much-needed update of a long-outdated, but well-intentioned, policy for national missile defense. We believe that in a day when our adversaries, even North Korea and Iran, are anything but limited, it makes no sense for the United States to limit the options that it might consider for its defense from ballistic missile attack.

We have seen, first hand, the impacts of such a limited ballistic missile policy—the options for the defense of the United States not pursued. We can no longer afford to be constrained by such a policy. We urge your support for a policy, such as that proposed in the House or Senate NDAAs, that recognizes the dangers our nation faces and the defenses we must develop."

The bottom line of our discussion and analysis is that the most effective BMD system to protect the American people and our overseas forces, friends and allies will be deployed in space—initially employing the fully matured application of miniature "hit-to-kill" space-based interceptors that minimize satellite launch costs. Subsequently, space-based directed energy systems should also be developed and deployed.

Such a SBI system was judged to be viable endeavor 25 years ago, after numerous intensive reviews of *Brilliant Pebbles*. With major technological advances since then, a twenty-first-century version would be far more capable and less expensive than was the case then. Those studies concluded that system could destroy with high confidence up to 200 Soviet/Russian warheads launched from anywhere toward the United States or its overseas forces, allies, or coalition partners—a far greater capability than the United States has deployed today against a lesser rogue state threat. Such studies, program reviews, assessments, and cost estimates—if made public and distributed to key missile defense stakeholders in the executive branch, the military, Congress, and the broader policy community—would show the painstaking and exacting process that *Brilliant Pebbles* underwent and which conclusively proved the feasibility of that concept. They would buttress the case that we make in this White Paper for an increasingly robust twenty-first-century missile defense that includes that key system.

Space-based missile defense provides the most credible and cost-effective way to get ahead of the offense/defense curve. It also enables boost-phase intercepts, during the most effective time to destroy ballistic missiles, including in EMP attacks. It also complements our objectives in achieving stable relations with Russia and China by discouraging the development and deployment of MIRVed and other threatening advanced ballistic missile systems. A twenty-first-century *Brilliant Pebbles* offers enhanced deterrence (by denial) and escalation control for assured survival in a security environment marked by the growing availability of nuclear weapons and delivery systems to a variety of actors. In addition, such a system offers more than missile defense: it is also capable of supporting several other critical national security missions such as space situational awareness, ASAT warning and interdiction, and tactical intelligence to cite only a few.

Space-based missile defense also should be seen as part of a broader concept that integrates space into our grand strategy for national security and the economic future of the United States. Technologies for space have extensive political-military and economic-commercial applications. Technologies developed for one purpose have potential uses elsewhere. Nowhere is this more fully illustrated than in the military and commercial applications of rocket-launch technologies. The result is that a *Brilliant Pebbles* constellation could be launched and deployed in orbit more easily and cheaply today than would have been possible in the 1990s. It would utilize launch vehicles having civilian, commercial, and military applications enabling us to counter cost-effectively the looming threats facing the United States in the years ahead.

About the Authors

Ambassador Henry F. Cooper was SDI Director, Chief U.S. Negotiator at the Geneva Defense and Space Talks with the Soviet Union and Deputy Assistant Secretary of the Air Force for Strategic and Space Systems.

Lieutenant General Malcolm R. O'Neill, USA (Ret.), was Deputy SDI Director, Director of the Ballistic Missile Defense Organization and Assistant Secretary of the Army for Acquisition, Logistics and Technology.

Dr. Robert L. Pfaltzgraff Jr. is President of the Institute for Foreign Policy Analysis (IFPA), Inc., and Shelby Cullom Davis Professor of International Security Studies at The Fletcher School, Tufts University and Chairman of the Independent Working Group on Missile Defense.

Colonel Rowland "Rhip" H. Worrell, USAF (Ret.), was Director of the SDI *Brilliant Pebbles* Task Force, Director of the National Test Facility Joint Program Office and Vice Commander of the USAF Space Warfare Center.

Institute for Foreign Policy Analysis, Inc.

Cambridge, Massachusetts   Washington, D.C.

Telephone: (617) 492-2116

mail@ifpa.org
DCmail@ifpa.org
http://www.ifpa.org