



THE NEXT FIFTY YEARS OF NUCLEAR PROLIFERATION

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Preface & Acknowledgements

This collection of essays on the future of nuclear weapons proliferation is part of a broader project funded by the John D. and Catherine T. MacArthur Foundation called the Nuclear Boundaries Initiative. The Nuclear Boundaries Initiative has aimed to identify areas of US and international nuclear policy and practice where equities overlap and yet are typically treated as separate, distinct issues. In the case of forecasts regarding nuclear weapons proliferation, analyses tend to focus on the strength of the Nuclear Nonproliferation Treaty, national export control and supplier control regimes and nuclear technology trends. This volume certainly covers those issues, but also speculates on how developments in other key areas – missiles, missile defenses, arms control, and emerging technologies – could affect nuclear weapons proliferation. In the world of US policy implementation, nonproliferation experts typically do not overlap with arms control specialists, and traditional analyses treat the problems and solutions as very different from each other. In countries with fewer resources, such stovepiping would be a luxury and, if we consider a trajectory of fewer and fewer nuclear weapons into the future, such stovepiping will be a detriment to a comprehensive solution to eliminating the risk of nuclear weapons.

This publication would not have been possible without the assistance of many people inside and outside the Elliott School. An advisory board helped develop topics and identify key experts, who in turn were thoughtful, patient, and willing to engage in discussions despite the difficulty of working in the midst of the COVID pandemic. Jennifer Knox, research associate, helped conceptualize and implement this project from start to finish, with equal parts creative genius, patience and humor. Christine Gilbert ably guided us all through the administrative landscape, and Dan Horner provided expert, thoughtful, and timely editing. Final thanks are due to Simone Larson of Simone Larson Design who made this project as beautiful and readable as it deserved.

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JENNIFER KNOX AND SHARON SQUASSONI

Introduction: The Next 50 Years of Nuclear Proliferation

Witnesses to the first detonation of a nuclear weapon in the pre-dawn New Mexico desert in 1945 knew that the world had changed forever but could not have foretold how. They likely would have been surprised by the constancy of nuclear weapons in the succeeding 75 years. To their advocates, nuclear weapons have been a reassuring fixture of international security, sometimes waxing and waning in their centrality. To their detractors, nuclear weapons are an indelible stain on humanity's hands and continue to pose risks no matter how many or in whose hands they are.

The spread of nuclear weapons has been a constant risk since that day, but predicting their spread has never been easy or accurate. In 1963, US Pres-

ident John Kennedy famously warned that as many as twenty-five new states might join the nuclear club within the following decade, a fivefold increase at the time. In a memo earlier that year, the US Defense Department predicted eight proliferators (for a total of twelve nuclear powers), judging that states might be deterred from developing weapons because of cost, lack of military need, legal restrictions, international repercussions, moral pressures, and the hope that nuclear weapons would not spread (US Department of Defense 1963). DoD specifically considered the impact of a test ban agreement on the spread of nuclear weapons.

Today, only nine countries possess nuclear weapons, although several more relinquished covert

programs. One country – South Africa – dismantled a half-dozen nuclear weapons. Most observers agree that the landmark 1968 Nuclear Non-proliferation Treaty (NPT) played the pivotal role in halting the spread of nuclear weapons. At the end of 1970, 57 states had joined the NPT, which today has 191 signatory parties.

The success of the NPT is widely heralded and, in some respects, taken for granted. The treaty itself has weathered a few failures (clandestine nuclear programs in Iraq and Iran; unreported activities in South Korea, Egypt and others) and suffered at least one defection (North Korea). On the other hand, treaty parties successfully navigated the disintegration of the Soviet Union, which could have resulted in three new nuclear states (Ukraine, Belarus and Kazakhstan), the nuclear disarmament of South Africa, and the treaty's indefinite extension in 1995. The International Atomic Energy Agency, which monitors compliance with obligations under the NPT, has improved its capabilities to detect undeclared activities over time. Still, the 2015 Joint Comprehensive Plan of Action for Iran to restrain its nuclear program and build confidence in the peaceful use of nuclear energy in Iran exceeded NPT obligations considerably, illuminating continued gaps in NPT restrictions.

In the fifty years since the NPT entered into force, technology has marched on and politics have changed. Gone is the division of the world into East and West blocs, with non-aligned states in between. Pandemics, terrorism, and the space and cyber realms know no boundaries. The contribution of remote sensing, precision guidance, machine learning and additive manufacturing to nuclear weapons proliferation is not, as yet, well understood.

To be sure, the nuclear nonproliferation regime faces many immediate, pressing challenges, including the accelerating breakdown of bilateral nuclear arms control between the United States and Russia; the fate of states like North Korea, which withdrew from the NPT to pursue a nuclear capability, and Iran, which has threatened to do the same; and the fault-lines of discontent that are intensifying between the nuclear powers and much of the non-nuclear world, represented in the new Treaty on the Prohibition of Nuclear Weapons.

With so many difficult problems in the present, it is not surprising that the nonproliferation field does not often solicit or reward speculation on a long time-scale.

The aim of this collection of essays is to provoke some long-term thinking within the nuclear nonproliferation community about the pressures, challenges, and opportunities in the coming decades as they may affect nuclear proliferation. Institutions, laws, and regulations often lag behind technological progress, and the nonproliferation regime will not be successful if it merely reacts to new technologies and their applications. By anticipating how new developments will change the nonproliferation landscape, we can not only prepare for but also shape what is coming. This kind of work requires the creativity to leap from the known to the unknown and a willingness – even an eagerness – to be proven wrong.

The essays cover traditional nonproliferation topics related to nuclear energy, nuclear weapons, and the role of treaties, but also missiles, missile defenses and space technology. Technological intersections affect not just whether states might pursue nuclear weapons but also how states assess the role that nuclear weapons play in their national security. For example, the development of highly precise conventional munitions, paired with sophisticated targeting guidance, has the potential to shift conventional force balances, altering the risk/benefit calculus of acquiring or using nuclear weapons. Missile proliferation has, arguably, become a much bigger problem. The potential weaponization of space could have far-ranging impact, either providing incentives for states to seek nuclear weapons as an assurance against new threats or making nuclear deterrence less appealing among other forms of deterrence.

Mark Hibbs and Hans Kristensen start off the collection with a survey of nuclear energy and nuclear weapons capabilities. Hibbs considers a future in which Russia and China, not the United States, are the primary parties responsible for the governance of nuclear energy programs and the consequences if the IAEA becomes a battleground for rising and falling powers. Kristensen considers the impact of continued modernization programs on proliferation.

Two essays on the future of the NPT point in different directions. Rebecca Davis Gibbons suggests that reduced cooperation among the United States, Russia and China will weaken the NPT but that the NPT could be amended to integrate non-parties that possess nuclear weapons, such as India. Henry Sokolski speculates on the pressures that the next decade may bring, arguing for the implementation of country-neutral approaches rather than the country-specific approaches of the recent past.

Four essays look at the role of bargains inside and outside the NPT. Corey Hinderstein challenges the conventional wisdom that nuclear cooperation is an entry point for influencing other countries' decisions about nuclear weapons. Jon Wolfsthal explores ways to reduce the demand for nuclear weapons by augmenting US credibility. Will Tobey argues that extended deterrence will continue to play a key role in halting the spread of nuclear weapons. Adam Scheinman explores how to alleviate political tensions within the NPT over the primacy of nonproliferation or disarmament.

On missiles, Melissa Hanham and Xu Tianran describe how the discrimination problem between conventional and nuclear missiles will intensify as missile technologies proliferate to non-state actors, who could launch a missile from within a nuclear-weapons-possessing state (or be blamed for such a launch). Laura Grego argues that, while Russia and China may tailor their nuclear force size and composition according to US missile defenses, there is little evidence to suggest that proliferators like North Korea are dissuaded at all. Robert S. Wilson suggests that space technol-

ogies have long aided detection of proliferation but that the greater transparency of objects on Earth and in space in the future may affect not just proliferators, but states with established nuclear weapons arsenals, particularly those that rely on space for command and control. David Santoro describes the crucial role that cooperation among the United States, Russia and China has had on nuclear proliferation and will have going forward.

Finally, Ankit Panda explores whether destabilizing technologies have the potential to make nuclear weapons less attractive, concluding that future proliferators will find the pursuit of a survivable nuclear force more challenging in the 21st century.

One thing is easy to predict: until nuclear weapons are abandoned as useless and dangerous, some states will continue to desire them. Given that countries are as likely to find the elimination of nuclear weapons just as, if not more, challenging than their development was in the first place, proliferation risks will continue to haunt us well into the mid-21st century. It is time to reexamine everything we know about nuclear weapons and their outsized influence in security affairs if we are to move beyond them to a stable and peaceful future. ■

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MARK HIBBS

Toward an Assessment of Future Proliferation Risk

A key question for nuclear nonproliferation efforts in the coming decades is what the risk associated with peaceful nuclear commerce will be and if this risk will increase from the current level. The history of nuclear power generation since World War II suggests that the answer will depend on the answers to two additional questions: How will nuclear technology evolve and be deployed? And how will governments and their stakeholders assess proliferation risk and then muster the political will and resources to prevent nuclear technology and materials from being used for nonpeaceful purposes?

When the age of the “peaceful atom” was launched in the late 1940s, it was obvious to all

concerned that nuclear electric power would rely on the same science that the US government had used just a few years before to build weapons of mass destruction and unleash their deadly power on the populations of two Japanese cities.

But after postwar leaders vowed to deliver a civilizing nuclear future, it took technologically advanced countries another two decades to fully grasp that wares intended to serve peaceful nuclear applications harbor the potential for doing great harm. Enthusiasts of nuclear power promised a cheap source of energy having virtually limitless potential; many expressed relatively little concern about the risk of severe nuclear accidents and still less about the prospect that technology

or materials might be misused to make nuclear weapons. During the late 1940s, a few individuals, including Bernard Baruch, Dean Acheson, and David Lilienthal, urged that an international authority be set up to control or own all the nuclear materials and technology that would be needed to make atomic bombs.

Their ambitions were not realized, but the creation of the International Atomic Energy Agency (IAEA) in 1958 and the entry into force of the Nuclear Nonproliferation Treaty (NPT) in 1970 were signposts of growing awareness that goods dedicated to peaceful uses could be diverted to make nuclear weapons. In 1974, India detonated a nuclear explosive made using a reactor supplied by Canada and heavy water supplied by the United States under bilateral peaceful-use agreements with India. At about the same time, a scientist serving Pakistan's nuclear program stole uranium enrichment know-how from a peaceful-use project in the Netherlands. Governments of nuclear supplier states, shocked by these events, thereafter more rigorously identified the proliferation risks associated with specific nuclear power generation and fuel cycle technologies. Since then, their assessments have served as the basis for today's decision-making on guidelines and procedures for safeguards, nuclear security, and nuclear export controls.

NUCLEAR POWER TECHNOLOGIES

For at least the next two decades, most types of materials, technologies, and installations used for nuclear power generation, including those for nuclear fuel processing and production, will not be very different from those in use today. Because the acceptance and dissemination of nuclear power technologies have been subject to industrial-commercial considerations and national government licensing requirements based largely on common norms and standards, these technologies have not evolved by leaps and

bounds. As a consequence, knowledge about their risks – including proliferation threats – has increased over time. On balance, the risk portfolios of these technologies have become well understood, certainly compared to a half century ago. Knowledge has also increased as a result of significant proliferation events.

Power Reactors

Power reactors are the technology mainstay of electricity generation based on fission energy. As was the case during the last half century, in coming decades, most power reactors will be based on proven technology and fueled with uranium. More-innovative reactor designs are currently under development, but most of these have far to go before they can be realized.

Light-water reactors. Beginning in the 1950s, several reactor technologies were deployed for power generation, including some initially developed for production of plutonium for nuclear weapons. But over time, the light-water reactor (LWR) design emerged as the most common reactor type for making electricity. Today, and for at least a few decades to come, most of the 500 or so power reactors in operation and under construction will be LWRs, the majority of these pressurized-water reactors.

In NPT non-nuclear-weapon states, all reactors are subject to IAEA safeguards, including power reactors. These are fueled with fissile material, and the plutonium they generate in irradiated (or “spent”) fuel can be used to make nuclear weapons. That said, LWRs have some features generally viewed as positive for nonproliferation: they normally operate using chemically stable uranium dioxide fuel enriched to a low level of enrichment level of about 5 percent uranium-235; they must be shut down to refuel; and the plutonium they generate in irradiated fuel is on balance less attractive for nuclear weapons than plutonium produced by some other reactor types and is more easily extracted.¹

1. There is no question that plutonium produced in light-water reactors, once separated from the irradiated fuel through reprocessing, can be used to make nuclear explosives. The matter was considered extensively during conceptualization of the international project under the direction of the Korean Peninsula Energy Development Organization (KEDO) from 1994 until 2006. Participants concluded that compared to a natural-uranium-fueled, gas-cooled, and graphite-moderated reactor built by North Korea – based on a design used in the United Kingdom for plutonium to be used in nuclear weapons – the two LWRs foreseen under the KEDO project posed less proliferation risk (Abushady 2001).

The IAEA currently safeguards more than 200 LWRs; the rest are in nuclear-armed states. The fuel cycle for these reactors is well understood for purposes of safeguards, and the IAEA's analysis of nuclear weapon acquisition paths includes scenarios and technical indicators for fuel diversion (Harms and Rodriguez 1996, 16-19). To date, the IAEA has never concluded that plutonium has been diverted for the purpose of making a nuclear explosive from a safeguarded reactor dedicated to power generation.

Most power reactors were designed for an anticipated lifetime of 30-40 years; some units operating today may be relicensed to continue operating for 60 years or more. How long they operate will

Were China (or another country) to overcome the very severe economic and technical challenges of establishing a self-sustaining industrial-scale fast-reactor program using plutonium, this feat would be a game changer for nuclear power and a major challenge for efforts to restrain the technology ambitions of non-nuclear-weapon states and the spread of nuclear weapons.

also depend on whether owners and governments conclude that continued operation is justified in light of market constraints and policies on electricity-generating fuels.

Fast-neutron reactors. Several advanced nuclear countries, including all five NPT nuclear weapon states, developed fast-neutron reactors (often known simply as “fast reactors”) decades ago. These countries intended to separate the plutonium from irradiated power reactor fuel and use it as fuel in fast reactors, including to “breed” additional plutonium fuel – that is, to operate these reactors to produce more plutonium than they consume. By 2000, only France, Japan, and Russia had succeeded in operating industrial-scale prototype fast reactors and planned to build more units. Today, Russia is the only country operating a big fast reactor; it may soon be joined by India, which after years of delays is on the threshold

of operating an initial industrial-scale unit. India plans to build additional fast reactors during the 2020s and beyond. Last year Russia halted its next scheduled project for at least a decade, apparently for cost reasons (World Nuclear News 2019). France in 2019 terminated its program for an industrial-scale reactor, and Japan's effort is also indefinitely stalled (De Clercq 2019; Japan Times Editorial Board 2020).

Today China is the only country building a new industrial-scale fast reactor, under a national research and development (R&D) blueprint to eventually replace LWRs with fast reactors after 2050 (Hibbs 2018, 29-32). Were China (or another country) to overcome the very severe economic

and technical challenges of establishing a self-sustaining industrial-scale fast-reactor program using plutonium, this feat would be a game changer for nuclear power and a major challenge for efforts to restrain the technology ambitions of non-nuclear-weapon states and the

spread of nuclear weapons. China has far less experience than France, India, Japan, or Russia with fast-reactor technology, operations, and advanced fuels; it is uncertain if China will commit sufficient resources for the decades needed to succeed in this undertaking.

New reactor types? In coming decades, more reactors will likely appear that are not large-scale nuclear-power-generating units (over 500 megawatts [electric]), are not based on LWR technology, and may serve applications other than electricity. The nuclear industry's interest in small and medium-sized or modular reactors (SMRs) is driven by declining sales for large LWR power plants. Some SMR models are based on LWR technology. Others are concepts or preliminary designs; comparatively little is known about their potential proliferation risks. Some concepts are under development for use as “nuclear batteries” and for innovative fast

reactors that may require reprocessing of irradiated fuel, depending on their mission. One concept for a molten-salt reactor involves breeding of thorium to produce the U-233 fissile isotope that in principle could be used to make nuclear explosives.

Since the 1970s, a few high-temperature gas-cooled reactors (HTRs) have been deployed; at least several more will likely be constructed. Some HTRs were fueled with highly enriched uranium (HEU); most of those that are under development feature pebble-type uranium fuel enriched to up to 20 percent U-235. For these reactors, irradiated fuel would be discharged and likely stored indefinitely, pending final disposal. In principle, the irradiated fuel can be reprocessed to recover fissile material, but HTR programs so far have paid comparatively little attention to a closed fuel cycle (see below) for these reactors.

Many non-LWR-type SMRs would likely require years of development and licensing before they could be deployed. China, for example, has invested heavily in molten-salt reactor technology but does not anticipate that a reactor will generate electricity before 2040. In the meantime, the IAEA is conferring with member states, and their R&D and industry firms, to encourage them to design safeguards systems for the fuel cycles for

For 75 years the most significant proliferation challenges related to nuclear power followed from two activities: efforts to “close” the nuclear fuel cycle by recycling plutonium recovered at reprocessing plants from irradiated power reactor fuel, and enrichment of the U-235 isotope to make reactor fuel.

novel technologies in advance of project licensing and construction. Some reactor concepts call for longer duty cycles or lifetime fuel loads, which may reduce proliferation risk by limiting refueling operations and by increasing the “burn-up” level of the fuel, rendering it marginally less attractive for nuclear weapons. Unique proliferation risks may arise for some reactors whose deployments are not stationary.

Fuel Cycle Technologies

For 75 years the most significant proliferation challenges related to nuclear power followed from two activities: efforts to “close” the nuclear fuel cycle by recycling plutonium recovered at reprocessing plants from irradiated power reactor fuel, and enrichment of the U-235 isotope to make reactor fuel. The threat posed by reprocessing and plutonium use is that the plutonium could be diverted to make a nuclear weapon. The threat associated with uranium enrichment is that the technology can be used to clandestinely enrich U-235 for a nuclear weapon.

Reprocessing and plutonium recycling. From its inception, the nuclear power industry projected that conventional uranium-fueled reactors would be replaced by fast reactors that would breed their future plutonium fuel supplies. When fast-reactor prospects diminished, the industry focused more on recycle in LWRs of plutonium recovered from irradiated LWR fuel. For civilian nuclear power programs, plutonium is used in the form of so-called mixed-oxide (MOX) fuel, a mixture of UO_2 and PuO_2 fuels.

Today only France and Russia reprocess nuclear fuel on an industrial scale. Without a business case supporting the comparatively expensive

recycling of nuclear fuel or continued significant French and Russian investment, the reprocessing industry will stagnate and may collapse. France’s industry was supported in the past by lucrative foreign contracts, but in recent

years its La Hague reprocessing complex has mostly reprocessed spent fuel from French LWRs (De Clercq 2015). Russian reprocessing is limited almost entirely to Russian reactor fuel.

In 2019, the uncertain future of this industry was underlined when the United Kingdom closed its Thermal Oxide Reprocessing Plant because clients had shifted their spent-fuel management

policy from reprocessing and recycle to long-term spent-fuel storage (World Nuclear News 2018). France must likewise decide whether a planned investment in an expensive refurbishment at La Hague is justified. If not, France may abandon its commitment to the closed fuel cycle, and in the long term, all of the country's electricity might be based on existing reactors and renewable sources supported by batteries.² Russia, facing similar investment challenges, has decided to extend the lifetime of its reprocessing industry and will up-

Uranium enrichment technology deployed for peaceful use has been repeatedly misused with intent to make nuclear weapons.

grade its RT-1 complex for operation until decommissioning in 2030 while building up a second reprocessing complex in Siberia. In tandem with Russia's decision to delay further fast-reactor development, the timetable for extending operation at nominal reprocessing capacity may be delayed for about a decade, according to some Russian sources; Russia has declared that the Siberian plant will begin operating in 2025.³

Plans elsewhere for industrial-scale reprocessing are uncertain. After 15 years, a project for a foreseen Franco-Chinese reprocessing plant in China has not been finalized.⁴ Japan's efforts since the 1980s to build and operate a La Hague-scale complex have been dogged by politics, technical problems, cost overruns, and finally a severe nuclear accident at the Fukushima-Daiichi nuclear power plant that raised fundamental questions about Japan's nuclear future; Japan nonetheless continues with the commissioning of the reprocessing plant (Kotsubo, Kuwabara, Ito, and Hayashi 2020). The United States under President Donald Trump in 2020 has expressed interest in foreign reprocessing of irradiated US power reactor fuel,

in a departure from long-standing US government policy and regardless of the apparent lack of interest by the US power industry. Beginning in the 1950s, India has operated several limited reprocessing installations, including to support its fast-reactor program; so far India has not attempted industrial-scale plutonium separation.

Current demand for plutonium fuel is very modest; fewer than 10 percent of the world's reactors are licensed to burn MOX fuel. Through 2030, at least some recycle may be driven by requirements to reduce inventories of separated plutonium stored in the United Kingdom and France. Like France at La Hague, Russia at RT-1 has accumulated a

huge inventory of separated plutonium during a half century of reprocessing. Russia has earmarked this plutonium for use in fast reactors, and some may be used at the BN-800 unit beginning in 2021. Historically, Russia's fast reactors have used mostly uranium fuel, in part out of consideration for the comparatively greater complexities of operating fast reactors using plutonium. Russia has long declined to recycle plutonium in LWRs, but with its plutonium stockpile continuing to expand, the policy may change. Should Russia succeed in routinely using large amounts of plutonium fuel in the BN-800, its biggest and most advanced fast reactor, it would move a step closer toward establishing a closed industrial nuclear fuel cycle. As with industrial reprocessing, industrial-scale fabrication of MOX fuel currently is limited to France and Russia, pending developments in China and Japan. A recent project to establish a US MOX industry failed, the outcome of partisan politics, ineffective oversight, and cost overruns (Holt and Nikitin 2017).

Uranium enrichment. Uranium enrichment technology deployed for peaceful use has been repeatedly misused with intent to make nucle-

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2. French commitment to a closed nuclear fuel cycle, according to a French government nuclear official, will be subject to ongoing development of alternative power generation and storage technologies (Hibbs 2018, 108).
 3. The International Panel on Fissile Materials currently estimates the throughput of the site as 250 metric tons heavy metal (MTHM)/year (IPFM 2020); according to an industry report, the plant will be finished in 2025 with throughput given as 700 MTHM/year (World Nuclear Association 2020).
 4. China and France have routinely said that ongoing negotiations are the reason for the delay in this project. According to European officials in 2010, French government ministries raised national security concerns that led France to condition the sale of the reprocessing plant to China upon steps taken by China to assure that the plant and its technology will not be used for nonpeaceful purposes (Hibbs 2018, 38-39, 119 [note 103]).

ar weapons. Between 1970 and 2000, several countries acquired gas centrifuge enrichment technology stolen from Europe. Iran, Iraq, Libya, North Korea, and Pakistan are confirmed to have obtained this purloined know-how; according to unconfirmed information, more states may currently have it. This stolen know-how has been replicated, including using digital electronic means, and it remains at large. In the future, it could be used by proliferators to make nuclear weapons. National governments and industry responded to these events by strengthening controls and security concerning equipment, technology, and materials for enriching uranium. Since 1997, countries whose IAEA safeguards agreements include an Additional Protocol are obligated to declare more fuel-cycle-related activities, including those connected with uranium enrichment.

Argentina, Brazil, China, France, Germany, India, Iran, Israel, Japan, the Netherlands, North Korea, Pakistan, Russia, the United Kingdom, and the United States host uranium enrichment plants. Some are dedicated to military use and some enrich uranium only for peaceful uses; all of the peaceful-use plants in states without nuclear

Since the 1980s, as the costs and risks of nuclear power projects have increased, the nuclear industry has undergone uninterrupted global supplier consolidation.

arms are under multilateral safeguards. Enrichment capacity dedicated to peaceful uses has exceeded demand for many years and may continue to do so for some time to come, partly as a consequence of the Fukushima-Daiichi accident in Japan. Several enrichment technologies have been used, beginning during World War II, but in recent decades, less efficient gaseous diffusion technology has been supplanted by gas centrifuge technology. The centrifuge will likely continue to serve as the leading industrial-scale uranium enrichment technology.

For half a century, the uranium enrichment industry has experimented with alternative technologies, especially laser excitation, but nearly all these

efforts were abandoned on economic grounds. During the last decade, investors in Australia, Canada, Japan, and the United States developed a molecular laser enrichment technology that has been licensed in the United States for operation of a test loop (APS News 2010). If this project inspires greater interest, a proliferator might attempt to use lasers to produce U-235 for nuclear weapons.

THE NUCLEAR POWER MARKET

Within three decades after World War II, firms in advanced nuclear countries were selling their goods to established domestic markets for nuclear power and also exporting power plants, research installations, fuel processing plants, and nuclear fuel to more than 100 countries. Much commerce in radioactive and nuclear materials, nuclear technology, and nuclear equipment was for non-power applications and research; however, nuclear power proved its value in a number of advanced countries and by 1980 was expanding to new markets in South America, Africa, and Asia. But before the end of the century, governments

and the IAEA were increasingly concerned about the levels of safety and security at 200 uranium-fueled research reactors worldwide, of which scores were idled or underused and

some woefully maintained. Severe accidents and the impact of the introduction of market forces in power markets revealed the risks and raised the costs of nuclear power projects; potential “nuclear newcomers,” including rapidly growing developing countries, considered these risks in weighing their options for power generation. During the 1990s, the nuclear power industry began predicting a nuclear power “renaissance.” This had not yet transpired when in 2011, Asia’s richest, most technologically advanced, and most nuclear-experienced country failed to prevent three LWRs at the Fukushima-Daiichi site from melting down within 72 hours in a severe nuclear accident that was ultimately caused by human error (Acton and Hibbs 2012a; Acton and Hibbs 2012b).

Since the 1980s, as the costs and risks of nuclear power projects have increased, the nuclear industry has undergone uninterrupted global supplier consolidation. Forty years ago, there were about two dozen vendor companies in advanced nuclear countries building nuclear power plants; today about one-third that number are active worldwide. When governments in the 1980s began deregulating their electric power sectors, market share for new fossil-fuel power plants increased. Ever-fewer

In 2005, China launched a crash construction program to catch up with advanced countries; today it is operating more than 50 nuclear power plants.

nuclear power plants were ordered, and vendors lost expertise, contributing to significant cost overruns for the handful of ongoing plant construction projects in Europe and the United States during the last decade.

In recent years, a few new suppliers have emerged, notably in South Korea. But most of the world's construction of new nuclear power plants in this century has been undertaken by companies in China – a development that underlines both the aspirations and the problems that will challenge the global industry during the 2020s and perhaps beyond. In 2005, China launched a crash construction program to catch up with advanced countries; today it is operating more than 50 nuclear power plants. But as was the case in the advanced nuclear countries whose reactor deployment China has replicated, it is not apparent that China's rapid nuclear expansion will be indefinitely sustainable. There are a number of reasons for this: Beijing planners, aiming to control and reduce the cost of electricity, are pressing for power market reforms that in the United States and Europe previously precipitated a crisis in the nuclear power industry. China's nuclear vendor firms have reached, and in some cases exceeded, the liability limit imposed by their government financial shareholder; this implies that China's rising debt load, on top of slower power demand growth, may discourage new nuclear investments by these firms, especially if rising production costs and regulation render new

nuclear investment comparatively less lucrative and if China's powerful fossil-fuel industry resists pressure to downsize. Finally, since Fukushima, nuclear plant construction on inland sites has been a Chinese political redline. It is not clear whether China's decade-long race for nuclear capacity portends a second wind for nuclear power beginning sometime in the 2020s or instead will be followed by the saturation and crisis that other countries have experienced, albeit not until the 2030s with perhaps more than 100 power reactors on line.

The continued depression in demand for nuclear power plants also reflects rising expectations that renewable sources – chiefly

wind, solar, and hydropower – will supply more and more power to meet future demand growth. According to some projections, global power generation may nearly double by 2050, and nearly all of the increase will be produced by renewables (US EIA 2019). Some forecasters also predict that in places where nuclear power is well established – for example, in Europe, Russia, China, and South Korea – by 2050, the nuclear share of total power generation will remain at or near current levels (IAEA 2018). A key question is whether countries with long-standing nuclear programs will build new nuclear power plants to replace aging and less competitive capacity. If not, nuclear power output in the United States, France, and Japan – in recent decades the world's leading nuclear-power-producing states – may decline through about 2030, putting vendor firms in these countries under still greater pressure to find foreign markets.

In this situation, the US nuclear industry is pressing the federal government to provide it financial assistance to compete with state-owned enterprises (SOEs) in China and Russia that benefit from government aid in securing contracts, subsidized financing, and price supports for nuclear power (Marshall and Dillon 2020). The leading US vendor, Westinghouse, was awarded its most recent nuclear power plant contract in 2007 (Schepers 2019, 3). By comparison, Russian vendor Rosatom in 2017 claimed to have foreign order books worth \$133 billion, lifted by sales contracts for

36 nuclear power plants in 12 countries including Armenia, Bangladesh, Belarus, China, Egypt, India, Turkey, and Uzbekistan (Schepers 2019, 4). Chinese industry, which until now has exported nuclear power plants only to Pakistan, aims in the coming years to build more than 20 nuclear plants for export, including through China's Belt and Road Initiative. These exports are to be bolstered by an active supply chain China has been setting up and expanding since the early 2000s (Hibbs 2018, 90-92).

The future of Chinese exports – not only in the nuclear sector – will depend in part on the goodwill of foreign governments and in part on the capacity utilization of Chinese industry. Beginning with agreements forged between Chinese SOEs and partners in the United Kingdom, China in the 2020s aims to sell its nuclear power plants in established, advanced-country nuclear markets. That may not be likely if great-power competition between China and the West increases, fed by allegations of Chinese cyberattacks and industrial espionage, including against foreign nuclear power companies and other “strategic” targets (US DoJ 2014). In 2018, the US government announced that, because of China's pursuit of “military-civil fusion” in its foreign nuclear trade, the United States will, with few exceptions, deny bilateral nuclear commerce (US DoE 2018). If China is increasingly perceived to be an aggres-

sive adversary and US policy has a signal effect, Chinese nuclear power plant exports, and bilateral industrial and R&D cooperation with Chinese organizations, will be judged around the world as net security risks. Independent of China's foreign relations, China's drive for nuclear exports will also be affected by capacity utilization of China's nuclear industry. This was built up during the last 20 years on the foundation of ambitious expectations for as many as 500 reactors installed by 2050. Should instead China demand less nuclear

power, its firms will be under pressure to export to take up the slack.

Unlike Chinese firms, Rosatom currently has contracts for foreign nuclear construction projects that may occupy it beyond 2030. But at least some of these may not prove sustainable, as they follow from “framework” cooperation agreements sought by Moscow with developing countries. Rosatom has long had a dual identity. On the one hand, the firm profits from routine market-driven business for domestic new power plants plus fuel and services for operating plants worldwide; on the other hand, it is the implementer of the Kremlin's “strategic” trade agreements that without sovereign guarantees would be fraught with project risk. Following from one such arrangement, Russia is assuming most of the risk to build, operate, and own nuclear power plants in Turkey. Rosatom's contracts to supply nuclear power plants to Bangladesh and Egypt rest upon massive Moscow-backed credits. It may be speculated that the Kremlin's political power structure discourages information flow from corporate management that would inform President Vladimir Putin of the project risk attached to “strategic” foreign trade deals he is making (Stanovaya 2020).

Elsewhere, firms in the nuclear power industry face similar challenges in their important markets. South Korea's nuclear export industry expanded on the

basis of serial domestic power plant construction, but the growth in South Korea's demand for power is slowing, raising pressure to export. For decades, the centerpiece of In-

dia's nuclear industry was technology copied from its pre-1974 cooperation with Canada. Beginning in the mid-2000s, the United States aimed to end India's isolation from the world's nuclear power business following India's 1974 and 1998 nuclear tests, but so far nuclear power industry cooperation between India and most foreign partners is bedeviled by liability considerations.

The ongoing drought in new business for builders of nuclear power plants has raised the specter of

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technological obsolescence. For over a decade, France has tried with little success to sell and build its EPR nuclear power plant. When the United Arab Emirates instead selected Korean firms, senior French officials claimed that the EPR – a hybrid Franco-German model from the 1990s – was myopically designed for European safety concerns and too big for modest power grids (NS Energy 2010). Similar thinking with regard to size may be advancing in the United States, where, in the absence of orders for big LWRs, the industry is embracing SMRs.

OUTLOOK

The nuclear power industry is mostly conservatively biased in favor of established technologies for which the proliferation risk is well understood; this knowledge serves as the basis for the deterrence of nonpeaceful uses. Risks associated with nuclear fuel cycle technology are more acute than with technology for power reactors. Great concern will remain focused on uranium enrichment, know-how for which has been stolen and may be further proliferated through clandestine transactions. Threats from reprocessing arise in part because chemical separation technology for many decades has been openly accessible. Proliferation risk will be greater if demand for nuclear power increases and the industrial fuel cycle is closed. Risk may also increase should the global nuclear industry shrink further and discharged personnel with sensitive know-how seek employment by proliferators. Effective management of proliferation threats will require a continuity of international governance; this will rest upon states' nuclear restraint and their support for effective IAEA verification.

Technology and Materials

Because nuclear power technology has evolved very slowly since the middle of the last century, the inherent risks from technologies and materials used for nuclear power generation and the nuclear fuel cycle in coming decades will likely not be very different from those encountered so far. (Some critics believe that the industry's failure to dramatically innovate means that nuclear power will become obsolescent during this century.) Most of the operating reactors in the world

in 2035 will probably be LWRs, even if some of those are SMRs. A small number of reactors fueled with natural (unenriched) uranium will continue to operate in a few locations. So long as the NPT remains a virtually universal treaty, all reactors in non-nuclear-weapon states will be under multilateral safeguards. Modern nuclear power plants are highly complex, expensive engineering projects that must meet international standards for quality and safety involving IAEA and global industry peer reviews. Innovations in manufacturing, materials, construction, and information management will not likely significantly alter their risk profiles, provided that government safety and security oversight keeps abreast of developments.

Since the 1980s, governments and the IAEA have become increasingly sensitized to the proliferation risks of reactor designs and fuel cycles. The more that agencies responsible for oversight, licensing, and nuclear material accounting and control are involved in the design of new reactors, the lower the concomitant risk will be. If vendors do not cooperate with the IAEA on "safeguards by design," proliferation risk associated with innovative technology may be greater. Because the SMRs most likely to be built soonest will probably be LWRs, they will pose few unfamiliar technology-based proliferation challenges. For others, including nuclear batteries, innovative fast reactors, and molten-salt reactors, the risk will depend on their "safeguardability" and whether their fuel cycles require reprocessing and direct-use fissile materials.

The proliferation risk associated with the operation of peaceful-use reactors should recede in part because fewer units will be operated using HEU fuel. Also, some national research programs and fuel processing and storage activities have been consolidated; some reactors have been converted to use low-enriched uranium fuel; and some HEU inventories have been repatriated to the United States and Russia, which in the past supplied HEU to their nuclear cooperation partners without great concern.

Reducing the amount of plutonium circulating in the fuel cycles of power reactors should also decrease proliferation risks. The benefit could be significant if, following the 2018 example of

the United Kingdom, the civilian reprocessing industry continues to wind down and if electricity producers are discouraged by the comparatively high cost of using plutonium in their reactors. Forthcoming French decisions may be critical, as France's reprocessing sector and fast-reactor program are in a deep crisis that might lead Paris to abandon them in the coming years.

On the other side of the ledger are developments in China, India, Japan, Russia, and South Korea. Independent of plans to accelerate domestic reprocessing, Japan is storing in Europe 45 metric tons of plutonium separated from its irradiated LWR fuel. If this material reenters the civilian nuclear fuel cycle, short-term proliferation risk will increase; perhaps the very long-term risk would be marginally reduced because less separated plutonium would be stored. Russia and China are intensifying a bilateral partnership for the development and deployment of technology to close the nuclear power fuel cycle. Russia has announced progress in

The IAEA is concerned about the prospect that so-called 3D printing or additive manufacturing techniques, and the underground internet, or darknet, may contribute to proliferators' efforts to defeat nuclear trade controls.

the development of advanced fuels using products from reprocessing and plans to market these fuels.⁵ Regardless of long delays following in part from decades-long diplomatic isolation, India continues to aspire to a nuclear energy future centered upon industrial use of plutonium fuel. On balance, in view of costs and technical challenges, there is little reason to expect that China, India, or Russia will create a self-sustaining nuclear power industry centered upon plutonium-fueled fast reactors before 2050. But if any of them does, the proliferation risk from nuclear power may rise considerably, in part because other states will be encouraged to engage in sensitive nuclear activities. South Korea has been

developing technology for a high-temperature electrochemical process called pyroprocessing to use on its irradiated LWR fuel. Some metallurgical know-how for this technology might be applicable in a nuclear weapon development program. Deployment of pyroprocessing so far has been inhibited by the realities of Seoul's bilateral nuclear energy and security cooperation with the United States, in which regional political and proliferation concerns play an important role.

Several hundred power reactors worldwide will continue to require enriched uranium fuel. Advanced nuclear states have in the past permitted gas centrifuge technology to be diverted from their peaceful-use nuclear programs to black market networks that have served proliferating states; governments and the IAEA therefore have few defenses today against the continued clandestine spread and use of centrifuge know-how that the proliferators have acquired in this way. The IAEA is concerned about the prospect

that so-called 3D printing or additive manufacturing techniques, and the underground internet, or darknet, may contribute to proliferators' efforts to defeat nuclear trade controls.

Should laser enrichment research resume, inspired by current (so far limited) commercial interest, the proliferation risk associated with uranium enrichment may increase.

In a singular exception among countries that export nuclear equipment, Russia has agreed in principle to take back spent fuel from power reactors it supplies to foreign clients, continuing a nonproliferation policy from the Soviet period. Should global competition among nuclear power plant vendors intensify, other supplier states might follow Russia's example. If so, pressure on countries operating nuclear power plants to reprocess

5. In the future, Russia may offer its foreign clients nuclear fuel made from uranium and plutonium that is recovered from reprocessing and that it claims is less weapon-usable than plutonium in MOX. In any case, this fuel may prove more expensive to produce than conventional LWR fuels (Federov, Dyachenko, Balagurov and Artisyuk 2015).

ever-growing stockpiles of civilian irradiated fuel and recycle the plutonium may be reduced.

Governance and Nuclear Power Demand

Sixty years ago it was frequently assumed that within a few years, the number of nuclear-armed states might rapidly increase, as John F. Kennedy had said during the 1960 US presidential debates, from four countries to 20 (Anderson 1997; CEIP 2003). By the beginning of the 1970s, all atom-

If Chinese and Russian firms eclipse US and other Western competitors in the world's nuclear power market, Beijing and Moscow will demand, and expect to obtain, primacy in nuclear energy governance that Washington and its allies have long enjoyed, especially during critical formative years.

ic-armed states but China were generating nuclear power, and numerous countries that were targets of speculation regarding suspected nonpeaceful nuclear intentions had already launched nuclear power programs: Argentina, Brazil, West Germany, India, Italy, Japan, South Korea, Pakistan, South Africa, Sweden, Switzerland, and Taiwan. While the roll of nuclear-power-generating states has expanded since 1970 from 13 to 35, the number of nuclear-weapon-possessor states has risen from five to nine. Horizontal proliferation was limited in part because other states, citing the rules and principles of international nuclear governance, intervened.

Beginning in the 1950s, budding nuclear supplier states agreed to establish a system of multilateral governance for the peaceful use of nuclear energy. This had many rationales, but in the shadow of an ideological Cold War joined between East and West, many governments – not least the United States and the Soviet Union – were mindful that geostrategic competition might ensue over the dissemination of nuclear materials and technology. The NPT became the centerpiece of nonproliferation governance; it provided supplier states a reference point for conditioning exports, especially of sensitive fuel cycle items. As

the nuclear power industry expanded, membership in the Nuclear Suppliers Group (NSG), the world's leading nuclear trade regulator, increased from seven to 48, assuring that nearly all foreign nuclear commerce involving states without atomic arms would be subject to rules set by the NPT and the NSG to limit risk. Between the 1970s and 2000s, a raft of significant horizontal proliferation events, involving lax nuclear trade controls and undeclared, clandestine activities to defeat safe-

guards, led governments and the IAEA to raise the bar. In 1997, they created an Additional Protocol for safeguards, giving the IAEA greater authority in participating states to pursue information indicating that states may be engaged in clandestine activities. Since

then, most states subject to IAEA safeguards have agreed to accept the Additional Protocol as an obligation.

During the 2020s, the fabric of existing collective multilateral understandings about preventing proliferation may come under pressure. Today, the US nuclear industry and the US government claim that state capitalism in China and Russia threatens US leadership in nuclear power. If Chinese and Russian firms eclipse US and other Western competitors in the world's nuclear power market, Beijing and Moscow will demand, and expect to obtain, primacy in nuclear energy governance that Washington and its allies have long enjoyed, especially during critical formative years. The impact of such a shift could be significant. Russia has increasingly accused the West of imposing a "rules-based order" on other countries – shorthand for principles of conduct that serve Western interests (Lavrov 2019). China, which generated no nuclear power until the mid-1990s, "may conclude that it wants to change the rules, because when the rules were made China wasn't sitting at the table," as one Western official put it at a 2011 meeting for governments that participate in the NSG.

China and Russia, perhaps in alliance with other states, may increasingly challenge Western leadership at the IAEA and in other multilateral nuclear forums. Since the 2010s, both countries have objected to Western-favored resolutions concerning IAEA nuclear verification (Hibbs 2020). Big-power competition has also invaded NSG decision-making on the question of including India (Hibbs 2017). Some participants in the NSG and in the Convention on Nuclear Safety, an IAEA-based treaty, privately express great concern about a future “race to the bottom” over nuclear governance standards if states aggressively support selected “champion” vendor companies. Should the United States continue to lose influence in the greater Middle East or disengage from that area, Russia or China (or both) might emerge as a brokering power in nonproliferation in a region fraught with nuclear tensions involving Iran, Israel, and Saudi Arabia.

If the center of gravity in the global nuclear industry shifts toward China and Russia, that does not categorically imply that proliferation risks will be greater because the West will have comparatively less to say. Neither Russia nor China can be interested in a world with more nuclear-armed states. If the multipolar strategic competition between Western states on the one hand and Russia and China on the other is successfully managed in the coming decades, Beijing and Moscow might raise their nonproliferation profiles as their stake in the international system increases, thereby contributing to continuity in multilateral governance.

But in a more aggressive international environment, a shift in global nuclear governance power away from the Western states that for years have frequently taken the initiative on setting the rules might contribute to an erosion of states’ participation in, or tolerance of, nonproliferation understandings. That could happen if Western states and rising powers fall out over how a more ambitious IAEA conducts verification, and if rising powers see multilateral nuclear governance as a theater to try to reduce Western influence, perhaps with the support of the majority of countries that have little stake in the nonproliferation regime. If this happens, global support for IAEA efforts to deter undeclared activities may decline, Western states’ embrace of nonproliferation may be judged by others as an expression of self-interest, big powers may intervene in the UN Security Council to shield their allies from accountability, and more opportunistic or strategic nuclear commerce outside of NSG rules may be tolerated. Without a shared view that the nonproliferation regime must be strengthened and adjusted to meet evolving threat scenarios, a static and defensive approach to states’ nonproliferation obligations, framed by governments’ assertions of their “nuclear rights,” may gain ground. A looming question is whether Iran’s 20-year challenge to the nonproliferation regime will prove an isolated case or instead will encourage other NPT parties to conclude that they have greater leeway to hedge, and potentially a great deal to gain, by engaging in sensitive nuclear activities. ■

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HANS M. KRISTENSEN

Nuclear Weapons Modernization And Nuclear Proliferation Triggers

Concern about proliferation of nuclear weapons most often focuses on the spread of nuclear weapons to new countries, but vertical proliferation – when existing nuclear-armed states modernize, add to, or increase their nuclear arsenals – should not be ignored for its impact on nuclear stability and nuclear risks. Triggers for nuclear proliferation vary depending on the country, region, and international security climate. The triggers may include direct nuclear or general military threats, modernization programs, fielding of new or significantly enhanced weapons, offensive military operations, adjustment of strategy and doctrine, and political rhetoric. Any one of these, or a combination of them, may cause a non-nuclear country to decide to pursue nuclear

weapons or convince a nuclear-armed state it needs to enhance or increase its nuclear arsenal.

Countries tend to react more to proliferation triggers during periods of deteriorating and tense international relations. The world is in such a period now where direct nuclear and general military threats are increasing and many countries are responding in kind. The US demonstration of overwhelming offensive conventional military capabilities in two Gulf Wars, as well as the decision to withdraw from the Anti-Ballistic Missile Treaty (ABM) to field a global ballistic missile defenses, triggered or significantly increased nuclear and general military modernization programs and strategies in Russia and China. Similarly, Russia's

invasion of Ukraine and its nuclear modernization triggered a significant adjustment and strengthening of NATO's posture and its strategy that includes a reaffirmation and invigoration of the role and importance of nuclear weapons in US and NATO strategy. And China's widespread military modernization - including a significant enhancement of its nuclear forces - has triggered adjustments to the US military posture, including the role and requirement for nuclear forces in the region.

These current adjustments and modernization programs seek to strengthen deterrence in response to adversarial military developments that in turn responded to earlier enhancements. Domestic institutional interests and competition also play an important role, but they tend to feed off the same external threat. This cycle of action and reaction is dangerous if it is not managed carefully as part of a broader grand strategy that seeks to steer relations in a positive direction that reduces tension and competition. Too much deterrence is dangerous and counterproductive - even destabilizing - because large military powers are unlikely to back down but instead develop countermeasures to safeguard their

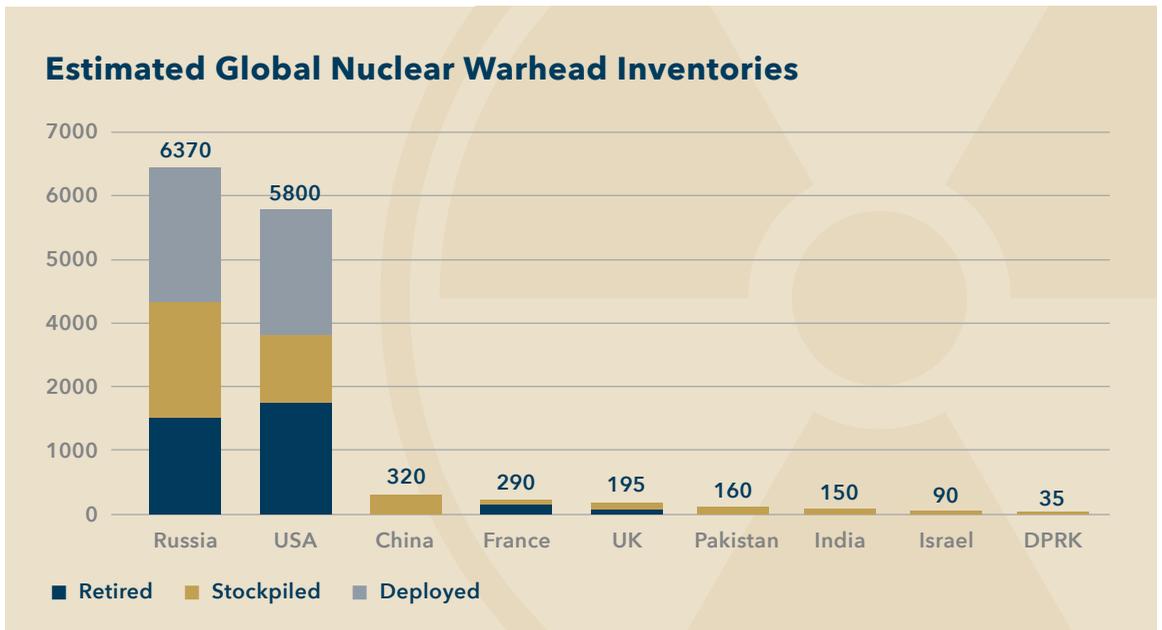
national security interests. That, in turn, drives arguments for "strengthening deterrence" even further, potentially triggering vertical proliferation and even an arms race.

Arms control treaties have played a key role in the past to halt the action-reaction cycle of weapons proliferation and thereby reduce the dangers of escalation. Several important agreements have been abandoned recently as the nuclear and military competition has grown and the appetite for arms control amid divisive rhetoric has weakened.

STATUS OF WORLD NUCLEAR FORCES

Although horizontal nuclear proliferation has been less than what was feared in the 1960s, it has nonetheless been significant. Nine countries (China, France, India, Israel, North Korea, Pakistan, Russia, and the United Kingdom) developed nuclear weapons after the first were fielded and used by the United States in 1945. Many other countries (including Iran, Iraq, Libya, Taiwan, South Korea, and Sweden) began nuclear weap-

Figure 1: Estimated Global Nuclear Warhead Inventories, 2020



Source: Kristensen and Korda 2020a

ons research development programs but abandoned them for various reasons. One country (South Africa) eliminated its nuclear weapons, and three countries (Belarus, Kazakhstan, and Ukraine) surrendered nuclear weapons left on their territories after the breakup of the Soviet Union and returned the weapons to Russia.

Today nine countries maintain nuclear weapons arsenals and combined possess an estimated 13,410 nuclear warheads (Kristensen and Korda 2020a). The vast majority of those weapons are owned by Russia and the United States, who each possess around 6,000 nuclear warheads (see Figure 1). These two arsenals are abnormally large; no other nuclear-armed state believes it needs more than a few hundred nuclear weapons to deter major conventional or nuclear attack.

After three decades of declining warhead inventories, reductions have been slowing for the past several years. The total inventory is still declining mainly due to dismantlement of a backlog of US and Russian retired nuclear warheads. But active arsenals are not decreasing anymore, and several countries are even increasing their arsenals: China, India, North Korea, and Pakistan. The United States is also accusing Russia of increasing its active arsenal after decades of reductions. France and Israel appear to have relatively stable arsenals, while the United States and Britain are reducing their total warhead inventories.

All the nuclear-armed states are modernizing their arsenals and adjusting their nuclear capabilities. Nuclear modernization cycles do not necessarily overlap between countries but depend on when they fielded their weapon systems and how long they last. Moreover, different countries don't necessarily maintain their nuclear forces in the same way; some prefer fielding entirely new weapons while others focus on maintaining and upgrading existing types. The public claims that "we're behind" other countries' nuclear modernizations can sometimes, therefore, be misleading.

When relations deteriorate and military competition intensifies, as is happening now, nuclear modernization programs may take on added importance and purpose and be used to signal resolve and add enhanced military capabilities - even new

or greater numbers of weapons - to "strengthen deterrence." The main outlines of the current US modernization program were drawn shortly before the current crises, but the Trump administration significantly increased funding, added new weapons, and embraced a more competitive and adversarial strategy coined "Great Power Competition" (US White House 2017, 27; US DoD 2018a, 6-7). Russia also adjusted its national strategy in response to NATO expansion and China has initiated a massive military modernization and strategy upgrade in response to what it sees as threats to its national security and in an effort to increase China's status in the world. Once political and military objectives have been articulated as the national security framework, all military services and agencies start to interpret and implement it into requirements and justifications for modernization programs, military operations, strategy and doctrine, and political rhetoric.

TECHNICAL EFFECTS OF NUCLEAR MODERNIZATION

Modernization of nuclear forces, strategies, and the policies that guide their potential use have always had a significant effect on the proliferation of nuclear weapons. That is a core dynamic of deterrence and nuclear arms competition. Once countries acquire nuclear weapons, they also acquire a never-ending requirement to demonstrate and improve the credibility of their capabilities to their potential nuclear adversaries. Nuclear-armed states react directly - and sometimes strongly - to a potential adversary's modernization of its nuclear posture that introduces enhanced new weapons, significantly improves military capabilities of existing forces, and modifies strategies and policies in ways that are seen as being more offensive or effective. The reaction may take the form of nuclear modernization programs, more and/or new nuclear weapons, changes to operations and exercises, articulation of national strategy and declaratory policy, and public rhetoric, or a combination of those.

Non-nuclear states also monitor nuclear modernizations to be assured they're protected against aggression by a "nuclear umbrella" or to consider

whether their region is getting so dangerous that they have to develop nuclear weapons to protect themselves. If allowed to proliferate, that dynamic can have serious and long-lasting consequences for national and international security. Within just two decades after the US bombed Japan with nuclear weapons, one nuclear-armed state with a few nuclear bombs had proliferated into five nuclear-armed states with more than 38,000 nuclear weapons in an out-of-control global nuclear arms race. By the mid-1980s, there were more than 70,000 nuclear weapons. Defense officials and military strategists insisted that nuclear weapons were intended to safeguard security, but instead, they became the most dramatic public symbol of danger.

Sea-Based Nuclear Weapons

Sea-based nuclear weapons are widely considered a source of stability if they are deployed on strategic submarines that cannot be destroyed in a surprise attack. As such, no aggressor would be able to conduct a surprise nuclear first strike without facing a devastating retaliatory attack. That is the core of nuclear deterrence and, by extension, strategic stability.

But sea-based nuclear weapons can also be a source of instability if they are so capable that they can be used in a first strike to destroy a sizeable portion of a country's nuclear forces and other strategic assets. The development of sea-based nuclear weapons in the mid-1950s enabled nuclear-armed states to continuously deploy nuclear weapons close to the territories of potential adversaries without being detected and to threaten destruction of important facilities with very short notice from stealthy submarines. During the Cold War, for example, the patrols by Russian nuclear-powered ballistic missile submarines (SSBNs) off the eastern and western

coasts of the United States was not seen a stabilizing development, but a grave threat of quick strikes on the US homeland. Likewise, the launch of highly accurate Trident II submarine-launched ballistic missiles (SLBMs) from US forward-operating SSBNs is seen by Russia and China as a significant threat to their retaliatory capabilities. A Trident II launched on a compressed trajectory could reach its target in less than 15 minutes, significantly faster than the 30 minutes required for a land-based intercontinental ballistic missile (ICBM) to reach its target. According to the US Central Intelligence Agency, China began its development of road-mobile solid-fuel ICBMs in the mid-1980s when it "became concerned about the survivability of its silos when the US deployed the Trident II-D5 because you could hit those silos" (Walpole 2002).

Over the years, the number of countries operating or developing nuclear-armed submarines has proliferated from one to nine. Four of these have been added since the end of the Cold War. Today's naval arsenals constitute approximately 30% of global stockpiles, up from 24% at end of the Cold War (see Table 1).

During the Cold War, many sea-based weapons were tactical nuclear weapons intended to sink

Table 1: Estimated Naval Nuclear Weapons, 1990 and 2019

COUNTRY	1990	2019
United States	7,524	1,920
Soviet/Russia	6,410	1,540 ^a
France	440	250
Britain	125	200
China	12 ^b	48 ^b
India	0	12
Pakistan	0	0 ^c
Israel	0	(5-10) ^d
North Korea	0	0
Total	14,511	3,980

Sources: Estimates based on Nuclear Notebooks, SIPRI Yearbooks, and author's estimates. ^a Russia's 1,540 naval nuclear weapons include 720 strategic and 820 tactical. ^b Two more SSBN's are fitting out. ^c Pakistan is developing the Babur-3 cruise missile for its submarines. ^d Israel might have a small inventory of submarine-launched cruise missiles.

other ships and submarines or attack targets on land (Kristensen 2016). Russia is the only country that continues to operate large numbers of non-strategic naval nuclear weapons. An important recent Russian addition is the Kalibr land-attack sea-launched cruise missile that is being incorporated into most new major surface ships and attack submarines. The Russian government claims the missile is nuclear-capable (Putin 2015); the US Intelligence Community calls it “nuclear possible” (US National Air and Space Intelligence Center 2021). With a range of up to 2,000 kilometers, the Kalibr can threaten targets all over Europe and, if launched from an attack

An important recent Russian addition is the Kalibr land-attack sea-launched cruise missile that is being incorporated into most new major surface ships and attack submarines.

submarine off the US coasts, deep into the territory of the continental United States. The Kalibr is probably replacing the SS-N-21 nuclear sea-launched land-attack cruise missile first deployed in the 1980s. The Russian navy is also acquiring a nuclear-powered long-range underwater drone designed to detonate a large nuclear warhead inside a harbor to make a coastal area uninhabitable, a mission that would clearly violate international law (Kristensen and Korda 2020a).

The United States has replaced all its non-strategic naval nuclear weapons with conventional weapons. Until 2010, the US Navy possessed a nuclear sea-launched cruise missile - the Tomahawk Land-Attack Missile (TLAM-N). It was retired because it was redundant after it had been stored on land for nearly two decades and the regional nuclear mission could be covered by dual-capable aircraft and air-launched cruise missiles.

But Russia’s modernization of its non-strategic nuclear weapons, an inventory the US military says is “likely to grow significantly over the next decade” (Richard 2020), has recently triggered plans in the United States to reinstate a nuclear-armed sea-launched cruise missile. The Trump administration’s NPR said the weapon is necessary to “pro-

vide a needed non-strategic regional presence, an assured response capability. It also will provide an arms control compliant response to Russia’s non-compliance with the Intermediate-range Nuclear Forces Treaty,” a treaty the United States has since abandoned, “its non-strategic nuclear arsenal, and its other destabilizing behaviors.” The nuclear cruise missile is also intended to provide “a valuable hedge against future nuclear ‘break out’ scenarios” (US DoD 2018a, XII).

Specifically, the Pentagon is concerned that Russia believes “its expanding anti-access/area denial (A2AD) networks will be able to neutralize the

airborne nuclear deterrent forces of the United States and NATO” and that it’s possible China could adopt a similar doctrine in the future. So, the “SLCM-N will bolster

allied confidence in U.S. security guarantees,” the Pentagon claims, and it will be fielding this new non-strategic nuclear weapon in the “hopes of persuading other states to eliminate these and related weapon systems” (US DoD 2019, 2).

This plan is a clear and recent example of the nuclear action-reaction dynamic that characterized the Cold War. The same line of argument could, of course, be used to argue that the United States also needs to acquire other non-strategic nuclear weapons that Russia has, such as nuclear torpedoes and short-range ballistic missiles. There is obviously no way to know if fielding a new nuclear sea-launched cruise missile will in fact result in the benefits claimed by the NPR and defense officials. Instead, Russia might see it as an additional US tactical nuclear threat against its territory that it has to defend against, for example by deploying attack submarines off the US coast. The deployment of the earlier TLAM-N did not persuade the Soviet Union to back down but caused it to field its own long-range nuclear land attack sea-launched cruise missile. Likewise, China would almost certainly view deployment of a new SLCM-N in the Pacific as an additional tactical nuclear threat intended to provide strike options against its nuclear forces below the strategic level.

This might cause China to field its own nuclear cruise missile in response, which in turn would increase the nuclear threat against US bases and allies in the region. These uncertainties and potential countermeasures illustrate the proliferation dynamic that nuclear modernizations can fuel.

Moreover, fielding of a new SLCM-N will likely reignite the political tension that used to follow US nuclear-armed warships wherever they sailed during the Cold War. Rather than reassurance and

Today's naval nuclear weapons are a lot more capable than they were during the Cold War. The Trident II SLBMs on US SSBNs are not simply reserve weapons but serve a daily front-line deterrent and warfighting role.

good will, port visits by nuclear-armed ships and submarines stirred up political controversy and bad press that complicated relations with allies and fueled local opposition to US military operations in the region in general (Kristensen 2006). Any claims about military needs will have to take these political issues into consideration as well.

Today's naval nuclear weapons are a lot more capable than they were during the Cold War. The Trident II SLBMs on US SSBNs are not simply reserve weapons but serve a daily front-line deterrent and warfighting role. And recent modernizations have increased the capability further. The life-extended W76-1/Mk4A warhead produced for the navy's Trident submarines includes a new fuse that increases the weapons target kill capability (Postol, Kristensen, and McKinzie 2017). And the future W93 warhead proposed by the navy will be even more capable and "improve the SSBN force's ability to hold all targets in current plans at risk" and "allow for more efficient targeting by expanding the footprint of targets the warhead can hit" (US DoD 2020b).

Potential adversaries will almost certainly view such modernizations as attempts to increase the US's ability to win a nuclear war and trigger countermeasures to strengthen deterrence

against the United States. Such countermeasures would, in turn, be viewed by US officials as increased threats that require the United States to strengthen its deterrent.

Non-Strategic Nuclear Weapons

Development and deployments of non-strategic nuclear weapons are potential powerful proliferation triggers that can have a significant effect on how nuclear-armed states and non-nuclear countries view security and threats. Non-strategic nuclear weapons are developed explicitly and overtly to provide nuclear options below the level of strategic nuclear weapons use, in "battlefield" and "warfighting" scenarios, including in the earliest phases of a conflict that escalates

from conventional to nuclear. Non-strategic nuclear weapons are therefore often seen as indicators of increased nuclear risks and risk-taking.

Nuclear-armed states often interpret non-strategic nuclear weapons as a sign of growing nuclear adventurism. A country that has non-strategic nuclear weapons – certainly one that begins to field more types of them – is viewed with concern because it could indicate that the country is increasing the role of nuclear weapons and may even be lowering the threshold for when they could be used.

This dynamic is currently playing out in the relationship between Russia and the United States. Non-strategic nuclear weapons are nothing new in Russia's military posture or strategy, and Russia has maintained significant numbers of non-strategic nuclear weapons for decades; it probably possesses fewer of them today than a decade ago (Kristensen 2012, 2019; Kristensen and Korda 2020b). But the Trump administration accused Russia of increasing the numbers and planning to use nuclear weapons first if it were about to lose a conventional war. According to the 2018 NPR:

Moscow apparently believes that the United States is unwilling to respond to Russian employment of tactical nuclear weapons with

strategic nuclear weapons...It mistakenly assesses that the threat of nuclear escalation or actual first use of nuclear weapons would serve to 'de-escalate' a conflict on terms favorable to Russia," whose non-strategic nuclear weapons are intended to take advantage of "an exploitable 'gap' in U.S. regional deterrence capabilities (US DoD, 2018).

The perception that Russia has become more willing to use nuclear weapons early in a conflict took hold after it invaded Ukraine in 2014. Even prior to that, Russian officials had made several explicit nuclear threats against NATO countries involved in the US missile defense program in Europe, including against Denmark (Vanin 2015) and Poland (de Quetteville and Pierce 2008). And Russian officials – including President Vladimir Putin himself – allegedly said nuclear forces might have been alerted if NATO used military force to push Russia out of Crimea, and potentially do the same in a clash over the Baltic states (Johnston 2015).

At the time, US nuclear strategy already included the “ability to project power by communicating to potential nuclear-armed adversaries that they cannot escalate their way out of failed conventional aggression” (US DoD 2014, 13). But contributors to the NPR persuaded the Pentagon that Russia

When the NPR was finished less than a year later, it included two “nuclear supplements” to the existing modernization program: immediate development and deployment of a new low-yield warhead on the navy’s Trident submarines and pursuit of a nuclear sea-launched cruise missile.

had moved beyond nuclear escalation in retaliation to “using an entirely different definition of ‘escalating to deescalate,’ employing the threat of selective and limited use of nuclear weapons to forestall opposition to *potential* aggression” (Miller 2015; emphasis added). STRATCOM commander General John Hyten, now the Vice-Chairman of the Joint Chiefs of Staff, said: “I don’t think the Russian doctrine is escalate to deescalate. To me, the Russian doctrine is to escalate to win.

So the purpose of their escalation is to win the conflict because they believe we won’t respond.” Even though Hyten said he was “very comfortable today with the flexibility of our response options,” his signal to the authors preparing the Trump administration’s NPR at the time was that “given the Russian escalate to win, if you like, or escalate to deescalate doctrine, the United States needs to have more options” (Hyten 2017).

When the NPR was finished less than a year later, it included two “nuclear supplements” to the existing modernization program: immediate development and deployment of a new low-yield warhead on the navy’s Trident submarines and pursuit of a nuclear sea-launched cruise missile. Although Hyten had just said he was “very comfortable” with existing US response options, the nuclear supplements were necessary, so the authors of the NPR argued, to “enhance the flexibility and responsiveness of U.S. nuclear forces” in order to “enhance deterrence by denying potential adversaries any mistaken confidence that limited nuclear employment can provide a useful advantage over the United States and its allies. Russia’s belief that limited nuclear first use, potentially including low-yield weapons, can provide such an advantage is based, in part, on Moscow’s perception that its greater number and variety of non-strategic nuclear systems provide a

coercive advantage in crises and at lower levels of conflict” (US DoD 2018a, 53-54).

Whereas Russia’s strategy of escalating to use tactical nuclear weapons to win a conflict was described by the NPR as danger-

ous and lowering the threshold for nuclear use, US pursuit of new nuclear weapons to “enhance the flexibility and range of its tailored deterrence options” by threatening escalation to deescalate a conflict was said to stabilize and raise the threshold for nuclear use (US DoD 2018, 54). The low-yield Trident warhead went to sea in late-2019, nearly one year after the NPR had advocated it (Arkin and Kristensen 2019). The Pentagon is pursuing the nuclear cruise missile to “improve U.S. capabilities for

detering limited nuclear use and assuring our allies that we will meet our extended deterrence commitments” (US DoD 2020a, 7). In a recent interview, the director of the US Navy’s Strategic Systems Program, Vice Admiral Johnny Wolfe, provided a clear-cut example of the vertical proliferation dynamic:

It goes along with the deterrent mindset game. Today we know, for instance, that Russia has many what they call tactical nuclear weapons. We all see it in the open press, this thought that we’ve heard many, many times, which is their idea that they could escalate-to-deescalate. In other words, they would use a tactical nuclear weapon in a regional threat scenario to back us down. Again, it’s a nuclear weapon, but they believe that by using those tactical nuclear weapons, ‘cause we don’t have anything that is in kind, that that would be a scenario that they could actually win and they would consider using it.

If you have a sea-launched cruise missile, which again starts to match where they’re at, it changes their thought-equation, OK. Because, as they play scenarios, their thought of escalate-to-deescalate, they can’t do that. Because if they escalate, and we’ve got something in-kind, you ‘gotta ask yourself, do they really want to do that?

So, a SLCM really calls...and I’ve heard a lot of things in this job like we’re lowering the threshold for which we would consider using nuclear weapons. I don’t believe that’s true. I believe we’re actually raising the threshold. You’re putting it back right where it needs to be so that nobody believes that by using any type of nuclear weapon the outcome could be favorable for them. Again, the essence of deterrence (Wolfe 2021; emphasis added).

Russia has had more types and numbers of tactical nuclear weapons than the United States for decades without anyone in the US military arguing that the United States needed to get a new tactical nuclear weapon to have something “in-kind.” And there is no public evidence that a Russian decision to escalate depends on whether the United States has a new non-strategic SLCM-N or a low-yield Trident warhead. The United States already has several hundred “tactical” nuclear

bombs - many deployed in Europe - that it could use in response. They are being modernized with the B61-12 guided nuclear bomb on the F-35A stealth fighter. And any Russian nuclear-use decision would have to consider the risk and consequences of the nuclear response it would trigger. Whether the new Biden administration agrees the SLCM-N is needed given the existing capabilities of the arsenal and the cost of producing the new missile and its warhead remains to be seen.

Another region where non-strategic nuclear weapon dynamics are causing concerns is in South Asia where Pakistan has fielded a nuclear-capable short-range ballistic missile with a range of only 70 kilometers (43.5 miles). The dual-capable weapon system, known as NASR (Hatf 9), is described as a “shoot and scoot” weapon that “carries nuclear warheads of appropriate yield with high accuracy” and was developed as a “quick response system” to “add deterrence value” to Pakistan’s strategic weapons development program “at shorter ranges” in order “to deter evolving threats,” specifically in response to India’s conventional “Cold Start” strategy (Inter Services Public Relations 2011; Inter Services Public Relations 2017). Both US and Indian officials have expressed concern about what the weapon means for Pakistani nuclear-use scenarios and command and control in a crisis.

China considers all of its nuclear weapons to be strategic. But it does operate nuclear-capable weapons that do not have intercontinental range that are therefore considered by the United States to be non-strategic. This includes the DF-21A/E medium-range ballistic missiles and the new DF-26 intermediate-range ballistic missile. A fact sheet published by the US Defense Department at the time of the 2018 NPR explicitly stated “China is also expanding and modernizing its *non-strategic nuclear weapons*, including the CSS-5 Mod 6 and DF-26, intended to threaten its neighbors and challenge the US’s ability to conduct regional operations” (US DoD 2018b). According to the NPR, US military planners are working on “increasing the range of graduated nuclear response options available to the president” to “strengthen the credibility of our deterrence strategy and improve our capability to respond effectively to Chinese limited nuclear use if deterrence were to fail” (US

DoD 2018a). So, while China may not officially possess tactical nuclear weapons, the US military is planning as though it does. But since China has operated medium-range and intermediate-range nuclear missiles for many decades, it is unclear why US planners are now “increasing the range of graduated nuclear response options.”

Another dynamic of non-strategic nuclear weapons is that most delivery platforms are dual-capable – that is, they can be used to deliver both nuclear and conventional warheads. A modernization or deployment might be partly or entirely conventional but be misinterpreted by an adversary as a nuclear development or signal. The Russian Kalibr land-attack sea-launched cruise missile is a current example of this dilemma. Since the weapon is dual-capable, governments and news media reports overwhelmingly attribute nuclear capability to any ship that is equipped with the missile. But it is not clear that all

Another dynamic of non-strategic nuclear weapons is that most delivery platforms are dual-capable – that is, they can be used to deliver both nuclear and conventional warheads.

platforms necessarily will be assigned a nuclear role. Likewise, although many tactical fighter-bombers are considered nuclear-capable, that does not mean all units are assigned nuclear weapons.

In a crisis, certainly in the phase where significant conventional combat operations have started, a deployment or activation of a dual-capable weapon could result in misunderstandings about intentions and result in overreaction. This is especially the case if the weapon being readied is a fast-flying ballistic missile or even a hypersonic weapon. Or, if a nuclear-armed state secretly begins preparations to arm dual-capable missiles without the adversary knowing about it, a conventional attack against that unit could be misinterpreted as a preemptive attack against its nuclear forces and trigger further escalation.

Non-Nuclear Capabilities

As mentioned above, it’s not just nuclear programs and operations that affect proliferation.

Non-nuclear capabilities - and increasingly so - have had a significant effect on proliferation. That effect is growing.

The conventional capabilities demonstrated in the two Gulf Wars had profound effects on Russian and Chinese perceptions about the vulnerability of and need for their nuclear forces. It significantly deepened Russian reliance on nuclear weapons at a time when the Russian economic crisis was depleting the country’s conventional forces. This was not just a matter of national prestige but also of pure military necessity: Russia would simply not have the capability to defend against a conventional attack from NATO, a potential risk Russian planners saw in NATO’s eastward expansion and its attack against Serbia in 1998. Moreover, US withdrawal from the ABM Treaty, in 2002, the ambitious missile defense program that followed, continued enhancement

of long-range conventional precision strike capabilities, and talk about pre-emptive strikes and “left of launch” strategies, all converged into a perception of

bad intent and strategic vulnerability that further fueled Russia’s nuclear modernization.

China, for its part, realized that it was more or less defenseless. Its newfound wealth made it possible for its leaders to set forth ambitious goals about modernization and China’s rise on the world stage. In addition to its general military modernizations and push into the South China Sea and Western Pacific, its nuclear modernization has been directly influenced by a perception of a US threat and how to counter it. That includes solid-fuel ICBMs, SSBNs, nuclear and conventional ballistic and cruise missiles, and in the near future also a nuclear bomber force. It has decided to equip some of its ICBMs with multiple warheads in response to US missile defense capabilities and increase the number of missile silos possibly with ICBMs on alert in response to offensive US nuclear and conventional precision strike capabilities. While China sees this as a prudent step to safeguard its nuclear deterrent

and national security, the United States sees it as signs of a growing Chinese threat.

Conventional strike capabilities now form an integral part of US strategic nuclear plans and are routinely exercised alongside nuclear forces in what used to be more or less exclusively nuclear operations. Some targets that used to be covered by nuclear weapons are now held at risk with conventional weapons. The 2010 Quadrennial Defense Review and Ballistic Missile Defense Review both explicitly described how advanced conventional forces would allow for a reduction in the regional role that nuclear weapons play in US military strategy. Offensive cyber capabilities are now part of the strategic portfolio as well, all serving to create a broad suite of strategic capabilities to deter, de-escalate, and, if necessary, defeat Russian and Chinese forces - including their nuclear forces.

Russia and China are mimicking these efforts. After having relied overwhelmingly on nuclear forces, Russia is now fielding a broad range of long-range conventional precision strike capabilities on land, at sea, and in the air. And it is rushing ahead with programs to field air-launched ballistic missiles and hypersonic missiles. All of China's short-range and most of its medium- and intermediate-range missiles are conventional, as are all of its ground- and air-launched land-attack cruise missiles. Like the United States, both countries clearly see benefits in building up conven-

Conventional strike capabilities now form an integral part of US strategic nuclear plans and are routinely exercised alongside nuclear forces in what used to be more or less exclusively nuclear operations.

tional strategic capabilities that give them military options below the nuclear threshold.

Ironically, while increased conventional capabilities may allow a nuclear-armed state to reduce reliance on nuclear weapons in regional scenarios, it may in fact fuel its adversaries' need to modernize their nuclear forces to better account for these capabilities. This may materialize as increased

requirements for keeping nuclear forces on high alert, deployment of hypersonic weapons to hold nuclear forces at risk or defend against them, and greater capability to defend nuclear forces against conventional attacks. Smaller nuclear powers and potential proliferators will almost certainly react to the continued enhancement of long-range conventional precision capabilities by increasing their reliance on nuclear weapons.

POLITICAL EFFECTS OF NUCLEAR MODERNIZATION

In addition to technical modernizations and operations, the rhetoric that military and civilian officials of nuclear-armed states use to justify and describe the need for and role of nuclear weapons is another powerful proliferation trigger. Not only does it help drive domestic defense spending and modernization programs, but it can also affect other countries' perceptions of the intentions of a nuclear-armed state and trigger countermeasures. As such, it can affect both military and political developments.

Some US officials and nuclear weapons advocates in recent years have begun to use the slogan that the United States is using its nuclear weapons every day. The slogan emerged in the 2008 Schlesinger report following the so-called Minot incident in 2007: "Though our consistent goal has been to avoid actual weapons use, **the nuclear deterrent is "used" every day** by assuring friends and allies, dissuading opponents from seeking peer capabilities to the United

States, deterring attacks on the United States and its allies from potential adversaries, and providing the potential to defeat adversaries if deterrence fails" (US DoD 2008 emphasis added).

The statement was intended at the time to be a "call to arms" for the nuclear community and reverse what was found to be declining proficiency in the nuclear forces. But it was quickly hijacked by

nuclear advocates to counter a widespread post-Cold War perception that nuclear weapons were losing their value and instead build support for the continued value and modernization of nuclear forces. The implication that nuclear weapons are “used” every day is entirely inappropriate because

Modernization of nuclear forces can also have a significant effect on the perception that non-nuclear states have of the long-term outlook for international security and the intention of the nuclear-armed states to limit and reduce nuclear dangers.

“use” has a particular meaning in nuclear terminology, which includes the detonation of nuclear weapons over Japan in 1945 and the much-debated questions of “first use” or “no-first-use” of nuclear weapons. The nonchalant claim that nuclear forces are “used every day” undermines repeated US official statements and policies that seek to ensure adversaries and allies that non-use of nuclear weapons is a central objective of US nuclear weapons policy. “The number one priority of the DoD,” Defense Secretary Mattis stated in 2017, “is that we maintain a safe, secure and effective nuclear deterrent so we make certain those weapons are never used” (Mattis 2017).

The 2018 NPR itself states: “For any President, **the use** of nuclear weapons is contemplated only in the most extreme circumstances to protect our vital interests and those of our allies...Our goal is to convince adversaries they have nothing to gain and everything to lose from **the use** of nuclear weapons” (US DoD 2018a, II; emphasis added). Moreover, US declaratory policy explicitly states: “The United States **will not use or threaten to use** nuclear weapons against non-nuclear weapons states that are party to the NPT and in compliance with their nuclear non-proliferation obligations” (US DoD 2018a, 21; emphasis added).

The principles of non-use and to only use nuclear weapons in extreme circumstances are closely linked to the issue of first-use and, by extension, to no-first-use because retaining the option to

use nuclear weapons first - certainly expanding it - appears to contradict these principles. The perceived erosion of these principles is deepened by the decision in the 2018 NPR to “expand the range of credible U.S. options for responding to... non-nuclear strategic attack...” (US DoD 2018, 55).

Since these expanded response options would be first use, this doctrinal development may fuel international perceptions that the United States is lowering the threshold scenarios for use of nuclear weapons.

Modernization of nuclear forces can

also have a significant effect on the perception that non-nuclear states have of the long-term outlook for international security and the intention of the nuclear-armed states to limit and reduce nuclear dangers. The pledge by non-nuclear weapon states under the NPT, which has achieved near-universal support, to not develop nuclear weapons rests in no small measure on the promise made by the nuclear weapon states to “pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control.”

Although the nuclear weapon states correctly argue that they have reduced nuclear forces significantly compared with the Cold War, this achievement is getting long in the tooth as reductions have slowed significantly, some nuclear weapon states are increasing their nuclear arsenals, many are adding new nuclear weapons to their inventories or enhancing their capabilities, all are modernizing their nuclear forces for the long haul, and all are reaffirming the importance and role of nuclear weapons in their national strategies.

The modernization of nuclear weapons for the long haul and reaffirmation of their importance and role coincide with the abandonment or weakening of several arms control agreements, including the Intermediate-Range Nuclear Forces

(INF) Treaty and the US withdrawal from the Iran agreement (JCPOA) and the Open Skies Treaty.

If, fifty years after the NPT entered into force, the nuclear-armed states significantly modernize their nuclear forces - even add new ones - for the purpose of possessing them further into the future than the NPT has lasted so far, reaffirm the continued importance of nuclear weapons, and increase offensive nuclear operations and military competition, non-nuclear weapon states would be justified in questioning whether the nuclear-armed states are in compliance with their obligations under NPT's Article VI.

Part of the nuclear weapon states' efforts to deflect criticism of their Article VI achievements is the argument that deep nuclear reductions - certainly disarmament - are unlikely to happen in the current security environment. The Trump administration has argued that "disarmament is - as the text of the NPT's Article VI makes clear - an

The good news is that the NPT countries that have also joined the TPNW have not decided to withdraw from the NPT.

endeavor in which all states have a responsibility" (Ford 2018). The subtle message is that the non-nuclear weapons states can't just demand that the nuclear weapon states eliminate nuclear weapons but must first help create the international security conditions that would make this possible. The US State Department has argued that those conditions must include: robust and reliable nonproliferation assurances, successful containment of other WMD, stability after "zero," and making "zero" desirable (Ford 2018).

In other words, nuclear disarmament comes last in the process after all other security challenges have been resolved - assuming "zero" is even desirable - even though it is overwhelmingly the nuclear weapon states that are the main actors and drivers of the conditions they say make implementation of Article VI impossible under current conditions. Moreover, many of the non-nuclear weapon states that over the years have pushed for more

progress on nuclear reductions rely themselves on protection from a so-called nuclear umbrella - extended deterrence - provided by some of the nuclear weapon states. Without this umbrella, so the argument goes, some of those countries might otherwise decide to develop their own nuclear weapons. In this entanglement, nuclear weapons are seen to prevent horizontal proliferation - a key objective of the NPT but also a roadblock to the disarmament process.

It is in this political context that significant nuclear modernizations - certainly increasing arsenals or adding new nuclear weapons or increasing military capabilities - can have a corrosive effect on the NPT and increase proliferation of nuclear weapons. Some of the frustration with the nuclear weapon states' behavior and their apparent violation of NPT's Article VI has led to the negotiation and adoption of the Treaty on the Prohibition of Nuclear Weapons (TPNW). The treaty went into force on January 22, 2021 (ICAN 2020). The nu-

clear weapon states and their allies have rejected the TPNW, even sought to coerce countries not to sign it, arguing that it lacks verification measures, undermines international security,

and could weaken the NPT. Clearly, nearly half of the states party to the NPT do not agree. This number is likely to increase.

The good news is that the NPT countries that have also joined the TPNW have not decided to withdraw from the NPT. As such, instead of being a threat to the NPT, as claimed by the nuclear weapon states and their allies, the TPNW might actually have helped protect the non proliferation regime by enabling countries to express their frustration about the lack of Article VI progress without withdrawing from the NPT in protest. The TPNW is now a reality and here to stay, and its members are likely to continue to pressure the nuclear weapon states and the countries that rely on the nuclear umbrella to live up their obligations under NPT's Article VI. Instead of demonizing the TPNW countries, the nuclear weapons states and their allies should instead work constructively with them to strengthen all arms control initiatives. ■

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REBECCA DAVIS GIBBONS

The Outlook for the Nuclear Nonproliferation Treaty

The year 2020 marks the 50th anniversary of the entry into force of the Nuclear Nonproliferation Treaty (NPT). Parties to the treaty, all but five of the world's states, will gather at some point in 2021 for their delayed quinquennial meeting to assess the treaty, plan for its future, and celebrate its 50th year. This milestone, while a cause for celebration, will likely be overshadowed by the treaty's uncertain future.

THE SUCCESS OF THE NPT

Concerned that many additional states would pursue nuclear weapons, particularly after the Chinese nuclear weapon test in 1964, the United

States and the Soviet Union began drafting the NPT in the mid-1960s. Other states, beginning with Ireland, had been calling for such an agreement since the 1950s, but it took the superpowers longer to make their strategic calculation about the risks of widespread proliferation. The final version of the treaty text acknowledged that some states already had nuclear weapons and obliged those states not to assist "in any way" the wider proliferation of nuclear weapons. All other states would join the treaty as non-nuclear-weapon states, obliged never to seek nuclear weapons or assistance in developing them. The treaty underscored the inalienable right to pursue peaceful nuclear energy and required non-nuclear-weapon states to conclude nuclear safeguards agreements

with the International Atomic Energy Agency (IAEA). In a “watered down” response to calls for a commitment to nuclear disarmament, all states agreed to “pursue negotiations in good faith on effective measures relating...to nuclear disarmament” (Dhanapala 2010; Goldschmidt 1980).

Perhaps the NPT’s greatest success has been in creating a robust norm against nuclear proliferation. While the norm may not be universal, there is evidence it matters and has become stronger with time. Regimes that have pursued proliferation activities in recent decades (North Korea, Libya, Syria, and Iran) are norm breakers in several arenas of global politics. Creating a nuclear weapon program is not an activity for norm followers. The ability of President Barack Obama to corral much of the international community behind his effort

Over the next half century, reduced great-power cooperation, changing power dynamics, and persistent disagreement over the treaty’s bargains will make the status quo difficult to maintain.

to repeatedly sanction Iran for its proliferation activities must be understood as an effort bolstered by more than just US material capabilities; the idea that Iran was taking inappropriate actions mattered too.

The NPT has made a significant contribution to international security in its 50 years. Over the next half century, reduced great-power cooperation, changing power dynamics, and persistent disagreement over the treaty’s bargains will make the status quo difficult to maintain.

REDUCED COOPERATION AMONG THE NPT’S NUCLEAR WEAPON STATES

The strong normative sway of the NPT has required the cooperation of the nuclear weapon states, especially the two powers with the largest arsenals. Even though they were bitter adversaries, the United States and the Soviet Union were able to cooperate to promote the regime and

address proliferators during the Cold War. For example, when the Soviets detected preparations for a nuclear test at Vastrap in the South African desert in the late 1970s, they alerted their US counterparts, and US leaders pressured Pretoria to stop the test (Bidgood 2018). US and Soviet diplomats engaged in regular consultations about nuclear nonproliferation concerns throughout most of the Cold War on issues including export guidelines, the nuclear fuel cycle, IAEA safeguards, limits on nuclear testing, and storage of fissile material (Potter 2018). During the Cold War, strategic interest in preventing proliferation trumped East-West differences.

After the end of the Cold War, collaboration persisted for many years until Russia’s incursion into Ukraine in 2014. There were signs of reduced cooperation before then, however. For example,

in 2012, at an IAEA technical meeting, Russia strongly questioned the agency’s effort to improve and streamline its safeguards process (Rockwood 2014).

Russia’s rejection of this attempt by the IAEA’s Department of Safeguards to enhance effectiveness within a stagnant budget was surprising for two reasons: Moscow had earlier supported it, and the new safeguards process would not apply to Russia as an NPT nuclear weapon state. Anti-US sentiments may have driven this Russian response. Russia’s policies on nuclear trade are another indicator of failure to support strengthening the safeguards system. The United States and its allies largely require their nuclear-trade partners to conclude an Additional Protocol, which provides IAEA inspectors broader access to a state’s nuclear facilities, as a condition of nuclear supply. There is little evidence Russia and China are pushing their customers to abide by the strictest safeguards in exchange for their nuclear assistance. For example, Egypt has deals in place to receive assistance from China and Russia for its planned nuclear reactor at El Dabaa despite refusing to conclude an Additional Protocol.

Great-power cooperation is critical to bolstering the nuclear nonproliferation regime today.

Building a stronger consensus that the Additional Protocol is the safeguards standard for all NPT parties requires not just the United States and its allies, but also Russia and China. The United States sometimes has promoted unpopular actions for the sake of nuclear nonproliferation, while China and Russia do little or even obstruct the process. Of course, Russia and China can point to US actions more recently to destroy the strong cooperation among the five nuclear weapon states, plus Germany, on the Joint Comprehensive Plan of Action (JCPOA) – the so-called Iran nuclear deal. (The group of countries that negotiated with Iran was known as the P5+1 because the nuclear weapon states also are the five permanent members of the UN Security Council.) The unraveling of the Iran nuclear deal will further undermine great-power cooperation in this area and will likely make it more difficult to solve nuclear challenges diplomatically in the future because would-be proliferators will not trust that deals will remain in place. Finally, great-power collaboration will be needed to strengthen responses to actions that are seen as an abuse of the NPT's withdrawal clause so that states are deterred from taking North Korea's path of obtaining "peaceful" technology only to exit the NPT and use the technology for its growing nuclear-weapon program. Deterring withdrawal is especially important at the time when leaders in Iran, Saudi Arabia, and Turkey – all NPT members – have recently hinted at the possibility of leaving the treaty or developing their own nuclear weapons (Rouhi 2020; Kalin and Hafezi 2018; Sanger and Broad 2019).

CHANGING POWER DYNAMICS

While no one should long for a return to the Cold War's ubiquitous nuclear terror, the nuclear nonproliferation regime benefited from the two superpowers' joint commitment to nuclear nonproliferation during that era of bipolarity. Today, global power is shifting, and changing power dynamics could negatively affect the well-being of the NPT and the broader nuclear nonproliferation regime.

Here it may be useful to consider the fate of the nuclear nonproliferation regime in the context of the broader crisis of global governance. During

the Cold War, the liberal order led by the United States and supported by its network of mostly democratic allies competed with the Soviet-led communist order. This liberal order became the liberal *international* order with the dissolution of the Soviet Union and the discrediting of its state ideology (Gaddis 2006). Scholar G. John Ikenberry suggests that "the seeds of crisis were planted at this moment of triumph," because now the liberal order was not simply made up of the United States and its allies. It was global, with a more diverse group of states and more issues to address (Ikenberry 2018). Along with those changes came the rise of nationalism and xenophobia and the disappointment that globalization has led to rising income equality rather than an improved quality of life for all – all factors that inhibit multilateral cooperation. Amid these challenges, US President Donald Trump (and to a lesser extent, President George W. Bush before him) has rejected multilateralism, weakening US global leadership and creating a more challenging environment for leaders in the future.

In 2020, the world lacks strong leadership for global governance at a time when the challenges to leadership are almost certainly going to become more difficult. The relative material power of the United States and its allies will likely continue to decrease as other states rise. In a true multipolar system, cooperation becomes more complicated as decisions must be made by three, four, five, or more nations working in tandem. Diverse interests, complex bilateral relationships, and a lack of practice working together hamper cooperation among so many states. This difficulty is evident in the 11-year-old "P5 process," whereby the five nuclear weapon states in the NPT meet regularly to assess the treaty's implementation. It would seem that nonproliferation should be a common area of interest among the five countries. Rhetorically it is, but there has been little in terms of real action today to shore up weaknesses in the regime (Hoell 2019).

In the coming decades, countries such as Japan, Brazil, and Indonesia may gain influence without acquiring nuclear weapons, and countries outside the NPT with nuclear weapons, such as India, might also gain influence. Leading the nuclear nonproliferation regime will become more chal-

lenging because these potential great powers may have different ideas about nuclear weapons. For example, Indonesia and Brazil participated in the negotiations for the Treaty on the Prohibition of Nuclear Weapons (TPNW), which rejects all activities related to nuclear weapons, including production, possession, and threatened use. In the future, if the current great powers continue their reliance on nuclear weapons, it is possible the emerging powers may decide that they too will seek nuclear weapons, as the weapons remain symbols of prestige and great-power status.

FAILING BARGAINS

The final challenge to the longevity of the regime is the perception among NPT non-nuclear-weapon states that the bargains undergirding the NPT are imbalanced. While nonproliferation has been continually strengthened, the pursuit of nuclear disarmament and the provision of peaceful nuclear technology have, at best, progressed slowly and fitfully. Expectations for nuclear disarmament, high since the end of the Cold War and the 1995 indefinite extension of the NPT, have been dashed by extensive nuclear modernization programs by most states holding nuclear weapons and the unraveling of both multilateral and US-Russian bilateral nuclear arms control. The US modernization plan, for example, anticipates fielding nuclear weapons through the 2080s (Panda 2017). The Comprehensive Nuclear Test Ban Treaty (CTBT), despite its signature more than 20 years ago, has not yet entered into force; negotiations to stop producing fissile material for nuclear weapons have been at a standstill for 25 years; and states with nuclear weapons have all rejected the TPNW. On top of this, the United States has withdrawn from the Anti-Ballistic Missile Treaty, the Intermediate-Range Nuclear Forces Treaty, and the Open Skies Treaty and has jeopardized the future of the New Strategic Arms Reduction Treaty (New START), completing the picture of crumbling arms control architecture between the United States and Russia. In short, nuclear deterrence is up against calls for disarmament and the NPT is stuck in the middle.

Nuclear modernization, the creation of new weapons, and overt nuclear threats directly undermine

disarmament efforts, but these trends also undermine nonproliferation by illustrating to non-nuclear-weapon states that these are desirable weapons – weapons that are militarily useful and symbolic of status and prestige. While some states may reject the idea that nuclear weapons are associated with prestige, others may see US and Russian leaders bragging about their nuclear capabilities and wish they had these weapons as well. Turkey's President Recep Erdogan illustrated the frustration over these circumstances in the summer of 2019 when he stated, "Some countries have missiles with nuclear warheads, not one or two. But (they tell us) we can't have them. This, I cannot accept" (Toksabay 2019). While Erdogan may be unique in 2019 in making a public statement that undermines the NPT by attacking the seemingly permanent two-tiered system of nuclear haves and have-nots, this type of rhetoric will likely increase as leaders from non-nuclear-weapon states grow frustrated with the status of the NPT disarmament bargain. Moreover, the US-led effort to make progress on disarmament, "Creating an Environment for Nuclear Disarmament," took as an operating assumption that disarmament can be achieved only when the international environment becomes more benign (US State Department 2019).

The loss of arms control, traditionally advertised by the United States and Russia as evidence of their efforts to fulfill Article VI of the NPT, will further alienate NPT countries deeply frustrated over disarmament. In 2020, the Trump administration demanded that China, with its estimated 300 nuclear weapons, must be at the table with the United States and Russia, which have more than 4,000 nuclear weapons apiece, in order to extend New START. For China this is a nonstarter. Holding arms control hostage to a demand to widen the circle of participants means no arms control and no way for the United States and Russia to credibly illustrate their continued commitment to eventual disarmament. Losing the constraints and the transparency provided by arms control agreements could lead to arms racing, further damaging the NPT. Moreover, in this environment it will be more difficult for the United States to secure cooperation on nonproliferation initiatives from NPT states that prioritize nuclear disarmament. Overall, it is difficult to see how the NPT regime can remain viable for the next 50 years if the five nuclear weapon states do

not make significant and meaningful progress on disarmament.

Another at-risk NPT bargain is enshrined in Article IV of the treaty – the promise of peaceful nuclear technology for all members. The IAEA does a great deal of work in helping developing countries harness nuclear technology for uses in medicine, agriculture, and nuclear power. In the early years of the NPT, interest in peaceful uses of nuclear energy helped bring several states into the treaty (Gibbons 2020). In other words, Article IV helped widen initial participation in the NPT and likely has been one of many factors keeping states within the regime. It is not clear how much further nuclear power will spread among devel-

their neighbors and the international community by other means. Many of them could signal their commitment not to develop nuclear weapons through continued membership in nuclear-weapon-free zones and adherence to the TPNW. In other words, most of these states would still be able to have the most important benefit from the NPT – the knowledge that their neighbors and potential adversaries will not acquire nuclear weapons – while being able to take a significant political stand over their disappointment with the failed bargain in the NPT.

Today, mass political withdrawals are unlikely – especially as supporters of the TPNW must constantly push back against the criticism that the new treaty undermines the NPT – but there are those who have suggested the option (Pretorius and Sauer 2019). If arms control continues to stall and nuclear weapons remain prominent in the national defense policies of the five nuclear weapon states, one can

While the commitment to eventual disarmament and the promise of nuclear technology matter for the future of the NPT, so too do the assurances that non-nuclear-weapon states provide each other.

oping countries, particularly in light of perennial issues of cost, safety, waste, and public opinion. A declining interest in nuclear power, however, could be one more reason the NPT has less value to those developing states. This is not to say that an increased desire for nuclear power would save the regime, only that reduced interest provides one more reason that these states would see the NPT as not worth the burdens it imposes on them.

imagine nationalistic leaders of non-nuclear-weapon states or members of their foreign ministries making the case that the NPT has been an unfair treaty and it is time to get out. Certain leaders may wager that the domestic political benefits of standing up to the great powers in this way may outweigh continued participation in the treaty.

While the commitment to eventual disarmament and the promise of nuclear technology matter for the future of the NPT, so too do the assurances that non-nuclear-weapon states provide each other. Prior to the NPT, a 1962 inquiry by the United Nations into reasons that states without nuclear weapons would adopt a notional nonproliferation treaty suggested that reciprocity was a driving force (United Nations 1970). If NPT members become disillusioned with the NPT over stalled nuclear reductions and find they have little interest in nuclear power, they could register their deep frustration with the treaty by withdrawing, while still making a nonproliferation commitment to

MAINTAINING THE NPT FOR THE NEXT 50 YEARS

The prognosis outlined above is dire. What must be done to change course so the NPT will be celebrating its centennial in 2070?

New Leadership

The single most important factor in the longevity of the treaty is far-sighted, global leadership that values multilateralism. The state with the most experience in leading in this arena is the United States. US leadership was vital to drafting the NPT, creating the Nuclear Suppliers Group, pushing for

a stringent Model Additional Protocol, and achieving the indefinite extension of the treaty in 1995 (Gibbons 2016). In fact, the many tasks involved in sustaining the regime, persuading states to join, addressing noncompliance, and leading adaptation when weaknesses became evident suggest

For the NPT to survive, global leaders at the highest levels of government will have to take on the issue of the NPT themselves and not relegate it to their foreign ministries.

the regime may not last without leadership from prominent dominant states.

The task of providing leadership in this area will be made more difficult in an era of multipolarity, but it is not impossible. US leaders will have to persuade their counterparts in other powerful countries, especially Russia and China, that nonproliferation is not just a US goal, or a goal of the West, but a policy that serves the security interests of all states. Today there are many venues for state cooperation in existing multilateral institutions, but leaders must value these institutions and, just as importantly, they need to maintain and expand habits of cooperation within these institutions. To do this, powerful states, especially the United States, must continue to send delegations and funding to institutions and provide leadership in terms of agenda setting, information sharing, and goal setting. When conflicts arise within extant organizations, leaders should send delegations to address the problems and look for compromises. Withdrawing from organizations should be a rare step after all other diplomatic options are explored.

For the NPT to survive, global leaders at the highest levels of government will have to take on the issue of the NPT themselves and not relegate it to their foreign ministries. Maintaining the NPT in the long term will require sustained attention at the top levels of government.

New Bargains

An NPT that exists in 2070 will almost certainly be the result of new bargains among states. One of the most difficult potential bargains must address

expanding the regime to include current hold-outs, especially India. While increasing the number of countries that the NPT designates as nuclear weapon states is difficult to imagine, as the treaty specifies that nuclear weapon states are those that exploded a nuclear device before January 1, 1967, a nonproliferation regime that

does not include one of the most powerful states in the system will lack legitimacy and sustainability. Should India achieve recent projections that it will

become a leading global economy (Singh 2019; PwC 2017), the regime would need to consider how to integrate a state that has openly criticized the treaty and its supplier controls as discriminatory. The idea of including India will not be popular among most nuclear nonproliferation experts and officials, though it is an idea that has been explored by several nonproliferation experts (Nielsen 2007). Nuclear supplier states have not yet seen fit to allow India to join the Nuclear Suppliers Group after the United States in 2008 forced an exception to NSG guidelines for New Delhi. It is reasonable to argue that India, an NPT outsider, does not deserve inclusion. But if India combines its nuclear weapon arsenal with significant economic strength and a massive population, previously dominant states might find it useful to bring India into the regime both for its commitment to seek eventual disarmament and for its help in promoting nuclear nonproliferation globally. Moreover, if a global regime is missing one of the top economic powers in the world, it may begin to lose legitimacy; a similar concern is often expressed about the UN Security Council, where its permanent membership has become mismatched with global power dynamics (Patrick 2015). Because the task of amending the treaty would be so difficult, India could be brought into a new political agreement with the five nuclear weapon states whereby it agrees to abide by the provisions of the NPT. If, after a period of time, the NPT parties consider this arrangement to be successful, they might consider bringing in the other current nuclear-armed states as well, with the goal of establishing truly universal commitments to nonproliferation and disarmament.

A key consideration in accepting new NPT nuclear weapon states must be their support for the disarmament provisions in Article VI of the treaty. Otherwise, adding nuclear weapon states as “grandfathered” could lead to the dissolution of the treaty. Before inviting in new nuclear-armed members – a controversial step – the five recognized weapon states first must work together to set out a more credible path toward nuclear reductions. As many have argued before, this likely means another round of US-Russian reductions before the other three nuclear weapon states – China, France, and the United Kingdom – can join. Inviting these three countries to observe some or all of the bilateral negotiations would provide knowledge and experience that would aid larger and more challenging negotiations down the road. Beyond these steps, the five should set out a time-bound plan to further reduce their nuclear arsenals. Entry into force of the CTBT and a Fissile Material Cutoff Treaty are also necessary steps. The leaders of the nuclear weapon states must start on this path to reductions and achieve some success in this process before undertaking efforts begin to bring

There are a number of scenarios in which nuclear-armed states make significant progress on disarmament during the coming decades. For example, there could be more widespread adoption of the idea that nuclear weapons are inappropriate to possess.

India, Pakistan, Israel, and North Korea to the table. Being invited to this table would require that these states commit to the same plan for disarmament established by the five states.

In addition to a bargain surrounding the expansion of the regime to reflect changing power dynamics – a long-term effort—the five nuclear weapon states may need to find bargains to entice the non-nuclear-weapon states to remain patient and within the treaty for another few decades. Providing more funding to the IAEA for peaceful uses of nuclear technology may be one useful method, but bilateral side payments, such as economic or military aid, and political pressure may be necessary.

New Ideas

Finally, if the NPT is still operational in 2070, it may be because new ideas have taken hold in the international community. Fifty years can seem like an eternity when it comes to societal ideas changing. Consider that in the early nuclear age it was assumed that all technologically capable states would build their own nuclear arsenals.

There are a number of scenarios in which nuclear-armed states make significant progress on disarmament during the coming decades. For example, there could be more widespread adoption of the idea that nuclear weapons are inappropriate to possess. This message animates the TPNW, whose supporters use a humanitarian frame to emphasize the devastating effects of nuclear weapons. In a nutshell, they argue that because possession of these weapons makes their use more likely and use of nuclear weapons in most instances would be inconsistent with humanitarian international law, nuclear weapons therefore should be banned. If this campaign is able to shape the thinking of populations and their leaders through their grassroots

activities, then perhaps it will be easier for the nine nuclear-armed states to significantly reduce their arsenals.

How might that happen? Today grassroots activists are promoting the norm of nuclear non-pos-

session in several ways: by supporting resolutions in favor of the TPNW in municipalities around the world, by educating people about the effects of nuclear weapons, and by promoting divestment from companies involved in the production of nuclear weapons. These weapons may be far from the minds of most citizens around the world today, but certain events could galvanize the population into considering them. A return to nuclear testing, something the Trump administration has explored (Hudson and Sonne, 2020), or a renewed arms race (Landay and Mohammed 2020) could increase the salience of nuclear weapons and make the public more open to the arguments of those promoting nuclear disarmament.

A second set of changing ideas surrounds conceptions of prestige. Today, possession of nuclear weapons and plans for their modernization by the nuclear weapon states encourage the idea that these weapons are a source of status and prestige. The rhetoric of these countries' leaders often reinforces that idea. Over the next 50 years, there will be countless innovative technologies developed. Some may become important sources of status for states, eclipsing the prestige of a decades-old technology. Global leaders should work to enhance sources of prestige in the international system that are not related to weapons. Examples would include technologies that solve societal problems, such as those addressing climate change and fighting the world's worst diseases. Leaders can imbue these innovations with prestige through increased funding, acclamatory rhetoric,

and public celebration of relevant individuals and attainment of key milestones. If powerful states treat these innovations as prestigious, other nations will follow.

The NPT and the broader nuclear nonproliferation regime have bolstered international security for 50 years. But the NPT's longevity cannot be taken for granted amid significant global change. Survival until the treaty's centennial will require strong leadership from multiple powerful states, new bargains, and perhaps new ideas about nuclear weapons. But 50 years is a long time, and big changes are possible. After all, it was only about 50 years before the Trinity test that the ideas that would lead to nuclear fission were beginning to enter the human imagination. ■

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HENRY SOKOLSKI

Has the NPT's Future Run Out?¹

This year marks the 50th anniversary of the entry into force of the Nuclear Nonproliferation Treaty (NPT) and the 10th five-year review of its status at the United Nations. It is one of the few treaties to enjoy almost universal adherence (191 states are parties). Its supporters already are talking about the treaty's next half century.

But will it see out the next decade? There are plenty of reasons to argue it won't.

North Korea (no longer a member) is estimated to have 20 to 60 nuclear weapons (Brunnstrom

2019) and Iran has long been positioning itself to be ready to sprint for the bomb if it decides it needs to do so. But compared to other urgent worries – such as cyber-terrorism, global warming, and Islamic extremism – nuclear proliferation today is so old and familiar, it hardly seems urgent. If states were going to proliferate massively or use nuclear weapons again, this surely would have happened by now. But it hasn't. The NPT may be partly responsible. That said, it can be argued that the treaty has done all the good it might and that Washington's declining cache of diplomatic capital would be best spent on more urgent concerns.

1. A shorter version of this article was published as "The NPT turns 50. Will it get to 60?" *Bulletin of Atomic Scientists*, March 9, 2020. <https://thebulletin.org/2020/03/the-npt-turns-50-will-it-get-to-60/>.

Then there's the complaint that the NPT is no longer the best way to achieve its grandest promise, to get the recognized nuclear-armed powers – the United States, Russia, China, France, and the United Kingdom – to eliminate their nuclear arsenals. China is building up its nuclear arsenal and the United States and Russia are upgrading theirs. The NPT formally recognized them as nuclear-armed states, and they are permanent members of the UN Security Council. Meanwhile, the number of nuclear-armed states outside of the treaty has grown since 1970 from zero to four (Israel, Paki-

In the next decade, it is all too likely that the NPT's past success in preventing the further spread of nuclear weapons among the world's nations will be reversed.

stan, India, and North Korea). About this, the treaty and its supporters have said relatively little. These inconsistencies are significant. In recognition of them, a new treaty on the prohibition of nuclear weapons was negotiated in 2017 and will enter into force in January 2021. Might the NPT's best days be behind it?

Perhaps, but the most profound reason to worry about the treaty's future cuts in a very different direction. In the next decade, it is all too likely that the NPT's past success in preventing the further spread of nuclear weapons among the world's nations will be reversed. That is because of three trends that have received too little attention.

First, there has been a decay of nuclear taboos. Long emphasized by anti-nuclear-weapon groups in states such as Japan as a legal-political barrier to the acquisition of nuclear weapons, the NPT has lost much of its legal luster. In 2005, the Bush administration announced it would share nuclear technology and uranium fuel with India in violation of the NPT's prohibition on such commerce, and the world mostly went along.

More recently, Saudi Crown Prince Mohammed bin Salman publicly announced in a *60 Minutes* interview that Saudi Arabia, a member of the NPT, would "follow suit as soon as possible" if Iran developed

nuclear weapons (CBS News 2018). Not long after, South Korean legislators, anxious that the United States might reduce troop levels there, called on their government to develop options to make nuclear weapons. South Korea is a member of the NPT.

Iran has also threatened to withdraw from the treaty. But if Tehran does, so too would Saudi Arabia, Turkey, Egypt, Algeria, and the United Arab Emirates (UAE) might later follow suit. All of these states except the UAE claim they have an "inalienable" right under the NPT to enrich uranium and to recycle plutonium – activities that can bring states within weeks of acquiring nuclear weapons.

Perhaps because of Iran's threat to pull out, Turkish President Recep Erdogan complained that it was

"unacceptable" that Turkey could not have nuclear weapons (Toksabay 2019; Gilinsky and Sokolski 2019). At the UN General Assembly, he went much further, making the case that the NPT regime of five recognized nuclear-armed states was illegitimate. There are more than five important states, he explained and said either no one should have nuclear weapons or all states should be free to acquire them. His comments were met with applause (Hafezi and Pamuk 2019; *PBS News Hour* 2019).

Second, and arguably worse, renewed vertical proliferation in China, Russia, and North Korea is threatening to fuel the bomb's spread. Combine this with possible Middle Eastern withdrawals and fraying US security ties with its East Asian allies – South Korea and Japan – and you have the ingredients for additional withdrawals by Seoul and Tokyo, and, in short order, the NPT's collapse. After a Japanese withdrawal, nuclear weapons pursuit by Australia, Vietnam, Indonesia, Brazil, Argentina, South Africa, and even Germany would seem conceivable.

Third, there's more on tap technically than ever before to fuel these nuclear breakouts and ramp-ups. Detailed nuclear weapon design information once was scarce. Now, after publication of Saddam's designs by the International Atomic Energy Agency (IAEA), the shopping of the designs for China's implosion device by Pakistani nuclear of-

ficial A.Q. Khan, Iran's pilfering of US and Russian design information, and the natural leakage of a 75-year-old technology, it is relatively plentiful.

Meanwhile, surplus military and civilian stockpiles of separated plutonium and enriched uranium, which were nonexistent a half century ago, now are measured in thousands of bombs' worth in Japan, India, China, the United States, Russia, France, and the United Kingdom. These surpluses took decades to acquire. Converting them into thousands of weapons, though, would take less time than it took the United States to acquire its first nuclear explosive.

Compounding this prospect are states' increasing capabilities to produce massive amounts of enriched uranium and separated plutonium. Japan plans in 2021 to open a large, long-delayed reprocessing plant at Rokkasho that could produce over 1,500 bombs' worth of plutonium a year, roughly as many potential bombs as the United States has in its entire deployed force (Royce, Engel, Ros-Lehtinen, and Sherman 2018). Japan is also completing a uranium enrichment plant that could annually produce approximately an additional 500 bombs' worth of highly enriched uranium.

China is doing even more. It's planning on adding enough enrichment capacity to its "peaceful" nuclear program to meet all of its domestic civilian reactor requirements and still have enough in

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surplus to produce more than 1,000 bombs' worth of weapons uranium a year (Zhang 2016). Beijing also is building enough reprocessing capacity to produce 2.5 tons of plutonium – enough for 500 weapons a year – and finalizing a deal with France to import a plant that would produce over 1,500 additional bombs' worth of plutonium annually.

India, which is completing a fast reactor that can make scores of bombs' worth of weapon-grade plutonium, also has a new, large uranium enrichment plant that will significantly increase its ability to make weapon-grade uranium.

Fortifying these nuclear proliferation trends is US, Russian, Chinese, Japanese, South Korean, and Indian enthusiasm for "advanced" reactors, most of which demand the recycling of plutonium and the enrichment of uranium to nearly 20 percent. South Korea, Japan, and India are eager to pursue these "peaceful" activities in collaboration with the United States. China and Russia are building and operating fast reactors and spent fuel recycling plants and have plans to build more. None of these activities is economical. All are extremely useful for making bombs.

Individually, each of these trends is hardly fatal. Together, however, they threaten a nuclearized world without precedent. Instead of it taking years or decades to ramp up nuclear arsenals to hundreds or thousands of warheads, the five largest nuclear-armed states would be able to do so in 12 to 36 months. Meanwhile, would-be nuclear states, such as Japan and South Korea, could acquire not one or 10, but scores to hundreds within the same time period.

What happens after such large nuclear ramp-ups or breakouts occur is anyone's guess. History offers no guide for such pronounced proliferation. The

last 75 years have seen only nine states acquire nuclear arms, and it took each decades to acquire the arsenals it currently holds. All this would change. Such hyperproliferation, in turn, is likely to occasion a significant revamp-

ing of doctrines for the use of nuclear weapons. China and India are moving toward doctrines that would contemplate early or first use. Russia, NATO, and Pakistan are already there.

Aggravating these catalysts to acquire and use nuclear weapons are the centrifugal diplomatic forces

further nuclear proliferation would release. If any of Washington's close friends or allies – Japan, South Korea, Saudi Arabia, Egypt, the UAE, Turkey, or Australia – chose to develop nuclear weapons, their decisions would stress and loosen existing US bilateral security relations. That, in turn, could make the prospects for further nuclear proliferation and first use more intense than at any time since the fall of the Berlin Wall.

Are these trends facts? Not yet. Can we block or reverse them? Perhaps. Three measures could help.

First, make further withdrawals from the NPT less attractive. Second, clamp down on the uneconomical stockpiling and civilian use of plutonium and highly enriched uranium and the means to make these explosive materials. Third, give meaning to efforts limiting the threats that existing nuclear weapons pose.

Regarding NPT withdrawals, the United States and its allies have dealt with only one case to date – North Korea. What Washington and others did, in this case, is the model of what not to do. The United States did nothing to deter North Korea from withdrawing even though Pyongyang had given a decade of formal warning. The IAEA first found North Korea to be in noncompliance with its safeguards agreement in 1993 and reported this to the UN Security Council. The council, however, only took hortatory action. When Pyongyang finally followed through early in 2003 on its

More generally, the NPT's pledge of providing civilian nuclear technology as a quid pro quo for nuclear inspections should be reconsidered.

announced intent to withdraw, which it had started making 10 years before, the Security Council decided merely to study the matter.

In this vacuum of inaction, North Korea was able to expel IAEA inspectors from the country. Legally, implementation of Pyongyang's original comprehensive nuclear safeguards agreement with the IAEA was tied to its adherence to the NPT. Once Pyongyang withdrew from the treaty, North Korea

was free from international nuclear inspections. As for sanctioning North Korea's nuclear activities, the United Nations did so only in 2006, after Pyongyang conducted its first nuclear weapon test, three years **after** Pyongyang withdrew from the NPT.

If the United States and other like-minded nations want to block more states from withdrawing as North Korea did, they must announce now what they will do, **before** any state withdraws or acquires a bomb. In this regard, Pierre Goldschmidt, a former deputy director general of the IAEA for safeguards, has several useful suggestions (Goldschmidt 2018; Ford 2018). First, the UN should agree now to give temporary expanded inspection authority to the IAEA and demand a subsequent shutdown of any enrichment or reprocessing plants if the IAEA asks the UN Security Council to take that step to deal with a noncompliant state. Passing such a country-neutral UN resolution now might by itself deter future noncompliance (think Iran).

Second, the IAEA and all nuclear supplier states should insist that non-weapon states place all of their civilian nuclear materials and activities under IAEA inspections in perpetuity. This would assure that if any state decided to withdraw from the NPT, all of its civilian nuclear holdings and plants would remain under IAEA supervision.

Finally, Goldschmidt recommends that the UN adopt a country-neutral resolution stating the

Security Council will consider it to be a "threat to international peace and security" for any state to withdraw from the NPT if it is found to be in noncom-

pliance with its IAEA safeguards agreement. This resolution should further stipulate that the IAEA should seal all nuclear equipment and materials subject to IAEA safeguards in the withdrawing state and remove these materials and plants as soon as practical.

If the state refuses to comply, the UN should ban all military cooperation with that state. In support of this resolution, the permanent members of

the Security Council should also make a political announcement in advance stating that all of them consider NPT withdrawals to be such a severe threat to international peace and security that none of them would exercise their right to veto a sanctions resolution if four other Security Council members supported it.

Getting such UN resolutions approved and having US sanctions laws align with them would go a long way to deterring future NPT withdrawals. To push the threat of NPT withdrawals back further, however,

Finally, the United States needs to develop a more convincing narrative about how it plans to limit existing nuclear weapon threats. It is difficult to persuade others to forgo nuclear weapons if you are making more nuclear weapons yourself.

will require limiting “peaceful” stocks of enriched uranium and separated plutonium and the means to make them. Given the negative economics of using plutonium as a civilian fuel, civilian reprocessing of spent fuel should be placed on hold. The United States, Germany, and the United Kingdom no longer reprocess; Japan, China, France, India, and Russia should stop as well. As a first step, the United States, China, Japan, and South Korea should agree to a moratorium on such civilian activities. Each has plans to proceed, and all have reasons to fear what the others might do. As for uranium enrichment, global capacity currently exceeds civilian demand significantly. It should be frozen until civilian demand approaches supply. Mohamed ElBaradei, the director general of the IAEA, suggested something similar 15 years ago (Aman and McMahon 2006).

More generally, the NPT’s pledge of providing civilian nuclear technology as a *quid pro quo* for nuclear inspections should be reconsidered. This NPT principle is rooted in a mistaken, outdated enthusiasm for nuclear power, which once was thought to be essential to “make the deserts bloom” and would be “too cheap to meter.” That was what engineers and economists thought back in the 1950s and 1960s.

These assumptions, however, have been mugged by reality. Nuclear reactors now are too expensive

to compete with many nonnuclear alternatives and – as the North Korean, Indian, and Iranian cases so clearly demonstrate – are nuclear-bomb starter kits. If the NPT is to have a future, nuclear supplier states should consider offering less dangerous, more economical forms of energy, including advanced natural-gas-fired plants, renewables, and electrical storage systems in the place of nuclear power.

Finally, the United States needs to develop a more convincing narrative about how it plans to limit existing nuclear weapon threats. It is difficult to persuade others to forgo nuclear weapons if you are making more nuclear weapons yourself. Article VI of the NPT calls on the United States, Russia, China, France, and the

United Kingdom to “pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament.” Failure to demonstrate progress on this front has arms control critics calling on the world’s nations to “ditch” the NPT (Pretorius and Sauer 2019). President Erdogan’s recent criticisms of the treaty at the UN General Assembly certainly focused on this point. The United States, Russia, and China, meanwhile, are investing heavily in modernizing or (in China’s case) expanding their arsenals. This trend is unlikely to change very soon.

What can be altered, however, is these states’ arms control ambitions. The United States currently seems more focused on explaining why it should abandon existing arms control agreements (the Intermediate-Range Nuclear Forces Treaty, the New Strategic Arms Reduction Treaty, the Open Skies Treaty, etc.) than in proposing or negotiating a new, major arms control agreement it favors. Russia, meanwhile, is all for extending existing agreements but is hardly very ambitious beyond this. Finally, China seems to be in denial that it should be involved in any arms control negotiations at all.

The United States, in collaboration with its allies, can and should change this. It will not be easy, however.

For one thing, US military and diplomatic capital right now is stretched thin. But Washington should make it clear that this will change – in a matter of a few years – and that engaging in fair negotiations on this front now is ultimately in everyone’s interest.

To help make this case, US military modernization efforts should be tailored to this purpose. They should be designed to diminish rather than enhance the value of relying more heavily on nuclear arms for security. In particular, the United States should invest in advanced conventional capabilities in which it has a comparative advantage – including space-based systems, advanced precision weaponry, and submersible technologies. Building up these capabilities should encourage China and Russia to invest in nonnuclear naval, air, and missile systems that are defensive rather than offensive. This, in turn, should make nuclear restraints and other strategic arms limits easier to reach in both East Asia and Europe.

This last point brings us to a larger requirement: the United States must update the way it views nuclear proliferation threats. At a minimum, it needs to recognize that its nuclear woes can no longer be resolved if it continues to view them as it did a half century ago during the Cold War. Then, the United States and its allies had a military and diplomatic narrative for reducing nuclear threats. This is what we need today (Sokolski 2018). Pushing bipolar nuclear and military “balances,” bilateral arms control summits, and “peaceful” global nuclear-powered development agendas are no longer reliable paths to peace.

During the Cold War, the United States could afford to react to strategic developments even after they occurred. Waiting to shape policies until a state’s violation of its international obligations was proven made sense when the United States and its allies merely wanted to stay ahead of the Soviet Union in strategic weaponry. The game was never to keep them from acquiring strategic weaponry. Today, this is no longer sufficient. The aim must be not just to stay ahead, but to discourage states from acquiring strategic arms.

To accomplish this, the US government cannot wait to react to other states’ successful tests or deployments of strategic weapons. Instead, it needs to identify future proliferation scenarios for specific

regions and countries that it wants to avoid and happy endings it wishes to secure. These alternative futures must be the basis for the plans Washington and its allies formulate.

What does this mean operationally? At a minimum, the US Defense Department must offer a clearer description of these futures in its own threat assessments and guidance documents. These narratives, in turn, should drive more of the intelligence community’s development of its National Intelligence Topics and priorities and its routine interactions with mid- and senior-level policy makers.

This effort must be normative in character, aimed at where Washington wants to get to rather than merely providing passive analysis. The fruits of and progress in institutionalizing this collaboration (perhaps in the National Counterproliferation Center, a revitalized Strategic Assessment Group, or similar body within the US intelligence community) should, in turn, be a topic for oversight by the congressional committees with jurisdiction over intelligence, foreign affairs, defense, and nuclear proliferation (Sokolski 2019).

All of this will place a particular burden on the intelligence community. As alliances shift, new coalitions form, and previous allies and longtime rivals seek new or expanded nuclear weapon capabilities, intelligence collection and analysis will need to be broadened. Intelligence will have to be gathered and assessed not just on adversaries, but on friends and emerging trends that could alter current alignments.

Finally, for nonproliferation to have any future, the United States, its allies, and its adversaries must be convinced that living under country-neutral rules serves their interests more than living in a global Wild West. That, in turn, will require national military and diplomatic efforts tailored to this purpose – a project that was once familiar but now is all too novel.

Assuming these steps are taken, the NPT could well survive and thrive for another half century. If not, it will simply be pushed to the margins of history along with the Kellogg-Briand Pact, which famously banned war a decade before the globe was engulfed in the most destructive war in recorded history. ■

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COREY HINDERSTEIN

Nuclear Cooperation and Political Influence

During the 75 years of the nuclear age, the dynamics and context for international cooperation in nuclear energy have changed dramatically and continuously. The current landscape includes tangled motivations for countries interested in acquiring nuclear reactors and related technology and for countries seeking to sell those goods. As long as states have conducted nuclear trade, some have asserted that these transactions are reliable nonproliferation levers and will result in relationships that would then allow the supplier to exert influence on the nuclear decision-making of the recipient country. This essay will test that assertion by examining five case studies of US nuclear relationships with other countries.

States that are considering using peaceful nuclear cooperation to advance nonproliferation must first define the nonproliferation objectives they are trying to achieve. They should choose nuclear cooperation as the means to that end only when it is a driver of specific risk reduction actions, not when it is merely aspirational about the ability to exert influence later. There are good reasons for international nuclear cooperation, but the hope of future influence on nuclear decision-making is not at the top of the list.

In 2020, arguments for building and operating a nuclear power plant (NPP) are not based primarily on economics. In the current economy, which does not place a price on carbon, the cost to build

and operate an NPP is not competitive with other types of electricity production. However, interest in nuclear power persists globally because of other factors. Some of the other reasons to pursue nuclear energy include pursuit of low-carbon, baseload electricity as a means to combat climate change; interest in energy diversity at a national level; and the potential strategic benefits of building or solidifying relationships between a nuclear reactor vendor and the purchasing country.¹

When thinking about strategic considerations, it is important to separate the vendor's goals from the purchaser's. Nuclear projects are multidecadal. Linkages between vendors and purchasers will last far beyond the term of office or the era of leadership when the decision to cooperate is made or even the lifetime of the particular policies that supported their development.

For vendors, the pursuit of nuclear cooperation could be aspirational. The vendor is looking to secure a closer level of cooperation with the buyer across a broad range of areas by linking the two countries for many decades. The goal also could be to protect or insure an existing strategic relationship by tying the two nuclear programs together. Purchasers may be looking strictly at the price of the project or their perceptions of the safety and reliability of the reactor, but they also may seek to create or solidify a relationship with a strategic partner. In other circumstances, commercial nuclear relationships are seen as a path to leverage or influence (in both directions), in the nuclear sphere and beyond.

WHAT DOES "COOPERATION" MEAN?

Cooperation in an NPP project can take many forms and can vary based on decisions by the purchaser at each stage of the project. Simply put, cooperation on the reactor unit itself is not the only way to exert influence. The purchaser has options for multiple relationships including through the balance of plant (the systems of a power plant needed to de-

liver the energy, other than the nuclear unit itself), regulatory cooperation, and use of third-country nationals in construction, operation and training, as well as through the extensive supply chain required to fuel, maintain, operate, and eventually decommission a nuclear power plant. There are therefore many ways to exert influence to lower the nonproliferation risks of a nuclear project. For example, regulatory cooperation may enable influence on strengthened domestic safeguards or export controls, or assured fuel supplies could influence sovereign decisions in the purchasing state to forgo domestic uranium enrichment or spent fuel reprocessing, processes that can be used to produce the explosive material for a nuclear weapon.

In the case of the United Arab Emirates (UAE), the US nuclear industry lobbied hard during the UAE procurement process of the mid- to late 2000s to convince the US government to push for a US vendor. Because US industry is private, it is not operating under the same terms as the state-owned or state-controlled nuclear vendors in Russia, China, or France. One of the arguments that US industry made in the UAE case, and is consistent throughout discussions of US nuclear competitiveness, is that the United States does not just export a reactor; it also exports its culture. This fundamentally refers to safety culture, but has been expanded to include nuclear security and nonproliferation.

The UAE chose South Korea's Korea Hydro & Nuclear Power Co. as the vendor and lead contractor for its four-unit plant at the Barakah site despite heavy bilateral governmental pressure from the United States, France, Russia, and China, whose companies were also bidding on the deal. The United States did manage to contract with the UAE on several activities related to the construction and operation of the plant. In conversations with the author, US nuclear industry representatives cited these ongoing relationships as strong strategic partnerships and key pathways for US nuclear culture. This outcome demonstrates that, even if one accepts the argument that direct commercial engagement is a vector for positive influence on non-US nuclear programs, it is not limited to the reactors.

1. Note here that the terms "vendors" and "purchasers" refer to countries, but the commercial transaction may be between private companies rather than government entities. In either case, nuclear trade is an extension of political and diplomatic relationships, but the extent of influence to engage in, for example, a deal with unfavorable financial terms will be under more or less control depending on how much government ownership or control the companies have.

For the United States, when considering how to respond to another country's interest in nuclear activities, there are multiple levels of engagement (including nonengagement) that are possible:

- The United States is a passive observer, accepting a country's interest in nuclear energy but not wading into the political or commercial activity directly. In this case, the United States would refrain from attempting to participate in the project or disrupt it, bilaterally or via international/multinational forums such as the United Nations Security Council.
- US companies freely compete to provide goods, services, or equipment on a commercial basis.
- The United States provides active government-to-government support enabling the program of the partner country through commercial arrangements, regulatory cooperation, and political and diplomatic channels, including in multinational/international forums.
- The United States creates full collaborative partnerships, as envisioned in models such as multinational facilities and build-own-operate arrangements.

One way to think about these options from a purely policy, rather than commercial, perspective is to identify the lowest level of engagement possible to maintain US proliferation objectives. Less policy

One way to think about these options from a purely policy, rather than commercial, perspective is to identify the lowest level of engagement possible to maintain US proliferation objectives.

intervention would require fewer resources, such as political capital, and lower risks. From a commercial perspective, on the other hand, the goal generally would be to get the highest and most sustainable level of US supplier activity in the project. In practice, however, nuclear projects do not tend to adhere to these strict, exclusive categories, and neither of these options reflects the complex-

ity of the relationships between states and the layers of influence and decision-making related to proliferation-sensitive activities.

CASE STUDIES

The following examples, chosen because they are the most cited cases, demonstrate the unreliability of nuclear cooperation as a means or measure of political influence on nuclear programs. The diversity of the examples suggests that such influence has been successfully wielded, but not consistently or predictably.

Taiwan

In 1969, Taiwan purchased a Canadian 40-megawatt (thermal) heavy-water-moderated research reactor, which could conceivably produce enough plutonium for up to two warheads per year if the plutonium were separated from the reactor's spent fuel through reprocessing. Over the course of the next several years, Taiwan procured a plant to make the heavy water (in which the hydrogen atoms are the rarer, heavier isotope deuterium instead of the isotope found in ordinary water) necessary to moderate the reactor, a fuel fabrication plant, and a small plutonium-handling facility in various international deals, along with a small reprocessing plant from a French firm.

After Taiwan's departure from the International Atomic Energy Agency (IAEA) in 1972,² the

IAEA continued to safeguard the Taiwanese nuclear program under a trilateral agreement with the United States. By the mid-1970s, US intelligence con-

cluded that Taiwan was conducting a small nuclear program with the ultimate goal of producing a weapon and could have the capability to do that within five years. By 1976, the IAEA had identified safeguards violations. In addition, news outlets in the United States were reporting that Taiwan had begun reprocessing, although those reports were not confirmed (Binder 1976).

As more and more potential violations came to light, the United States demanded in 1977 that Taiwan cease all nuclear fuel cycle operations – that is, activities that could take place before and after fuel is loaded into the reactor, including enrichment of uranium and reprocessing of spent fuel. Taiwan, however, continued, and the United States found signs of a covert uranium enrichment program. In 1978, the United States threatened to cut off supplies of low-enriched uranium (LEU) fuel for Taiwan’s reactors; that threat helped lead Taiwan to finally acquiesce to demands not to develop further reprocessing facilities or engage in reprocessing or enrichment activities. Taiwan shut down its research reactor and a plutonium chemistry laboratory, and all “hot cells” were converted to remove their reprocessing functionality. Taiwan sent 863 grams of plutonium (Fitzpatrick 2017) to the United States, which had been the supplier of the LEU fuel that Taiwan had irradiated and then reprocessed to extract the plutonium.

In this case of nuclear relations, it was a combination of nuclear leverage – the risk to Taiwan that it would not be able to operate NPPs without US-supplied fuel – and political isolation resulting from the growing power of Beijing that influenced Taiwan’s decision to step away from proliferation-sensitive activities.

India

Canadian aid to India in the nuclear field began in 1956, revolving primarily around the building of two Canadian-design nuclear power plants at Trombay and in the Rajasthan Desert in India. In May 1974, India detonated the covertly developed “Smiling Buddha,” the first confirmed nuclear test by a country that is not one of the five nuclear weapon states recognized by the Nuclear Nonproliferation Treaty (NPT). India declared that this event was a peaceful nuclear explosion. The plutonium for the nuclear test was produced in the CIRUS reactor in Trombay, which was supplied by Canada and used heavy water supplied by the United States. Within a week, the Canadian government publicly declared that the nuclear test was a clear violation of the agreement between the two states and suspended its aid to the Indian atomic energy program.

The Indian government said that the Smiling Buddha test did not violate the terms of the agreement with Canada because it was a peaceful nuclear explosion (Committee on International Relations 2006, 75). India was not, and is still not, a party to the NPT, but in the early 1970s, the idea that peaceful nuclear explosions might have value was widely held. The NPT not only allowed for them but, in Article V, instructed the states parties to develop a process for nuclear weapon states to share the “potential benefits from any peaceful applications of nuclear explosions” with non-nuclear-weapon states. Mitchell Sharp, Canada’s secretary of state for external affairs, responded, “We have made it clear in international discussions and in bilateral exchanges with India that creation of a nuclear explosion for so-called peaceful purposes could not be considered as a peaceful purpose within the meaning of our cooperative arrangements” (Fitzpatrick 2017).

The United States did not likewise cut off nuclear supply to India in response to the Smiling Buddha test, but officials did successfully convince India to discontinue nuclear testing for a time. However, mostly out of sight of the public, India continued its research and development on nuclear weapons, coming to a head with the “Pokhran II” tests, a series of five nuclear weapon tests in May 1998. Condemnation was strong, in part because the Comprehensive Nuclear-Test-Ban Treaty had been concluded and opened for signature in 1996, and several countries cut off assistance and imposed sanctions (apart from humanitarian aid). While some of the sanctions were short-lived, a ban on nuclear trade instituted after the first nuclear test continued until 2008. In that year, the international community reopened nuclear trade with India in response to urging from the United States, which sought a new strategic relationship with India during the George W. Bush administration (2001-2009). The US-India civil nuclear agreement, which entered into force in 2008, was a major step backward from the consequences levied against India after its nuclear weapon tests. Bush administration officials described US cooperation with India in the context of the long-standing strategic relationship with India and as a potential boon to the struggling

2. The IAEA followed the United Nations in switching recognition of Chinese sovereignty to the People’s Republic of China.

American nuclear export sector. The results have not borne out the hopeful rhetoric surrounding the US deal or the related waiver granted to India by the Nuclear Suppliers Group to expand India's participation in global nuclear trade.

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Despite optimistic assertions during the negotiation and socialization of the Indian nuclear deal in the United States, nuclear cooperation has not proven a successful entry point into Indian nuclear posture or decision-making.

proven a successful entry point into Indian nuclear posture or decision-making. Moreover, the deal did not lead to a rush of nuclear trade with the United States, as no significant nuclear contract has been concluded between India and a US vendor.

South Korea

In his article "Atomic Leverage: Compellence with Nuclear Latency," scholar Tristan Volpe explores when, in a given country's nuclear technical development, officials have the most capacity to leverage nuclear weapon ambitions to practice coercive diplomacy with partners or adversaries. While focusing on how potential proliferant states use nuclear latency to compel political action, his case studies also identify areas where nuclear suppliers held cooperation at risk in order to influence problematic, proliferation-related activities by potential customers (Volpe 2017).

After beginning nuclear cooperation with the United States in the 1950s, South Korea steadily expanded it. This relationship coincided with growth in the country's civilian economic trade in many sectors after the Korean War. As the major partner on nuclear projects in South Korea, the United States could exert more leverage to constrain the country's potential interest in fissile material production and possibly other nuclear hedging behavior.

South Korea worked in the 1970s to diversify its pool of potential suppliers by seeking to procure

a nuclear reactor from Canada, a fuel fabrication facility from Belgium, and a spent fuel reprocessing facility from France. By developing a capacity to produce fissile material, South Korea wanted to influence the United States' decisions about withdrawing more forces from Korean territory. In response to Seoul's actions to develop a potential nuclear weapon capability, the United States not only refused to provide

stronger security assurances to the South Koreans, but also compelled them to cancel their reprocessing contract with the French. This action was clearly not just about the threats

to nuclear cooperation, however. The Ford administration sent a message instructing the US embassy in Seoul to deliver a *démarche* to the South Koreans, saying in part, "We must make indelibly clear that far more than our nuclear support is at stake here, that if ROKs proceed as they have indicated to date [the] whole range of security and political relationships between us and ROK will be affected" (Sneider 1975).

The example of South Korea demonstrates that leverage resulting from nuclear cooperation is not a one-way street; the purchaser can attempt to influence the supplier as well as the other way around. Similarly, resolution of nuclear "hostage-taking" may extend beyond the nuclear sector, potentially affecting the broad bilateral relationship.

Japan

Japan, like South Korea, was an early recipient of US technical assistance in nuclear energy, mostly to boost its economy in the post-World War II era. Japan is a special case for nuclear latency since it is the only non-nuclear-weapon state to have acquired the capability both to enrich uranium and to reprocess spent fuel. Efforts in the early 1950s by Japan to threaten that it would develop its own nuclear deterrent left US officials unimpressed. Volpe asserts that the Eisenhower administration never took Japan's threats seriously because the United States maintained too much control over the supply of fuel for Japanese reactors and

could have blocked any overt Japanese attempt to produce a nuclear deterrent.

A decade later, Japan tried the same tactic again. By this time, Japan had made significant progress in its own fissile material activities, including conducting reprocessing experiments. Over the course of several years, Japan successfully used the nuclear threat of developing further nuclear capabilities in negotiations that eventually led to the return of Okinawa to Japanese territorial control in exchange for Japanese accession to the NPT in 1970 (Kissinger 1969) and the elaboration of the Three Non-Nuclear Principles, which (mostly) ended Japanese official discussion about pursuing nuclear weapons for self-defense.³ This example shows the limits in negotiating room when the domestic nuclear activities under discussion are more autonomous and less reliant on international cooperation.

Ukraine

Ukraine is heavily dependent on nuclear energy; it has 15 active reactors, fulfilling approximately half of the country's electricity needs. Although Ukraine has fairly substantial natural-uranium reserves – it mines enough of its own uranium to fulfill approximately 30 percent of its domestic needs – it does not have domestic enrichment capabilities. Historically, Ukraine has relied on Russia for most of its nuclear services and fuel supply.

The example of South Korea demonstrates that leverage resulting from nuclear cooperation is not a one-way street; the purchaser can attempt to influence the supplier as well as the other way around.

However, the annexation of Crimea in 2014 led to a significant rift in Ukraine-Russia relations, which spilled over into energy supply. For example, from 2011 to 2013, 92 percent of imported gas and 40 percent of imported oil in Ukraine came from Russian suppliers. By 2015, 63 percent of imported gas was coming from the EU, and imports of Russian oil were down to 20 percent. By 2019,

Ukraine was importing no natural gas from Russia (Naftogaz, n.d.).

Despite these extremely frayed relations, there is very little evidence to suggest that Russia threatened to cut off nuclear fuel or other nuclear services to Ukraine over the last five years. Over the same time period, Russia has threatened oil and natural gas supplies, so it has not demonstrated qualms about interfering in Ukraine's energy security. However, either because Russia has made threats that are not public or because Ukraine is acting proactively to reduce future uncertainty, Ukraine has taken significant steps to diversify nuclear services and uranium and fuel supplies to reduce reliance on Russia. Westinghouse, for example, has taken a much stronger role in Ukrainian nuclear fuel supply. As one of only two suppliers of VVER fuel, the other being Russia's Rosatom, Westinghouse went from supplying fuel for two Ukrainian reactors in 2016 to six reactors in 2018. (All of Ukraine's reactors are the Russian-supplied VVER type.) It also signed a new contract that would allow it to supply the fuel for an additional reactor starting in 2020. Westinghouse's share of the Ukrainian nuclear fuel market therefore will be nearly as large as Rosatom's (Timchenko 2018).

Energoatom, Ukraine's state nuclear enterprise, has also been active over the past several years in signing agreements with nuclear companies based outside Russia for things such as safety upgrades and reactor capacity uprates (with Belgium's Tractebel Engineering); upgrading of turbine hall equipment (with Poland's GE Power Sp. Zo); and

completion of Units 3 and 4 at Khmelnytsky NPP, an agreement formerly with Russia's Atomstroyexport (with South Korea's Korea Hydro & Nuclear Power Co.) (World Nuclear Association 2020). Ukraine's actions indicate that it does not have confidence that the nuclear sector will be immune from attempted influence or coercion, but they also reflect the general turning away from Russia

3. The three principles are "not possessing, not producing and not permitting the introduction of nuclear weapons" (Sato 1967).

across economic sectors as an understandable response to Russia's invasion. The United States has actively sought to support Ukraine's efforts to sever nuclear dependence from Russia. US policy in support of Ukraine crosses sectors, and energy independence has been a high priority for Ukrainian leadership.

The Ukraine case is not about influence on proliferation-related activities; it is an example of tying nuclear cooperation into the broader strategic relationships between countries. In this case, Ukraine used the potential vulnerability of its energy and nuclear energy to draw in the United States as a strategic counterweight to Russia. For its part, the United States seized the opportunity to use nuclear fuel supply as a counter to Russia's leverage on Ukrainian infrastructure.

CONCLUSIONS

From the above case studies, it is hard to draw broad conclusions about the role of nuclear cooperation in influencing proliferative behavior. That is exactly the point. The evidence to date, admittedly from a relatively small sample, is that peaceful nuclear cooperation has at best an incremental effect on a country's decision as to whether it will pursue proliferation-sensitive activities and that established nuclear relationships have inconsistent effects on the success of efforts to sway nuclear decisions in partner states. It is therefore unjustified to advocate for reactor sales on the basis of nonproliferation influence. Timing, bilateral relationship dynamics, economic interdependencies, influence of third parties, and historical anomalies all have played a part in whether an existing or proposed nuclear collaboration will supersede other priorities or recede when bilateral political decisions that are fundamental to national security, posturing, or signaling are being made. Even relationships founded on trust and cooperation can shift due to administration changes and technological advances. Neither attempted influence on nuclear decision-making nor attempted leverage through proliferation threats have proven consistent tools for supplier or customer countries. No sweeping statements about the effects of peaceful cooperation hold up to scrutiny.

Those who support US nuclear trade cannot continue to parrot the message that US nuclear cooperation is a primary point of access into other countries' decision-making down the road on nuclear weapons and proliferation. First, this message is not consistently borne out by historical examples. In the cases in which such linkages between supply and policy have been successful in influencing proliferative behavior, the broader security dynamic between the countries appears to be more influential than nuclear cooperation alone. Second, clinging to this outmoded thought process limits the imagination needed to develop holistic approaches to nuclear nonproliferation and nuclear security that are tailored to each country and its specific political and geostrategic position.

There may be cases in which the United States can compel nonproliferation behavior through nuclear cooperation. Such cooperation does not necessarily have to involve the provision of nuclear reactors themselves but could instead include fuel services and assurances or regulatory cooperation. These tools can and should remain viable options, but their effectiveness should not be overstated.

Nonproliferation actions that the United States is seeking must coincide with the nuclear cooperation. For example, if the United States wants to influence **another country's** decisions about national enrichment or reprocessing or openness to international verification, **the country must make its commitments in those areas up front.** That is the moment of effective political leverage, if it exists. Commitments to take action in the future are much less reliable. To offer nuclear cooperation now in the hope that one might have influence later is the nuclear equivalent of Popeye's friend Wimpy saying "I'd gladly pay you Tuesday for a hamburger today."

The nonproliferation toolbox needs to be much bigger than leverage through nuclear cooperation. If countries pursue nuclear cooperation for the purpose of political leverage over proliferation-sensitive activities, they should make it part of a broader, flexible approach that keeps the focus on the most important goal – reducing the risk of the spread of nuclear weapons – and does not allow the means to become the end. ■

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JON B. WOLFSTHAL

Reducing Demand-Side Pressure on Proliferation

The global nonproliferation regime has been remarkably successful in limiting the spread of nuclear weapons. The United States has been a leader in this effort, making nonproliferation a top priority for two generations. Part of this success has come from restricting access to the means to produce nuclear materials through export controls, sanctions, and even the use of military force. These “supply-side” efforts get much of the attention in policy and academic circles. However, a critical and often overlooked part of the nonproliferation success story has been Washington’s ability to reduce the demand for nuclear weapons among friendly states through a variety of tools.

One such tool has been the use of alliances, particularly in Europe and East Asia, often backed by broader economic, diplomatic, military, and political engagements and integration. This alliance-focused approach is vital to maintaining a strong, vibrant, and globally competitive United States. Today, however, the ability of the United States to use its strong global position to empower its alliances and maintain its friendships as tools to lessen the demand for nuclear weapons is in question, along with its future global status.

The United States has an overriding security interest in keeping the global stockpile of nuclear weapons at the lowest possible level, preventing new states from acquiring these weapons, and

reducing the prospects for nuclear use. As the world's lone conventional superpower, working to reduce the role played by nuclear weapons globally and the prospect of their use is directly in Washington's security interest. A proliferated world is inherently less stable and more complicated. One need look no further than the hand-wringing that accompanied the prolonged

There is growing uncertainty among US allies about the future direction of Washington's foreign policy and the extent to which allies can continue to rely on US security assurances for their own security.

absence of North Korean leader Kim Jong Un in early 2020 and the concern that his unexpected death could lead to the loss of control over his country's nuclear weapons to understand some of the reasons why. The same type of concern was even more starkly apparent when the Soviet Union collapsed, and the United States, the European Union, and others spent billions to help Russia secure all of the Soviet Union's former nuclear assets under effective control. Nuclear weapons can make normal situations problematic and can make hard problems even harder.

This essay looks at potential proliferation dynamics among US allies in Europe and East Asia and steps the United States can take in the future in both cases to help maintain the role alliances play in blocking proliferation.

KEEPING ALLIES CLOSE

The United States is seeing a shift in some of the traditional concerns about allies and nuclear proliferation. The dangers facing states in East Asia are different from those facing Europe, and the perception of risk within the NATO alliance is very different from state to state. Generally, there is growing uncertainty among US allies about the future direction of Washington's foreign policy and the extent to which allies can continue to rely on US security assurances for their own security. The

latter issue, of course, is not new. Doubts about the depth of the US commitment to allied security have been a feature of US alliance management since these alliances were created. Questions about Washington's underlying belief in the value of alliances are a more recent challenge. While tensions among NATO allies – especially in the run-up to the invasion of Iraq – were a major source of concern,

the more recent doubts about whether the United States is actually committed to European allies under President Trump are a major shift.

These doubts and concerns, however, do not mean that any

US allies are about to “go nuclear” anytime soon. It is common to hear such concerns among US policymakers committed to current nuclear policy; they argue that allies might pursue independent nuclear weapon programs should the US move to reduce its reliance on nuclear weapons. And there are increasing calls within some NATO allies to reconsider their reliance on the US nuclear deterrent (Drozdiak 2019; Hurlburt 2018). Yet, to date, despite major changes to US policy in all of these areas, none of these predictions has come true. While several US allies and friends have, in the past, considered acquiring nuclear weapons, sometimes even taking steps to research the technology needed to build such weapons, no formal US treaty ally has crossed the nuclear threshold since the Nuclear Nonproliferation Treaty (NPT) was signed in 1968.

While past performance is not a guarantee of future success, the United States has proven very capable of preventing proliferation to allies as long as it remains committed to a strong alliance system. US allies have not gone nuclear because the United States has worked to maintain vibrant and credible alliance systems, and Washington has seen indicators of nuclear interest as signs of concern about its commitment to the security of allies. This points to a basic truth about nuclear weapons: states that acquire nuclear weapons do so based primarily on their own internal security calculations, and the credibility of the US commitment to allies' security is a major component of that calculation in many

states. To the extent that the allies see the United States as being less than fully committed to their security or less than fully capable of protecting their interests, the potential demand for nuclear weapons can be expected to rise.

DIFFERENT ALLIES HAVE DIFFERENT INTERESTS

There is an unfortunate tendency to lump the views of all allies together and to treat each ally as a monolith. In fact, the diversity of opinions within these states is often as great as within the United States, and the views one hears about the risk of alliance disruption tend to be a reflection of the people one chooses to ask. Defense officials in the United States tend to work with their defense ministry counterparts, who are focused on the need to maintain the strongest possible military capabilities to enhance deterrence and reassurance. State Department officials, on the other hand, often hear from their foreign ministry counterparts that the United States needs to maintain a strong commitment to nuclear restraint and arms control. Views within the NATO alliance are in fact quite diverse

When states consider building their own nuclear weapons or moving in that direction, that interest often signals concern about their security position as much as a direct interest in proliferation.

on these nuclear issues, with some eager to maintain and even increase the role played by nuclear weapons and others supporting moves to reduce the role nuclear weapons play in NATO strategy as a means of reducing nuclear risk overall.

There are two other realities that are worth noting before discussing the various security perceptions among US allies and the steps the United States should take to reduce potential nuclear demand among its allies. The first is that when states consider building their own nuclear weapons or moving in that direction, that interest often signals concern about their security position as much as a direct interest in proliferation. To be sure, there are

cases in which US allies have sought either to create nuclear weapons or reduce the time it would take them to acquire an independent nuclear deterrent (Kurosaki 2017). But public debates about nuclear status, or even hints about whether or not a state might have to reconsider its non-nuclear-weapon status, can also be seen as messages to US policymakers that things are trending in the wrong direction. Because of the US interest in preventing proliferation, those signals have often led the United States to increase its efforts at alliance engagement and management and to find alternative ways to enhance the confidence in US security commitments.

Second, Americans have a tendency to think it is all about them when in fact there are many factors at play in states – even close US allies – when it comes to security decision-making. The starkest example currently is that of Turkey. In September 2019, President Recep Tayyip Erdogan told a political audience, “Some countries have missiles with nuclear warheads, not one or two. But (they tell us) we can’t have them. This, I cannot accept” (Toksabay 2019). This potential interest in nuclear weapons likely has much more to do with internal political dynamics and long-standing concerns

about balancing Iran than any questioning of NATO’s willingness to come to the defense of Turkey in the face of a military threat. Understanding these security and

political dynamics is critical with allies, just as it is with regard to the possible acquisition of nuclear weapons by any other state if US and global efforts to stop proliferation are to be successful.

Some European countries continue to struggle with the desire to remain secure in the face of a potentially hostile and nuclear-armed adversary in Russia while also pursuing their desire to reduce global nuclear arsenals as part of a process leading toward elimination. There remain several states active in NATO’s nuclear sharing – including Germany and the Netherlands – where broad public support for nuclear reductions and disarmament remain major factors in broader public

policy. In these states and others, the high costs of buying a new generation of new F-35 aircraft for possible joint nuclear missions are also important domestic political considerations. Signs of the tension between NATO nuclear doctrine and a desire for change are emerging more openly, with the chair of Germany's Social Democratic Party, the junior partner in the country's coalition government, recently suggesting Germany should independently eliminate its role in NATO nuclear sharing and basing arrangements (Jones 2020).

Other NATO countries have very different concerns. Some worry about any changes that would reduce the perceived viability of NATO nuclear commitments, increasing the risk of Russian action to undermine the alliance. The recently announced US decision to reduce its military deployments in Germany is a case in point that will inevitably lead to increased concern among allies (Stewart and Ali 2020). These pressures are generally more acute the closer one gets to Russia. In France, there is an additional concern that such changes might put pressure on the continued national consensus behind the *force de frappe*. For France, nuclear weapons remain a vital symbol of French power and a factor that complicates any efforts by other major powers to undermine French security or its global standing. For states located much closer to Russia, including those that were forcibly incorporated into the Soviet Union or under Warsaw Pact domination, anything that could be seen in Moscow as weakening the US commitment to the security of NATO members – including reducing the perceived commitment by NATO to use nuclear weapons in the defense of allies – creates further doubts in the bedrock of their new security arrangements.

US CREDIBILITY AND PROLIFERATION

While US policy is not the sole determinant of whether allies will maintain their current nuclear postures, Washington has the dominant role to play. When US commitments are credible, security is enhanced and demand for proliferation reduced. The opposite is also the case; US moves that undermine confidence in its commitments and capabilities can increase the potential for

nuclear demand. Thus, a strong and credible US security commitment to Europe and East Asia – including a wide range of military, security, diplomatic, and economic factors – remains the most effective way to provide stability and prevent conflict.

However, this interaction between US credibility and proliferation has never been and is unlikely to be a stark binary choice. There is no obvious tipping point when one would be able to predict that a state that had previously decided that it does not need nuclear weapons suddenly decides the opposite. Any move by a state to fundamentally reconsider its nuclear-weapon status is by its very nature a complex decision, with political, economic, diplomatic, and, of course, military and technical implications. It would be overly simplistic to argue that evolutionary adjustments to US nuclear or military policy would by themselves lead one or more states to suddenly go nuclear.

EUROPEAN ALLIES

Europe is where states face the greatest risk that the United States and its allies will come into conflict with a nuclear-armed adversary. Russian leaders have demonstrated a continued willingness to use heightened risk of conflict as a tool of state policy. The increased pace of Russian military exercises and military signaling, combined with sustained efforts by Russia to influence the internal political dynamics within NATO countries, including the United States, has the potential to spark a direct confrontation between nuclear-armed states at almost any time. Different analysts have different ways of assessing the level or risk, but few would deny the potential for a small conflict to flare up and to grow beyond the control of the major actors.

In this environment, NATO is working to reassess the way it addresses the security landscape. Current NATO concerns include Russia's invasion of Ukraine and the risk of that frozen conflict spreading, Moscow's use of hybrid warfare more broadly (Radin 2017), Russian opposition to enhancements in NATO missile defense and conventional forces, Russia's increasing conventional deployments and

operations, Moscow's deployment of intermediate-range missiles (previously banned by treaty), and ongoing interference by Russia in internal political affairs in NATO states. The challenge of addressing all these issues, which would be considerable under any circumstances, was made harder by President Trump's general skepticism about NATO and statements that undercut the perceived commitment of the US president to fulfill his country's security obligations. Other US steps, such as the abrupt decision to withdraw 9,500 American troops from Europe; the decision to withdraw from the Open Skies Treaty; the refusal by the Trump administration to extend the New Strategic Arms Reduction Treaty, which covers strategic nuclear weapons with Russia; and the move to reduce funding for the US-led European Defense Initiative (EDI) to pay for other Trump administration priorities also undermine the belief in certain NATO states that the United States will act in ways that are consistent with European security concerns.

Yet, remarkably, in the face of both growing risks and growing uncertainties, there have been no

Yet, remarkably, in the face of both growing risks and growing uncertainties, there have been no discernible indications by NATO members to pursue an independent nuclear weapon capability.

discernible indications by NATO members to pursue an independent nuclear weapon capability. There are perhaps two exceptions to this assessment. One is the political statements by President Erdogan hinting that outside powers were somehow denying Turkey the ability to pursue nuclear weapons. The second is the previously mentioned and growing debate in Germany over the benefits of nuclear sharing within NATO, which includes the deployment of forward-deployed nuclear weapons in Europe and operational plans for non-US NATO aircraft and pilots to deliver them in a conflict. Some are saying that Germany should no longer allow US weapons to be deployed in Germany or participate in NATO nuclear operations and planning, while others are arguing Germany should instead develop a nuclear sharing or explicit extended-deterrence relationship with

France (Drozdiak 2019). But neither Turkey nor Germany is seen as likely to make any immediate decision to pursue its own nuclear deterrent.

Thus, even after four years of uncertainty under the Trump administration, the demand for nuclear weapons by US non-nuclear-weapon-state allies remains weak. This suggests the enduring strength of the barriers to proliferation and of US and NATO capabilities to deter and respond to Russian aggression. It is also clear that there are no viable alternatives to the United States at present for European states eager for security cooperation. Yet, despite this lack of alternatives, there appears to be an important reassessment taking place among European states about how they might enhance internal European security cooperation. Even here there are barriers to overcome, including the deepening German resistance to militarization and the impending retirement of Angela Merkel, who has guided German and European security policy for the past 15 years. New leaders and new ideas are needed, and it is likely that European states will continue

to look at European mechanisms to enhance internal cooperation. Regardless, European states will likely remain eager for US efforts to enhance the broader NATO

collective security commitment, giving Washington considerable leverage in broader European security and a tool to prevent possible interest in nuclear weapons among US allies in NATO.

The barriers to proliferation in Europe are strong, but should not be taken for granted. Several states have the technical and economic means to pursue independent nuclear programs and thus, US goals should be three-fold: 1) enhance the credibility of America's security commitments through further political and military cooperation and engagement; 2) further enhance the global system of rules and norms against the further spread of nuclear weapons; and 3) work to address the underlying sources of instability through direct and principles engagement with Russia. These three steps could help ensure that no new

NATO states ever perceive a security need to consider their own nuclear weapon options.¹

Enhance US Credibility

NATO remains one of the most significant US accomplishments. In combination with the Marshall

As NATO seeks to enhance both deterrence and reassurance, the priority within the alliance should be political unity.

Plan, NATO gave rise to postwar Europe, one of the most successful and prosperous political entities the world has ever known and a boon to US security and economic prosperity. Reassuring NATO allies that the United States was willing to risk its security for them was never an easy proposition, however. There is no single point during the Cold War standoff at which all allies had absolute confidence that the United States would defend their security regardless of the risks. In fact, one notable feature of NATO's history has been constant reassessment and second-guessing by allies about the full nature of this commitment, as evidenced by the frequent need to adjust military, security, and economic actions under the NATO umbrella. Increases or adjustments in force deployments and upgrades in conventional and nuclear capabilities were the norm, not the exception, in NATO history as the alliance worked to respond to what the West thought (wrongly) was Russian conventional superiority and to reassure its jittery members in the face of concerns that conflict could erupt at any time.

The level of risk to NATO today is much different than it was during the Cold War. While the alliance rightly worries about potential conflict with Russia, there is little risk of a sudden large-scale Russian effort grab part or all of Western Europe. Instead, the alliance must grapple with the more complex challenges of maintaining deterrence in an environment of instability and reducing the chance that a small conflict might grow quickly to include the larger-scale use of conventional or even nuclear

weapons. And striking the balance remains hard. How can NATO show its resolve and provide reassurance without demonstrating its capabilities and exercising them – some of the very same steps that create a risk of accident or escalation? Steps designed to reduce these risks of escalation, including

enhanced communication and risk reduction measures such as the Vienna Document and Open Skies Treaty, have been among those put at risk through Russian actions designed to de-

stabilize its so-called near abroad. Sadly, such steps have also been put at risk under President Trump and his administration's aversion to legally binding agreements and procedures.

As NATO seeks to enhance both deterrence and reassurance, the priority within the alliance should be political unity. Its members should send strong signals of commitment to each other, even in the face of ongoing discussions about how much states can and should invest in NATO's collective defense. Thus, high-level political statements by all presidents, prime ministers, and defense officials need to demonstrate the continued vitality of NATO's collective defense commitments. Furthermore, pledges to fund key initiatives, including the European Deterrence Initiative, as well as to improve the ability of NATO to identify and respond to lower-level actions by Russia, such as cyberattacks and election interference, must be enhanced and fulfilled. A key consideration should be reducing the perception both in NATO and in Moscow that there are divisions within the alliance that might prevent an effective response to a Russian threat.

This also applies to nuclear planning and operations within NATO. The majority of states want to maintain the status quo when it comes to NATO's nuclear posture, partly because they believe it is the most effective option available and partly because they fear that reopening this discussion will reveal major cracks within the alliance over nuclear policy. Some states believe that the United States should maintain its current forward-deployed

1. This may have little to no impact on internal political factors, including those at work in Turkey - a complex issue beyond the scope of this paper

capabilities and that nuclear sharing is important to NATO's credibility. Others, however, worry about the costs and security risks associated with the current policy. Lastly, some states want to avoid any broad discussion about forward-deployed capabilities because they do not want to face the domestic political implications of acknowledging the continued deployment of nuclear weapons on their territory.

The nuclear status quo has prevailed – without any real cost-benefit analysis of security and stability – for more than 20 years. A full discussion about NATO nuclear policy might yield the same outcome, unless the United States were to decide

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independently against continued forward-deployed nuclear weapons in Europe. For that to happen, the US would have to assess that the costs to security and stability were greater than the benefits of deterrence and reassurance they are thought to provide. Some in the United States would argue against such a dramatic and unilateral decision, worrying that it might be the nuclear tipping point for one or more European states. It is hard to imagine the United States doing such a thing, however, absent other steps designed to compensate for the loss of the military or political capabilities these weapons and their deployments are designed to provide. The process and outcome, therefore, would likely seek to dampen any potential increase in nuclear interest among US allies. If the United States or NATO were to decide not to keep forward-deployed nuclear capabilities in Europe, there are other steps the US could take to compensate for any perceived loss of reassurance or deterrence – including using funds intended for nuclear operations for more immediate and meaningful security programs, such as the European Deterrence Initiative. In an environment where the United States is recommitting politically to NATO and European security, it seems such an approach is viable even in the face of some European and internal US opposition.

Enhance Nonproliferation Systems

Another major success story has been the creation and maintenance of a global system of rules, laws, and norms that impede the ability of states to acquire nuclear weapons. The effort to address supply-side proliferation has been widely successful. Several states in Europe have the independent capabilities to build defense-scale uranium enrichment or plutonium separation plants and build nuclear weapons should they chose to do so. The barriers to proliferation within European states are more political, economic, and normative than technical. Here the rules within both the European Union and European states, including strong export control laws, adherence to Euratom and

IAEA safeguards, and a strong record of support for the NPT and against the proliferation of nuclear weapons can have a major impact on internal thinking regarding possible nuclear hedging and

acquisition. It is hard to imagine a European country deciding to become a nuclear-armed state without being deterred to a certain degree by the risk of facing major resistance, condemnation, and sanction from other EU partners.

Thus, the United States has an incentive not only to boost the vitality and capabilities of the global systems of nonproliferation rules and sanctions, but also to reinforce the European Union as a political and economic bloc. The more states believe that remaining in the EU is in their economic interest, the larger a role the EU's nonproliferation norms and objectives can influence internal security debates. While membership in the European Union by itself would likely not be enough to prevent a state from going nuclear, losing access to the economic and political benefits of being an EU member would be a powerful disincentive to pursuing independent nuclear options.

Address the Underlying Dangers

The problems NATO faces are primarily driven not by US policy or internal divisions, but by a potential threat from Russia. To the extent that NATO has internal divisions or challenges, they start with a need for the allies to ensure their collective security in the face of a perceived risk that Moscow

will seek to create instability or even use force against them. Thus, by far the most effective tool the United States has for preventing proliferation by NATO states is to ensure that alliance members feel secure and have confidence in the commitment and capabilities of all allies to deter and, if needed, effectively respond to any provocation from Moscow and elsewhere. Primary among these is reducing the risk that a conflict might start and taking steps now to reduce the risk that such a conflict, if it did start, would escalate to the nuclear level. This is more easily said than done, however, and even a highly effective effort would not eliminate all European concerns that originate in Russia. But smart, effective, and targeted policies by Washington can go a long way toward reducing the threat perception within NATO states.

Pursuing new or revitalized efforts in risk reduction and crisis management with Moscow, extending or enhancing arms control agreements, and finding ways to reduce the incentives for Moscow to destabilize European security are all part of that process. Even if ultimately unsuccessful, US efforts in this direction can bring security benefits by demonstrating that Moscow, not Washington, is the reluctant security “partner.” Preparing a broad new arms control proposal to pursue with Moscow, restarting the NATO-Russia Council’s work on crisis management and de-escalation, and reaffirming the unity of NATO instead of being a major source of its instability would be places to start.

The top objective is for the United States to make clear to Moscow that Washington’s commitments to NATO are ironclad and inviolable. This requires

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political steps such as statements, regular and well-orchestrated visits by key US officials, and other responsible uses of political tools of US power. Such efforts need to be coordinated with a more sustained effort to engage Moscow over security and stability issues – including but not limited to nuclear arms control issues. Reducing the risk that a conflict will erupt requires the

United States/NATO and Russia to develop and more closely abide by risk reduction measures, including between military forces. Steps such as developing common rules for possible interaction by ground forces and aircraft are needed, as well as an agreement by political leaders to reduce the number and severity of unsafe military interactions. The practice by US and Russian aircraft and navy ships of coming into close proximity and failing to always operate in a safe manner is seen – rightly or wrongly – by each side as being conducted on purpose and authorized by the political superiors of the other side. Reducing the pace of such incidents would go a long way toward reducing the risk of aggressive accidents becoming much worse.

Above all, however, the United States and NATO have a strong incentive to avoid any conflict that might lead to the use of a nuclear weapon by Russia against them. There are and will continue to be strong policy disagreements within the United States and in NATO on how to address this risk, but it remains true that such risks will not be reduced in the absence of serious, high-level, and sustained dialogue with Russia. Talk may be cheap, but it remains in short supply. Russia has sought to destabilize border areas and spread disinformation in ways that undermine political stability within NATO states, and the harmful impact of these steps is increased through the absence of such dialogue.

The security landscape in East Asia is much different and in many ways much more straightforward than in Europe. Yet at the same time, the risk of a US ally – either South Korea or Japan – deciding to pursue independent nuclear capabilities is more acute, given the lack of other options should US security commitments erode or disappear.

Japan and South Korea have two very different sets of concerns, with correspondingly different approaches to dealing with them, as well as historical and ongoing political tensions in their own bilateral relations that complicate US efforts to

manage regional security. The sources of instability and security concerns are also more complex because there are two states that are the focus of these concerns – North Korea and China. In the near term, North Korea remains the greater challenge, as its nuclear and missile programs continue to grow and pose a danger to the security of Japan and South Korea, as well as to the United States. A much greater longer-term challenge is that posed by China's growing economic and military power and the resulting questions about the ability of the United States to reassure its allies of their security in spite of that growth.

The main focus of US efforts toward North Korea is deterring the use of nuclear weapons and reducing the risk of conventional war. The long-term goal should remain the eventual elimination of nuclear and long-range missiles from North Korea. The prospects for this seem low at present, but the goal of a non-nuclear North Korea remains squarely in the interest of the United States and

Keeping South Korea or Japan from acting on any interest in acquiring nuclear weapons requires the United States to be effective in addressing the complex challenge posed by China's rise.

its allies in the region. Pursuing a realistic goal of incremental steps by North Korea toward nuclear restraint with the goal of nuclear elimination in exchange for US and South Korean economic and political engagement remains the only viable path forward in this critical area.

Keeping South Korea from considering an independent nuclear option in the face of a nuclear North Korea is a long-standing challenge, but also one the United States has vast experience in addressing. The key to this durable commitment is for the United States to remain engaged in the evolving security situation in South Korea as well as Seoul's domestic political evolution. Current irritants in the US-South Korea relationship, such as Washington seeking exorbitant payments for the basing of US troops, actually work against the long-standing US interest in maintaining a close and stable political relationship with South Korea.

Should a state such as South Korea seek to pursue nuclear weapons, it is critical that it face economic and political consequences that would outweigh the perceived benefits of going nuclear. Economic and technological sanctions from the United States may be particularly effective in the case of South Korea if the United States can develop and sustain such a policy.

Japan is a more complicated case, but one in which the country's unique historical experience of having been the only victim of nuclear attack continues to play an important role in buttressing nonproliferation objectives. Japan has multiple security concerns related to North Korea and China. These include its location within range of North Korean nuclear and missile capabilities and its shrinking technological advantage over China's conventional forces. Among the most important factors in maintaining Japan's strong commitment to its status as a non-nuclear-weapon state is a clear US approach to managing these challenges and maintaining a

robust nonproliferation regime that reinforces the costs of going nuclear.

The United States has to be a strong, reliable, and capably ally for Japan and

South Korea. As with Europe, this has as much or more to do with conventional capabilities and political management of the alliance than with nuclear capabilities. In particular, keeping South Korea or Japan from acting on any interest in acquiring nuclear weapons requires the United States to be effective in addressing the complex challenge posed by China's rise – particularly Chinese activities in cyberspace and outer space, two areas Beijing seeks to exploit to overcome US technical superiority in conventional weapons. While neither Japan nor South Korea represents a likely military threat to the other, the historical tension between the two states and the ability of that history to inflame tensions between them cannot be ignored. Should one country decide to move toward an independent nuclear capability, there would be intense domestic pressure on the leaders of the other to follow suit. Thus, US efforts to contain any proliferation pressures in any one state can pay double dividends.

CONCLUSIONS

The United States, a global economic and military superpower, has sought to prevent other states from acquiring nuclear weapons. Nuclear proliferation has been and remains one of the few developments that could undermine US freedom of action, influence, and power. In addition to reducing the prospects for wide-scale death and destruction, preventing the spread of these weapons has helped the United States maintain a dominant position globally and among its allies.

Thus, maintaining strong alliances has been both a consequence of and a key element in the US strategy of nonproliferation. If states were secure in their belief that the United States was willing and able to provide a workable system of security, then they would have no need to pursue other—possibly nuclear—means to achieve that goal. At the same time, not having to navigate a world with dozens of nuclear-armed states has made it easier for the United States to wield influence and ensure its own security, as well as that of its allies.

None of this, however, can or should be taken for granted. US allies have long relied on Washington to maintain a credible capability and intent to

protect allied interests as well as its own. Doing so is part of the compact among allies. Thus, it should come as no surprise that when the US commitment to its allies is in question—because of circumstances and personalities—there is renewed debate about whether allies might reconsider their nuclear options. Historically, the possible demand for nuclear weapons among US allies has increased as confidence that Washington would protect their interests waned. The United States needs to take these concerns more seriously. At the same time, it is important to note that the United States cannot replace intent with capabilities. The concern that allies might revisit their nonnuclear positions is not driven by any concern over US capabilities. Indeed, the United States has increased its nuclear capabilities and even its perceived willingness to use nuclear weapons under President Trump. At the same time, US credibility has declined. Instead of relying on one-dimensional tools (such as new nuclear weapons) to reassure its allies, the United States must recommit to a complex, multifaceted approach that addresses underlying security drivers while also demonstrating its firm commitment to long-standing nonproliferation norms and agreements. ■

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WILLIAM TOBEY

Extended Deterrence and Nonproliferation

DETERRENCE AND NONPROLIFERATION AT THE BIRTH OF THE NPT

Forecasts should rest upon histories at least twice as long as the period to be projected. That standard governs analyses commissioned by the US Defense Department's Office of Net Assessment to improve the Pentagon's predictive powers.¹ Such rigor is, of course, impossible in forecasting the next 50 years of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), but it underscores the importance of considering how the treaty's framers viewed the relationship between deterrence and nonproliferation to predict how deterrence and nonproliferation will evolve.

Susan J. Koch observes that the dominant narrative of the NPT's foundational bargain – nonproliferation by non-nuclear-weapon states in exchange for disarmament by nuclear weapon states – is incomplete (Koch 2018, 1). It ignores other key bargains struck by the parties, not least one at the heart of the security matter.² Two of the treaty's leading negotiators, George Bunn and Roland Timerbaev, explained it this way:

Since the first attempts to negotiate the Treaty on the Nonproliferation of Nuclear Weapons (NPT), security assurances to non-nuclear-weapon states (NNWSs) have been considered an important component of a credible world-

wide nuclear nonproliferation regime. They have been viewed by NNWSs as one of their major requirements for achieving an adequate balance between their obligations and those of nuclear weapon states (NWSs). Put simply, the NNWS proposal to NWSs has always been: “If we agree not to get nuclear weapons, will you agree not to attack or threaten us with them and to come to our aid if someone else does so?” (Bunn and Timerbaev 1993, 1)

The negotiators cited not only the assurances by the nuclear weapon states that they would not exploit their advantage, but also their promise of aid if another weapon state brandished its atomic arsenal. They added that this reality extends back to “the first attempts to negotiate the Treaty.”

Today both the NPT and extended deterrence – the promise of a nuclear-armed state to defend an ally – are sometimes regarded as inevitable, but this was not the case at the treaty’s founding. There is a rich and spirited political science discussion about why states do or do not get nuclear weapons (Reiss 1995; Sagan 1996/1997; Sagan 2011; Walsh 2001; Hymans 2010), but the

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statesmen and diplomats who devised the NPT told each other and the world what drove their decisions – in memoirs, deliberative documents, and memoranda of conversations.

As Koch explains, extended deterrence was an “essential” factor in the decision by several important states to accede to the NPT, including

West Germany, Italy, and Japan. Bonn in particular needed to be assured that its nonproliferation commitment would remain binding only as long as it received protection from NATO, which includes nuclear-armed members (Koch 2018, 1-2).

Measured by financial and technological resources, these states were among those most capable of obtaining nuclear weapons. Had they explicitly chosen not to ratify the treaty, its credibility would have been deeply impaired. Extended deterrence was necessary for their adherence, and their adherence was necessary for a viable NPT. Thus, extended deterrence was essential to the NPT at its founding.

Moreover, there was serious concern that important US allies might not ratify the NPT. The Central Intelligence Agency (CIA) judged in November 1968 that, while early US ratification would boost the treaty’s prospects, “inertia and delay have already taken their toll of support, and will be hard to overcome” (CIA 1968, 1).

The CIA elaborated, “Naturally, the *sine qua non* of the non-nuclears [sic] for yielding the nuclear option has been freedom from nuclear blackmail and a credible security arrangement in the event of nuclear attack” (CIA 1968, 2). Some NPT negotiators argued

that the necessary assurance could be provided through the UN Security Council, but with vetoes held by members of both blocs in the Cold War, the likelihood of stalemate was high. The non-nuclear-weapon states demanded that the nuclear weapon states “harden” the assurances with bilateral pledges. Even India sought protection under the US or UK nuclear umbrella³ (CIA 1968, 3).

1. Winston Churchill said in 1944, “The longer you can look back, the farther you can look forward.” (Roberts 2018, 688)

2. Additionally, the treaty was, in the first instance, an agreement between the United States and the Soviet Union not to broaden further their nuclear competition to their respective allies by giving them such weapons. Second, it was an agreement between non-nuclear-weapon states and nuclear weapon states to provide a nonproliferation pledge in exchange for access to nuclear energy for peaceful purposes and a disarmament commitment by the nuclear weapon states. Third, it was an agreement among the non-nuclear-weapon states not to engage in a costly and likely fruitless competition that would leave them less secure and less prosperous than when they had begun. Although it is often overlooked, this last bargain is a source of strength for the NPT. It likely explains why wide swaths of the globe remain free of nuclear weapons.

3. In seeking but failing to achieve protection under the US or UK nuclear aegis and then choosing to deploy its own nuclear forces, India became a natural experiment.

The five nuclear weapon states resisted those entreaties. As the CIA observed, “The nuclear powers, however, continue[d] to see the Security Council’s peacekeeping machinery as a protection against commitments and circumstances that might prove catalytic to nuclear war” (CIA 1968, 3). They squirmed under Thomas Schelling’s observation that “[t]he *commitment* process on which all American overseas deterrence depends – and on which all confidence within the alliance depends – is a process of surrendering and destroying options that we might have expected to find too attractive in any emergency” (Schelling 1966, 44; emphasis in the original).

Indeed, by any standard, extended deterrence is an extraordinary bargain, as Frank Miller explains:

In its broadest form, extended deterrence involves the commitment of American military power in all of its forms to the defense of allied interests . . . [including] the pledge that – if deterrence provided by U.S. conventional military power fails to deter aggression or coercion – the U.S. will threaten to employ its nuclear forces and will, if necessary, use them in defense of allied vital interests. . . . This puts the U.S. homeland directly at risk to a nuclear-armed aggressor in defense of our allies . . . really one of the most amazing acts of a nation state. (Murdock and Yeats 2009, 10)

Moreover, by agreeing to depend upon such a guarantee, and thereby to abjure nuclear weapons, the recipient states are also making “an extraordinary statement of faith” (Murdock and Yeats 2009, 10). Such is the core relationship between deterrence and nonproliferation.

What forces might undermine or reinforce this extraordinary bargain over the next 50 years? “Deterrence is the product of a nation’s available force multiplied times the strength of that nation’s intent to use that force” (Seybold 1979, 23) Thus, both political intent and material capability determine the effectiveness of deterrence.

POLITICAL FORCES AFFECTING DETERRENCE AND THE NPT

According to Schelling, intent is key: “To fight abroad is a military act, but to persuade *enemies* or *allies* that one would fight abroad, under circumstances of great cost and risk, requires more than a military capability. It requires intentions” (Schelling 1966, 36; emphases in the original). Will the United States⁴ continue to adhere to its “amazing” act of commitment via extended deterrence? Will the allies continue to have confidence in that commitment, and sustain their “extraordinary statement[s] of faith?”

On paper, the commitment appears unbreakable. In the first formal US Nuclear Posture Review (NPR), the Clinton administration resolved that it “strongly support[ed] continued commitment to NATO and Pacific allies”⁵ (US DoD 1995). Each subsequent NPR affirmed that commitment, including the Trump administration’s 2018 effort, which argued that “conventional forces alone are inadequate to assure many allies who rightly place enormous value on U.S. extended nuclear deterrence for their security, which correspondingly is also key to non-proliferation” (US DoD 2018, 2-3).

Of course, for extended deterrence to succeed as a nonproliferation policy, the perceptions of US allies are just as important as US capabilities and intentions. Former UK Defense Minister Denis Healey observed that it “only takes a 5 percent credibility of American retaliation to deter an attack, but it takes a 95 percent credibility to reassure the allies” (Healey 1989, 243). This paradox, sometimes known as the Healey Theorem reflects an understandable aversion to risk by states in matters related to nuclear war. Not only must the United States have the capability to deter, it must also be perceived by its allies as having the willingness to do so.

Evolving US Intent?

Unfortunately, the Trump administration, while ostensibly supporting policies of extended deter-

4. US extended deterrence is uniquely important. The US web of alliances dwarfs those of Russia and China. Moreover, Beijing appears to have tolerated (in the case of North Korea) or even assisted (in the case of Pakistan) proliferation by its comrades.

5. The policy of extended deterrence dates from the earliest days of the NATO alliance, and even before. The NPRs are only the latest authoritative manifestations of that policy.

rence and nonproliferation, did much implicitly and explicitly to undermine both. It undercut long-standing US nonproliferation policy in three ways: challenging the logic of extended deterrence; making statements casting doubt on US commitments to its alliances; and, taking abrupt and hostile actions against allies and friends.

When CNN's Anderson Cooper challenged then-candidate Trump in 2016, noting that extended deterrence and nonproliferation had been bedrock US policy for decades, Trump responded, "Can I be honest are you? Maybe it's going to have to be time to change, because so many people, you have Pakistan has it, you have China has it. You have so many other countries are now having it." He continued, "Japan is better if it protects itself against this maniac of North Korea" (Cillizza 2016). CNN later reported the response from East Asia: "Confused, shocked, bewildered. Just a few of the words used in recent days to describe Japan and South Korea's reaction to some of Donald Trump's latest comments about the region." Both Prime Minister Shinzo Abe and his foreign minister took the extraordinary step of responding to a US presidential candidate (Hancocks 2016).

Once in office, the Trump administration also cast doubt on its commitment to nonproliferation policies. In two interviews in March 2017, Secretary of State Rex Tillerson raised the possibility that the United States could, at some point in the future, favor acquisition of nuclear weapons by Japan or South Korea if North Korea failed to eliminate its nuclear arsenal (Hayes 2017). President Trump reportedly went even further in confidential diplomacy with ROK President Moon Jae-in.

President Trump also routinely railed against the economic burdens of long-standing US alliances, casting doubt on US commitment to them. Was he seeking to reclaim options surrendered or destroyed by his predecessors (as Schelling would have it)? Typical was a tweet from 2018: "What good is NATO if Germany is paying Russia billions of dollars for gas and energy? Why are there only 5 out of 29 countries that have met their commitment? The U.S. is paying for Europe's protection, then loses billions on Trade. Must pay 2% of GDP IMMEDIATELY, not by 2025" (Trump 2018a). These tweets might be considered political show to rev

up a nationalist base rather than a serious policy pronouncement on the alliance, but at the NATO summit meeting that followed,

Angela Merkel, the German Chancellor, proposed a closed-door emergency meeting. The emergency was Donald Trump. Minutes earlier, the President had arrived late to a session where the Presidents of Ukraine and Georgia were making their case to join NATO. Trump interrupted their presentation and unleashed a verbal assault on the members of the alliance, calling them deadbeats and free riders on American power. Trump threatened to go his "own way" if they didn't immediately pay more for their own defense. (Glasser 2018b)

Moreover, the level of personal animus between President Trump and other NATO leaders was astounding. Another typical tweet from 2018 sniped, "[French President] Emmanuel Macron suggests building its own army to protect Europe against the U.S., China, and Russia. But it was Germany in World Wars One & Two - How did that work out for France? They were starting to learn German in Paris before the U.S. came along. Pay for NATO or not!" (Trump 2018b).

Not surprisingly, NATO's 70th anniversary ceremonies – intended to celebrate and reinforce alliance unity – induced angst: "NATO leaders, for example, considered not holding a 2019 summit to mark the seventieth anniversary this spring as they did in decades past. They feared President Trump would blow up a meeting in controversy as he has done each time he has met with NATO leaders during the past two years. Wary of his past behavior, NATO plan[ned] a scaled-down leaders' meeting for December 2019" (Burns and Lute 2019, 2). Unfortunately, the meeting nonetheless ended in acrimony, humiliation, and a walkout by President Trump, with President Macron pronouncing NATO's "brain death" and the US president calling Macron's remarks "nasty" and "insulting." So bitter was the meeting that aides had to talk the American president out of withdrawing from NATO (Bolton 2020).

Nicholas Burns and Douglas Lute, two former US ambassadors to NATO, consulted a wide array of deeply experienced US and European diplomats

and reached the following conclusion: “President Trump’s open ambivalence about NATO’s value to the US, his public questioning of America’s Article 5 commitment to its allies, persistent criticism of Europe’s democratic leaders and embrace of its anti-democratic members and continued weakness in failing to confront NATO’s primary adversary President Vladimir Putin of Russia, have hurtled the Alliance into its most worrisome crisis in memory” (Burns and Lute 2019, 2). (Article 5 of the North Atlantic Treaty requires that an armed attack against one ally is to be considered an attack on all NATO allies.)

President Trump’s skepticism about US alliances reached across the Pacific too. Just prior to the 2019 G-20 Summit in Osaka, while acknowledging US treaty obligations to defend Japan, he said, “We will go in and we will protect them and we will fight with our lives and with our treasure. We will fight at all costs, right? But if we’re attacked, Japan doesn’t have to help us at all. They can watch it on a Sony television, the attack”

Beyond questioning extended deterrence or the value of alliances, President Trump pursued policies to punish allies.

(Higgins 2019). South Korea too has raised President Trump’s ire. At a fundraiser in 2018, he appeared to threaten to withdraw US troops from the peninsula and said of South Korea, “Our allies care about themselves. They don’t care about us” (Stracqualursi 2018).

As a result, Asia experts fret as much about America’s Pacific alliances as their Europeanist counterparts worry about NATO: “The U.S. is moving toward a rupture with two important allies, South Korea and Japan. Already, President Trump has reportedly demanded a five-fold increase in the amount South Korea pays toward the cost of stationing U.S. forces there, raising the amount to \$5 billion a year. Reports suggest that Washington is likely to seek a similar increase from Tokyo to

support the cost of U.S. troops based there in next year’s negotiations” (Klingner, Pak, and Terry 2019).

Scott Snyder explained, “The main side effect that I see is that it raises questions about the credibility of the United States as a protector, as an alliance partner and that’s not good for the relationship” (Gaouette 2019b). Vipin Narang quipped, “Nothing says ‘I love you’ like a shake-down” (Gaouette 2019b).

Beyond questioning extended deterrence or the value of alliances, President Trump pursued policies to punish allies. Such actions have little precedent within the US post-World War II alliances. Tariffs on steel and aluminum hurt key US allies. The Trump Administration threatened to impose secondary sanctions on European Union (EU) members to cut off trade with Iran, prompting EU legal action barring European companies from complying with US sanctions. Speaking of a NATO ally in October 2019, Treasury Secretary Steven Mnuchin said, “We can shut down the Turkish

economy if we need to,” after Ankara’s use of force in Syria (Pramuk 2019). Earlier, the administration also threatened to impose sanctions on Turkey for acquiring a Russian air defense system (Rappeport and

Sanger 2019). Sanctions expert Richard Nephew observed, “They are sanctioning everybody for everything. The Administration seems to think that sanctions are a surrogate for foreign policy” (Rappeport and Rogers 2019). Previous US administrations reserved sanctions mainly for adversaries, not allies.⁶

Perhaps worse was the perception that the United States selfishly cost lives in allied countries during the competition for masks that has broken out in the response to the Covid-19 pandemic in early 2020. Andreas Geisel, the Berlin state’s interior minister, accused the United States of “an act of modern piracy” when 200,000 N-95 masks that had been ordered for the Berlin police force were diverted in Thailand (Willsher, Borger, and Holmes

6. Contrast this with the George W. Bush administration’s 2004-5 refusal to support even IAEA notification of the UN Security Council of South Korea’s past violations of its safeguards agreement, although the activities had been admitted and halted and such notification is required by the IAEA Statute.

2020). Radoslaw Sikorski, a former Polish defense minister, concluded, "This pandemic has been another nail in the coffin for European trust in U.S. leadership" (Erlanger 2020). A former US official referring to the struggle to get personal protection equipment (PPE) said, "It's 'Lord of the Flies: PPE Edition.' We need some global solidarity, and instead we have global competitions" (Toosi 2020). If America's allies cannot trust the United States to protect their interests during a pandemic, why should they have higher expectations during a war?

The Allies' Response

None of the European or East Asian allies have yet adopted policies that would cast doubt on their commitments to the NPT. Nonetheless, they have begun to reassess long-standing policies that made their alliances with the United States the foundation of their security.

The head of the Bundestag's foreign affairs committee, Norbert Rottgen, said of Washington's policy under the Trump administration, "It's like your parents questioning their love for you. It's already penetrated the subconscious" (Glasser 2018a). Although less emotional, German foreign minister Heiko Maas, drew the important policy point, "That world order that we once knew, had become accustomed to, and sometimes felt comfortable in – this world order no longer exists. Alliances dating back decades are being challenged in the time it takes to write a tweet" (Glasser 2018a).

Reflecting all of these frustrations, President Macron proposed a European army in November 2018; a week later German Chancellor Angela Merkel concurred. While proposals for such forces have been around for decades – and are far from being funded, much less fielded⁷ – there can be little doubt that European confidence in America's commitment to the alliance is shaken. Hence, "Westlessness" was the leitmotif of the 2020 Munich Security Conference.

Of course, European nations do not necessarily need to acquire nuclear weapons because they

doubt US nuclear protection. The United Kingdom and France are already nuclear powers and NATO members, and their arsenals might more explicitly be devoted to extended deterrence in Europe. In 2016, the parliamentary spokesman for Germany's ruling party said in response to the incoming Trump administration, "The U.S. nuclear shield and nuclear security guarantees are imperative for Europe. If the United States no longer wants to provide this guarantee, Europe still needs nuclear protection for deterrent purposes." He proposed a European budget to finance a Franco-British nuclear umbrella (Shalal 2016).

In East Asia, Japan has the fissile material and technical capacity to deploy nuclear weapons in a short period of time, but the nuclear taboo remains strong for obvious reasons. If the US alliance remains intact, there is very little chance that Japan would choose to go nuclear. If, however, the alliance that is the foundation of Japan's security were to dissolve, Tokyo would necessarily reevaluate its other fundamental choices and assumptions.

In South Korea, a majority of citizens favor acquiring an independent nuclear deterrent (Lee 2017). More than once, the United States has had to intervene to curb South Korean nuclear-weapon research. When US President Jimmy Carter contemplated withdrawing US troops from the peninsula, he worried that he might provoke Seoul to develop nuclear weapons. According to a 1978 CIA report, "Officials in the Korean nuclear research community believe that, even while bowing to U.S. preferences on the line of work they pursue, certain activities can and should be undertaken to keep Seoul's nuclear option open." As a result, President Carter directed that South Korean President Park Chung-hee "should be told that any move to produce nuclear weapons would terminate our security relationship" (Lanoszka 2018, 140-145). Seoul is now much stronger economically and militarily than it was in the 1970s, especially relative to the North's economy and conventional forces. Pyongyang, however, now has a nuclear arsenal. In the absence of a firm US

7. The Covid-19 pandemic and its economic consequences will set back such proposals further.

8. These examples of conflict with Turkey and Saudi Arabia are raised without prejudice as to which side was right. That is less important than the fact that President Trump threatened both nations' vital interests and the effect those threats must have on the credibility of US defense commitments.

alliance commitment, South Korea would face strong incentives to build its own nuclear arsenal and its public is already willing to do so.

The examples of Saudi Arabia and Turkey will also not be lost on national leaders as they consider the credibility of US alliance commitments.⁸ In 2019, US-Turkish relations deteriorated extremely

President Biden will surely work to restore and repair America's relations with its allies, but this work will be neither easy nor immediate in its effects.

quickly, to a point once unthinkable. US military leaders believe that Turkish forces deliberately fired on one of their posts in Syria in October 2019. In response to that and a broader Turkish military incursion into Syria, President Trump said, "I am fully prepared to swiftly destroy Turkey's economy if Turkish leaders continue down this dangerous and destructive path" (Gaouette 2019a). This is not the normal behavior of allies. In the face of such threats, how could any Turkish leader take as credible US alliance commitments? Just a month earlier, Turkish President Recep Tayyip Erdogan said that he could not accept being told that his country could not have nuclear weapons (Toksabay 2019).

Similarly, the United States has repeatedly threatened Saudi Arabia. First, Congress tried to impose sanctions on the kingdom in response to the killing of journalist Jamal Khashoggi, but President Trump vetoed the measure. Later, he was the source of the threat, reportedly telling Saudi Crown Prince Mohammed bin Salman that unless Saudi Arabia cut oil production, the United States would withdraw military support (Gardner, Holland, Zhdannikov, and El Gamal 2020).

President Biden will surely work to restore and repair America's relations with its allies, but this work will be neither easy nor immediate in its effects. Moreover, if President Trump's view of alliances prevailed once, there is no guarantee that it could not again. The Biden campaign's four percentage point victory hardly stands as an irrevocable repudiation of Trump Administration policies. Defense planning

and procurement decisions take years to make and decades to implement. Under the Trump Administration, some alliance relationships deteriorated with breathtaking speed. These jolts would give any military planner pause. For most US allies, their relationship with the United States is not a peripheral matter. It is a vital national interest. If it can be washed away in an instant by a torrent of tweets, current and potential allies will seek alternative strategies and the capabilities to sustain them – perhaps including nuclear weapons. At the very least, they will try to keep their options open. Moreover, the Trump administration's America

First policies were part of a global rise of nationalism antithetical to alliances. Thus, we are unlikely to know the full extent of the injury done to US extended deterrence for years to come.

MATERIAL FORCES AFFECTING DETERRENCE AND THE NPT

In addition to intent, capability is a force for change in the relationship between deterrence and the NPT over the next 50 years. Capabilities will change in two ways. Technology will advance – leading to novel weapons – and the power balance between nation-states will evolve.

Perhaps ironically, it was not progress in the nuclear weapon realm that created the strongest imperative for nuclear proliferation; it was improvement in conventional forces fielded in the 1980s and used in war in the 1990s – stealth aircraft relatively impervious to air defenses, precision targeting, and real-time intelligence, surveillance, and reconnaissance. North Korea lived with a US nuclear weapon capability for the first five decades of its existence. It was, however, only after the United States demonstrated the ability to inflict a swift defeat on a large army while incurring few casualties – as it did in the 1991 Gulf War – that Pyongyang moved in earnest to acquire nuclear weapons. The apparent ease with which the United States used "a revolutionary advance in military capability" to inflict losses at a ratio of roughly 1,000 to 1

on what was then the world's fourth-largest army (Perry 1991) no doubt startled military planners in North Korea. Indeed, the similarities between Iraqi and North Korean armed forces must have been striking to the Kim regime – both held over 1 million men under arms, both were ill-equipped with obsolete Soviet weapons, and both relied on conscripts with dubious skills and morale. The

The ability of the United States and other great powers to deter pursuit of nuclear weapons by threatening to use those same advances in conventional military capabilities might offset imperatives for proliferation, but the record is littered with decades of failure.

imperatives to compensate for conventional force inferiority still obtain for countries that fear US use of force, such as Iran and Syria.

The ability of the United States and other great powers to deter pursuit of nuclear weapons by threatening to use those same advances in conventional military capabilities might offset imperatives for proliferation, but the record is littered with decades of failure. In North Korea, deterrence has for more than 30 years failed completely to halt Pyongyang's nuclear program because the costs of conventional war would be catastrophic for both sides. Thus, the threat of military attack was rarely credible, and even then lasted only briefly, as in 1994. While neither the Libyan nor the Syrian nuclear weapon program succeeded, neither government was *deterred* from its pursuit of the bomb. A combination of interdiction and diplomacy ended Tripoli's ambitions in 2004 and limited military force thwarted Damascus when Israel bombed the plutonium production reactor at al-Kibar in 2007.

The case of Iran is more complicated. When Israeli intelligence operatives spirited from Tehran a "nuclear archive" in 2018, they also removed any reasonable doubt that Iran had an active nuclear weapon program until 2003 – just as the International Atomic Energy Agency had concluded in its work on the "possible military dimensions" of the Iranian effort (Arnold et al. 2019). Why leaders in

Tehran decided to cancel that program remains unclear, although the presence of US forces in two countries bordering Iran may have inspired the choice. What is more apparent is that for decades, Iran has treated the nuclear issue as an optimization problem – make as much progress as possible while avoiding military attack and delaying or minimizing sanctions. Thus, deterrence did not solve the

Iran nuclear weapon problem although it might have delayed it, and solution by deterrence will remain elusive. (Similarly, because the Joint Comprehensive Plan of Action removed neither Iran's desire for nuclear weapons nor

its long-term capabilities to attain them, it deferred, but did not solve, the problem.)

The possibility of novel weapons – such as hypersonic glide vehicles, nuclear-powered long-range cruise missiles, and long-range nuclear-armed underwater drones – sometimes provokes speculation about whether and how deterrence might be affected. In fact, however, none of these potential systems would fundamentally affect either the state of nuclear deterrence between the United States and Russia or incentives or disincentives faced by would-be nuclear-armed states. Moscow and Washington already have the capability quickly to inflict catastrophic damage upon each other, and each has a reliable capability to retaliate. The novel weapons will not change that. Similarly, potential proliferators are already vulnerable to both overwhelming conventional and nuclear forces. Maneuverable reentry vehicles would improve North Korea's ability to project power into the South, particularly with conventional warheads. But Pyongyang already holds Seoul at risk, and with it, about half of the country's citizens.

What will likely set the next 50 years apart from the past 50 of deterrence and the NPT are Chinese capabilities – economic and military, both conventional and nuclear – and Beijing's choices in wielding them. China is already an economic peer of the United States. Its military capabilities and defense spending, though, lag those of the

United States, particularly in the nuclear realm. The military gap will close, certainly in the conventional realm, and very likely in the nuclear one; both are relevant to deterrence. For example, over the past two years, China launched 80 naval vessels (Erlanger 2020), while the United States averaged fewer than 10 per year. Moreover, while the United States chooses to accept global defense responsibilities, Beijing is free to concentrate its forces closer to home,⁹ where it already enjoys clear advantages in short- and medium-range ballistic missiles, which can be armed with either conventional or nuclear warheads.

“China has stood up, grown rich, and is becoming strong”; now it aims “to win the initiative and have the dominant position,” says Xi Jinping (Brands 2020) – no more of Deng Xiaoping’s modest 1990 “hide and bide” strategy. As China’s capabilities grow and its strategy evolves (or at least becomes more transparent), Beijing’s neighbors will be watching, calculating, and planning. The Soviet threat generally caused NATO allies to shelter under the US nuclear umbrella; the heavier the downpour, the closer they huddled. A similar plot might unfold in Northeast Asia. Beijing once proclaimed pacific intentions. Now, with broken promises on respecting human rights in Hong Kong and refraining from militarizing its anthropogenic atolls in the South China Sea, “pan-Pacific ambitions” seems a more apt than pacific intentions.

Five years ago, Joseph Nye presciently warned against accepting Chinese attempts to establish “spheres of influence in which the U.S. restricts its activities primarily to the Eastern Pacific... such a response to China’s rise would destroy American credibility and lead regional states into bandwagoning rather than balancing China. Instead, a continued U.S. presence in the Western Pacific can reinforce the natural balancing reactions of regional states and help to shape the environment in a way that encourages responsible Chinese behavior” (Nye 2015).

Whether or not East Asian states seek the shelter of US deterrence, succumb to Beijing’s sway, or pursue independent means of defense – perhaps

including the acquisition of nuclear weapons – will depend on whether or not future US administrations can heed and implement Nye’s advice.

CONCLUSIONS

Ironically, those states most capable of building nuclear weapons – the technologically and economically advanced democracies in Europe and East Asia – made their acceptance of the NPT contingent on extended deterrence, which requires the continued existence of nuclear weapons. For 50 years, that bargain has stood. It has done more to prevent the spread of nuclear weapons than any other single nonproliferation policy. Because it stood so long, extended deterrence became second nature for many defense planners and diplomats, causing amnesia over how extraordinary the bargain was and how much trust it required by both the grantor and the recipient nations. The bargain has also withstood severe tests, such as the Suez Crisis, the Berlin Crisis, and deployments of intermediate-range nuclear forces in Europe.

Over the past four years, deterrence’s fundamental premise – alliance among like-minded nations dedicated to freedom and democracy – was under assault. Rising nationalism calls into question whether such alliances, so conceived and so dedicated, can long survive. The fractures caused by recent US policies are deep and sharp, even if it is in no allied nation’s interest now to discuss their full extent. Untended and unrepaired, they will grow and will provoke policies years or even decades from now implementing more-independent defense capabilities. Its defeat notwithstanding, the Trump administration will be seen as a symptom, not the cause of, nationalism and isolationism (Bremmer 2019). Under the Healey Theorem, it will take sustained, consistent, and dedicated diplomacy over a period of years longer than a presidential term to repair the damage. Moreover, this work will be done, if it is to be done, under the pressures of a historic rise in military power centered in China. That will make the next 50 years of NPT implementation fascinating to watch. ■

9. China has a base in Djibouti, and it is possible that overseas outposts will grow with the Belt and Road Initiative. But for now, these posts do not command significant resources.

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ADAM M. SCHEINMAN

Crossing the Nonproliferation-Disarmament Divide¹

The debate surrounding the relationship of nuclear disarmament to nonproliferation is a hardy perennial within the community of nuclear weapon experts and policymakers. A central, and polarizing, question is whether progress on one determines progress on the other. Wrestling this question to ground is hardly academic, since states make assumptions about that relationship when setting national policies on the whole panoply of issues on the international nuclear agenda. This essay suggests that although the evidence linking disarmament steps to specific nonproliferation outcomes is thin,

decoupling the two as a matter of policy or strategy would be enormously counterproductive, precipitating a crisis of confidence in the nonproliferation regime and the role of arms control in stabilizing major-power relations. Because neither nuclear deterrence alone nor nuclear disarmament alone can guarantee international stability, the wider effort to address nuclear weapon risks requires updated strategies that hold each strand in balance. In a period of geopolitical transition, how well the United States and others rise to this challenge may well be a defining strategic issue of the next decade.

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ASSESSING THE NONPROLIFERATION-DISARMAMENT NEXUS

Does history support the claim that disarmament steps slow proliferation? A fair reading of the record is largely inconclusive and not terribly revealing. On one side of the ledger, during the 1990s and into the 2000s, Iran and North Korea, the two most significant proliferation cases of the last two decades, accelerated their covert nuclear and missile programs at a time when the United States and Russia, the two largest holders of nuclear weapons, were reducing their strategic nuclear stockpiles to levels not seen since the early years of the Cold War. This was also a period in which the A. Q. Khan network was peddling black-market nuclear technology and India and Pakistan conducted a series of nuclear weapon tests in May 1998, bringing their bombs out of the basement and ending proliferation reversal as a realistic policy option for South Asia.

On the other side of the ledger, the 1990s produced a series of major nonproliferation wins: indefinite extension of the Nuclear Nonproliferation Treaty (NPT), adoption of the Additional Protocol to International Atomic Energy Agency (IAEA) safeguards agreements to help detect covert proliferation programs, and the wholesale update of the Nuclear Suppliers Group policies and control lists to regulate exports of sensitive items and technologies. There was more good news. In 1991, South Africa dismantled nuclear weapons it had developed in secret and joined the NPT as a non-nuclear-weapon state, becoming the only nation in history to build and give up the atomic bomb. In the same year, Brazil and Argentina gave up their presumed nuclear weapon programs following the transition of each from military to civilian rule. And by 1995, Ukraine, Belarus, and Kazakhstan had returned nuclear weapons inherited after the collapse of the Soviet Union and joined the NPT as non-nuclear-weapon states.

One problem with making judgments about proliferation choices is that the sample size is so small (Sagan 2011, 227). Because only a handful of states have developed nuclear weapons, much more is understood about the reasons states have not done so. Nine states are known or thought to have nuclear weapons today, the same number

as 30 years ago. (South Africa dropped out of the club, and North Korea opted in.) This is a remarkable accomplishment given predictions in the 1960s that 20 to 25 states could soon have nuclear weapons. The proliferation literature enumerates a wide range of contributing factors, including widespread support for a nonproliferation norm and a set of rules to uphold it, major-power cooperation on nonproliferation, and the role played by US nuclear security guarantees extended to treaty allies. On occasion, US diplomatic pressure played an outsized role, for example, in turning off undeclared nuclear programs in South Korea and Taiwan in the 1970s and 1980s and conforming multilateral nuclear trade standards to the US Nuclear Nonproliferation Act of 1978.

For the handful of known proliferation cases, security considerations best explain state behavior. Pakistan and Israel fought multiple wars against regional adversaries and likely view nuclear weapons as necessary for national survival; India sought nuclear weapons to counterbalance Chinese power and keep Pakistan in check; and North Korea presumably sees nuclear weapons as providing protection from coercion or military attack. While Iran seems to have deferred a decision on whether to pursue nuclear weapons, its record of nonproliferation violations, paired with its regional aspirations, suggests security motivations are very much in play. Dynastic survival (North Korea), political legitimacy (Iran, Pakistan), and national or scientific prestige (India, Iran) also factor in these proliferation cases, but none can be explained in the absence of a security-based rationale or by failures to advance nuclear arms control or other disarmament-related actions.

Just as security drove US and Soviet acquisition of nuclear weapons in the 1940s, security considerations brought them to cooperate on nonproliferation two decades later. China's entry into the nuclear club in 1964 set off alarms, leading the Johnson administration to pivot from talks on transferring nuclear weapons to Europe for NATO defense to talks on a global treaty to prevent their further spread (Gavin 2012, 76). The benefits of barring German or Japanese nuclear armament were hardly lost on the Soviet leadership, bringing the superpowers together in multilateral talks just several years removed from the Cuban Missile Crisis. The draft treaty texts tabled by US and

Soviet negotiating teams contained no obligations relating to nuclear disarmament. That came later at the insistence of non-nuclear-weapon states who sought to balance a pledge of abstinence against a commitment to end the arms race and take steps that contribute to nuclear disarmament.

The priority and precise relationship of nonproliferation to disarmament in the NPT remains an unsettled issue even now, 50 years into the treaty. It is the source of intense debates that roil the NPT's political process, dividing parties into rigid camps whose disagreements on disarmament are legion. Some see spotty progress on disarmament as an indication of bad faith whereas others regard it as a function of major-power relations. Some anticipate that entry into force of a Comprehensive Nuclear-Test-Ban Treaty, a follow-on agreement to the New Strategic Arms Reduction Treaty (New START), or other such treaties will bear on the decision of states to pursue nuclear weapons or tighten nonproliferation rules, whereas others are less sure. Still others worry about

The priority and precise relationship of nonproliferation to disarmament in the NPT remains an unsettled issue even now, 50 years into the treaty.

backsliding on nonproliferation with the collapse of the Intermediate-Range Nuclear Forces (INF) Treaty, whereas others are less concerned.

Supporters of arms control are generally bullish on linkage, citing the potential to generate political support for nonproliferation reforms or coercive measures to confront proliferators. Arms control skeptics are far more bearish, dismissing these gains as wishful thinking or juice not worth the squeeze on the grounds that arms control constrains the very type of military power required to deter would-be proliferators (Knopf 2012/13, 93). How to account for these very different attitudes and conclusions on the question of linkage? To get at this, below are three takes on the nonproliferation-disarmament divide expressed as problems:

first, the problem of differing understandings of the NPT's legal requirements; second, the problem of "isms" and how states understand the world to operate; and third, the problem of hedging both by nuclear weapon and non-nuclear-weapon states. Each reveals sources of friction that say more about what separates states on this issue than what might bring them together.

The Legal Problem

Where one stands on arms control linkage largely tracks with assumptions made about the legal relationship of nonproliferation and disarmament under the NPT. One perspective treats these obligations as equivalent, meaning parties are not free to insist on total implementation of one (nonproliferation) while deferring work on the other (disarmament). According to this theory, the NPT's five nuclear weapon states (the United States, Russia, the United Kingdom, France and China) are obligated under Article VI of the treaty not only to *pursue* nuclear disarmament, but to *achieve* it.

A majority of the treaty's non-possessor states support this formulation, consistent with an advisory, nonbinding opinion of the International Court

of Justice in 1996 (Highsmith 2019, 9-29). Seen from this perspective, the nuclear powers not only lag far behind the non-nuclear weapon states in meeting their NPT commitments, but also risk hollowing out support for the treaty by failing to advance one of the treaty's principal requirements.

An alternative legal view holds that the two are indeed unequal obligations, as might be gleaned from the treaty's title – the Treaty on the *Non-Proliferation* of Nuclear Weapons. Disarmament from this perspective is best understood as a supporting element rather than the treaty's primary purpose; it is regarded as an aspirational target lacking anything near the operational precision written into the treaty's nonproliferation articles, a difference not explained by sloppy drafting (Ford

2. Article VI of the NPT reads as follows: "Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control."

2007, 403). Other than calling for negotiations to end the arms race, the treaty provides no guidance on how, when, with what verification or enforcement, and under what political conditions nuclear disarmament is to be achieved.

Adding to the legal turbulence, Article VI marks out two pathways to nuclear disarmament – a stand-alone agreement or as part of a treaty on general and complete disarmament. Neither is

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remotely attainable at this point in history (the latter even less so), but partial steps along the way are – evidenced by the massive cuts to nuclear forces achieved over the last 20-plus years. To the five NPT nuclear weapon states and others, these and a laundry list of other meaningful arms control steps are evidence of implementation of Article VI (P5 2015). Those prioritizing the disarmament obligation welcome such steps, but generally regard them skeptically as partial, reversible, or lacking in urgency or imagination (Kmentt 2013).

Unfortunately, such legal quarrels reveal little about the effect of disarmament on nonproliferation. Upswings or downturns in nuclear arms control tend to track with successful or failed NPT review conferences held every five years (success defined as the parties reaching consensus on a final document). However, there is no direct evidence of such upswings or downturns affecting the proliferation behavior of states or generating the political support necessary to repair cracks in the foundation exposed by North Korea, Iran, and their illicit supply networks.

While it may be hard to trace a positive correlation of arms control to nonproliferation, there is, regrettably, a negative one. This involves non-nuclear-weapon states *withholding* support for nonproliferation actions as leverage to secure

commitments on disarmament. Because of this, sensible proposals to strengthen nonproliferation – for example, establishing the Additional Protocol as a legal standard for verification or nuclear trade, discouraging abuse of the treaty's withdrawal clause, or restricting the further spread of the most sensitive civilian nuclear technologies – remain on the shelf after years of futile debate. Opposition takes the form of a grievance: that non-nuclear-weapon states should not be asked

to take on added nonproliferation obligations until they see a deeper commitment to disarmament. It arises from a perception of uneven implementation of the NPT's non-proliferation and disarmament aims,

but also a conviction that disarmament actions are open to negotiation by all states, not just the possessors. This speaks to very different conceptions about how the world works and the place of nuclear weapons in it.

The Problem of “Isms”

Is nuclear deterrence essential to prevent major-power conflict, or does it pose unacceptable risks to the rest of the world? Is slow progress on disarmament a reflection of the security environment or a failure of political will and imagination? Has proliferation been held in check because of the force of a rules-based nonproliferation system or for other reasons? International relations theories are of little help here, providing vastly different answers depending on whether one favors constructivism, realism or liberalism. Under a constructivist approach, a peaceful and just world order can be shaped by broad acceptance of ethical and legal standards; under realism, states do not seek peace or justice but merely power and political survival; and under liberalism, principles and collective action are key components (Snyder 2009).

A constructivist approach is the intellectual home for the Treaty on the Prohibition on Nuclear Weapons (or “ban treaty”), which was completed in 2017

at the initiative of Mexico, Austria, and a spirited civil-society campaign to abolish nuclear weapons. Of the 80 or so state signatories of the ban treaty, none possesses nuclear weapons or sits under the US nuclear umbrella (by virtue of a treaty alliance). This seems unlikely to change for the foreseeable future, meaning that the ban treaty will not result in nuclear reductions or alter nuclear deterrence policies. However, this may not be how supporters measure success. Rather, drawing on an earlier campaign to outlaw anti-personnel landmines, it seems the aim is to delegitimize nuclear weapons on humanitarian and legal grounds, emphasizing their indiscriminate, destructive power and the incompatibility of nuclear use with the law of armed conflict. Supporters likely anticipate that the number of ban treaty signatories will grow over time, powered by a new ethic and social value that rejects nuclear weapons as a basis for human or military security.

The realist critique is generally skeptical of arms control on the grounds that it inhibits nuclear deterrence and freedom of action and may undermine the power relationships that make war less likely (Maurer 2018, 10). In the United States, arms control realists shed no tears over the collapse of the Anti-Ballistic Missile Treaty in 2002 or the INF Treaty in 2019. They warn against the dangers of arms control becoming an end in itself, producing “unsatisfactory treaties that have channeled strategic arms competition in ways that have proven inimical to US security interests” (Joseph and Edelman 2019). The nonproliferation benefits of arms control are also largely discounted. As Republican

Whether the NPT’s reconciliations are sustainable under the shadow of major-power competition and an international order stretched to the breaking point is an increasingly urgent problem.

Senator Jon Kyl from Arizona said in 2010 during floor debate on New START, US and Russian nuclear cuts have “had no discernible effect on nuclear proliferation. We have had more proliferation since, after the Cold War, we began to reduce these weapons” (Congressional Record 2010). The NPT blends elements of both realism and

liberalism. By not setting a deadline for nuclear abolition, the NPT acknowledges that nuclear deterrence may be around for some time, a nod to realism’s emphasis on military strength to preserve peaceful relations among states. And yet, by lowering the salience of nuclear weapons, the NPT embraces liberalism’s appeal to international institutions, rules, and collective action for security. In a sense, the treaty is a reconciliation of multiple traditions, drawing in states that rely on nuclear weapons for security and value the NPT’s role in blocking the emergence of nuclear-armed challengers, but also those states that prioritize disarmament and value the treaty’s energy and technology benefits and the predictability of a rules-based system.

Whether the NPT’s reconciliations are sustainable under the shadow of major-power competition and an international order stretched to the breaking point is an increasingly urgent problem. It is one that risks unsettling barriers to proliferation that the world relies on to keep the number of nuclear-armed states down and interest in arms control up. Amid such uncertainty, the temptations of states to hedge their nuclear bets is almost certain to rise.

The Problem of Hedging

Hedging is hardly a new phenomenon in the nuclear sphere. It has been a part of the nuclear order going back decades and is woven into the fabric of the NPT. States with nuclear weapons tend to look unfavorably on options that may minimize the military value of these weapons, just as

states without them hesitate to forgo development of civilian nuclear-fuel production technologies that also have military applications. For nuclear possessors, hedg-

ing can be seen in nuclear postures, deployments, and modernization campaigns and support or rejection of arms control proposals. For non-nuclear-weapon states, it is most often associated with pursuit of the full nuclear fuel cycle – enrichment of uranium and reprocessing of spent nuclear fuel. Enrichment and reprocessing (ENR) can be

used for production of fissile material for nuclear energy or nuclear bombs. Both types of hedging affect the nonproliferation-disarmament divide: the prospect of more proliferation drives nuclear deterrence requirements and tends to dampen enthusiasm for arms control, just as hedging by the nuclear powers may stimulate proliferation or hasten a loss of faith in the NPT system.

US hedging on nuclear weapon policy has a long pedigree. It colored Cold War debates on nuclear deterrence strategy and it helps explain why more far-reaching options to reduce nuclear weapons or delivery platforms were set aside in the Clinton, Bush, and Obama Nuclear Posture Reviews. Those reviews were conducted in a relatively benign security environment, with Russia reeling after the Soviet collapse and China still focused inward on economic growth. The appeal of hedging is greater today after a decade of Russian and Chinese nuclear and missile buildups and aggressive behavior by these countries in their regions, and with North Korea's emergence as a blustering, nuclear-capable state. As Brad Roberts explains, each has developed a "theory of victory" to prevail against the United States in a local military conflict by escalating to the nuclear level without inviting retaliation (Roberts 2020). The most recent US Nuclear Posture Review sought to close this gap in deterrence through deployment of precise, lower-yield nuclear weapons that are proportionate to the threat of use by adversaries (US Department of Defense 2018).

It is too soon to know whether increased reliance on nuclear deterrence will help or harm efforts to reduce nuclear risks. On one hand, US allies in Europe and Asia generally welcome steps to strengthen extended nuclear deterrence; they worry about Russia, China, or North Korea and seek options for defense other than developing their own nuclear weapons. It is also possible that upgrading nuclear deterrence would allow the United States and allies to negotiate new strategic agreements with Russia or China from a position of strength. On the other hand, pursuit of new nuclear capabilities arguably risks triggering the very action-reaction dynamic that drove the Cold War nuclear arms race. Russian and Chinese advances, for example, in hypersonic and intermediate-range ballistic missiles elicit calls in the United States for matching capabilities or strategic fixes that may require a decade or more

to deploy. Under these conditions, each country is likely to make worst-case assumptions about the forces it will face in the future, leaving arms control to wither on the vine as the nuclear powers adjust to this new military reality.

Hedging by non-nuclear-weapon states is also not a new phenomenon. Because of the inherently dual-use nature of ENR technologies, limiting their spread has been central to the nonproliferation mission from the earliest days of the nuclear age. That so few states have ENR technology or programs today is a major nonproliferation win, even if the reasons for that success are not perfectly understood. High financial cost, efficacy of multilateral and national export controls, national preferences, and the negative political attention that would accompany acquisition of these capabilities have likely all played a role to one degree or another. Possession or interest in ENR technology is not necessarily a predictor of proliferation, but it naturally raises a red flag. Intent must also be judged. It is more useful, therefore, to assess non-weapon-state hedging as the interplay of technical and political barriers to proliferation. For Japan, a country that possesses both uranium enrichment and plutonium separation plants, the technical barriers to proliferation are low, but, as a treaty ally of the United States and a state in good standing in the NPT, the political barriers are high. Of course, that could change if Tokyo had reason to doubt the US commitment to Japan's defense. For Iran, a country that built uranium enrichment plants in secret before being outed, the technical and political barriers to proliferation are low, and certainly lower today with the 2015 Joint Comprehensive Plan of Action having all but collapsed.

Non-weapon-state hedging affects nonproliferation and disarmament in a number of important ways. At a strategic level, for example, Iran's acquisition of nuclear fuel cycle capabilities drives the interest of others in the region to match it. It should therefore come as no great surprise that successive US administrations have failed to condition bilateral nuclear trade agreements with Saudi Arabia and Jordan on a legal commitment to forgo ENR technology. Arab states or Turkey are unlikely to accept a position of technical inferiority should Iran accelerate its uranium enrichment or make a dash for a nuclear weapon (Lynch 2019;

Johnson 2019). Nor do such conditions bode well for Israeli interest in arms control.

There are also effects at a national level, as seen from South Korea's interest in matching Japan in ENR technology. As one of the world's leading users of nuclear energy, South Korea bristles at US reluctance to grant it prior consent to reprocess spent fuel, as was done for Japan in the early 1980s. A recent renewal of the US-South Korea bilateral nuclear trade agreement essentially papered over differences on the issue of consent,

The disarmament and deterrence camps make very different assumptions about the requirements for security in a nuclear-armed or nuclear-capable world.

though it is certain to resurface in the coming years (Squassoni 2015). And once South Korea breaks the ENR barrier, others in Asia could follow, whether for reputational reasons or strategic need as a hedge against China.

Finally, hedging affects NPT politics and debates over treaty rights and responsibilities. Amplifying an argument made by Iran, the nonaligned bloc of treaty parties – the majority of members – insist that the right under Article IV of the NPT to peaceful nuclear energy extends to a right to possess ENR technology. Others are not convinced, noting that the treaty makes no reference to such a specific right, only to the use of nuclear energy for peaceful purposes in conformity with the treaty's nonproliferation requirements. This dispute generates diplomatic contortions in the NPT process. Non-nuclear-weapon states protect a fuel cycle "right" that, if exercised, would dramatically complicate the achievement of nuclear disarmament, while those seeking strict limits on the fuel cycle invite the resistance of the states whose support is needed to enact nonproliferation reforms (Miller 2012, 3).

A couple of points are worth highlighting in this smorgasbord of frictions. First is evidence of a shared and abiding interest in preventing the further spread or next use of nuclear weapons, notwithstanding differences on how best to secure those

goals. This is good news, as it suggests that options to advance both nonproliferation and arms control remain within reach, even in the absence of consensus on the contribution one goal makes to the other. The bad news is that efforts to mobilize international cooperation on the nuclear agenda will become more difficult if the divide on priorities deepens.

Second is a pronounced disagreement over means and ends, in particular whether military or political instruments are best suited to prevent proliferation or the outbreak of a nuclear conflict. The

disarmament and deterrence camps make very different assumptions about the requirements for security in a nuclear-armed or nuclear-capable world. One side credits the role of military alliances and extended deterrence with keeping proliferation

in check, while the other gives greater weight to international agreements and norms. Sequencing is another point of significant disagreement. One side seeks disarmament to make the world safe, whereas the other believes the world must first be made safe for disarmament.

STRATEGIES FOR NUCLEAR RISK REDUCTION

Where should policy go, given such differences on the fundamentals of the nuclear issue? This is a challenge in three dimensions – supporting nonproliferation, securing major-power cooperation, and encouraging broad international support. It is a nuclear-policy version of a Rubik's cube. Three alternatives are compared below: a disarmament approach centered on the ban treaty, an option centered on nuclear deterrence, and a course that integrates deterrence, arms control, and nonproliferation.

The Ban Treaty

The ban treaty is an illustration of a disarmament-first approach to nuclear-weapon issues. Supporters aim to build a community of interest that rejects nuclear weapons as the basis for security, aiming ultimately to establish that nuclear weapons are illegal as a matter of international law

(Highsmith 2019, 13). The campaign targets in particular countries that benefit from US extended nuclear deterrence but in which public support for disarmament tends to be strong.

An approach centered in the ban treaty is unrealistic and unlikely to generate wins on nuclear disarmament and nonproliferation where the NPT has failed (Scheinman 2019). Because no nuclear possessor will join, the treaty will not lead to the elimination of a single nuclear weapon. It will not end the arms race in South Asia; it will not reverse or freeze North Korea's nuclear program; and it will not create new or better opportunities to deal

The implication that disarmament can be divorced from the wider security context is a serious misjudgment.

with nonproliferation violations. Supporters of the ban treaty may believe these problems will disappear once states agree to get rid of their nuclear weapons, but such a leap of faith fails to explain how the security drivers that led states to pursue nuclear weapons in the first instance are to be resolved. The implication that disarmament can be divorced from the wider security context is a serious misjudgment.

Nuclear Deterrence

The antipode to a ban treaty is an approach centered on nuclear deterrence. Under this approach, the United States would do what Russia and China are doing: modernize and increase reliance on nuclear weapons to improve its competitive position. According to this view, US military superiority is thinning due to the Russian and Chinese buildup of conventional and nuclear-capable systems over the last decade, in turn impacting the credibility of US assurances to allies. The United States therefore requires new nuclear weapon capabilities and operational concepts to help dispel ideas percolating in Moscow and Beijing (and perhaps Pyongyang) that these countries can pull off a *fait accompli* in a local military conflict in Europe or Asia without risking a US nuclear response (Colby 2018, 145). As two US experts put it, Washington "must retain and modernize its lowest-yield and

most accurate weapons" if nuclear deterrence is to remain credible (Lieber and Press 2011). This camp would not welcome more proliferation by US treaty allies, but may accept it as either inevitable or tolerable if it improves the US security position in Europe or Asia (Colby 2014).

As noted, allies facing rising nuclear threats may welcome enhancements to US extended deterrence, including the current administration's decision to deploy low-yield nuclear options. On balance, however, an approach reliant principally on deterrence to the exclusion of nonproliferation or arms control is unsustainable and can do more harm than good. It would risk alienating US treaty allies, such as Germany, the Netherlands, Japan, and Australia, which play a bridging role in the NPT to keep faith with the NPT's disarmament goals. A deterrence-centered

approach would also generate new pressures for arms racing, leaving little space for arms control as a tool to foster stability or cooperation on nuclear weapon issues. Additionally, such an approach makes overly confident (and thankfully untested) judgments about the prospect of controlling escalation in a limited nuclear conflict. It also fails to explain why a deterrence-centered approach would achieve better results on nonproliferation than current regimes or why the United States should not double down on advanced conventional capabilities rather than nuclear weapons to offset the *fait accompli* scenario described above.

Implied in this strategy is a decoupling of nonproliferation from arms control and disarmament. This could prove enormously counterproductive. Given that a broad majority of UN member states support arms control and the NPT's ultimate disarmament goals, relegation of arms control to the policy boneyard would serve only to alienate states whose support is needed to sustain the nonproliferation system. It would also reduce the bargaining power of possessor states on the proliferation agenda, supply political oxygen to the ban treaty, and ultimately create a crisis of confidence in the NPT as an instrument for nuclear restraint. It may also reveal a regrettable lack of imagination on the various formal and informal

ways that arms control can be applied, even in a tumultuous security environment (Brooks 2020).

Between Disarmament and Deterrence – A Three-Legged Stool

A third approach would aim to integrate nuclear deterrence, arms control, and nonproliferation, advancing each simultaneously. This would acknowledge the essential and particular roles that military and political instruments play across the spectrum of nuclear threats. Deterrence is needed to prevent major-power crises from escalating to nuclear war while assuring allies that attempts at nuclear coercion will fail; arms control helps stabilize deterrence by correcting imbalances in nuclear forces and guarding against a race for strategic superiority while also signaling support for the NPT's disarmament goals; and nonproliferation limits the number of fingers on the nuclear trigger and erects a barrier between peaceful and military use of the atom. No single element is sufficient to meet the aims of the others; each is best understood as a load-bearing leg of a three-legged stool with the sum being greater than its parts.

A comparative advantage is its appeal to a broad cross section of states. At a political level, support for nonproliferation unites the major powers with the rest of international community (with the possible exception of North Korea). Similarly, support for arms control links the disarmament interests of non-possessors to the war avoidance aims of the nuclear powers. At a military level, this approach would best limit the competitions that give rise to nuclear arms racing and would reserve options for new agreements, cooperation, and dialogue on strategic stability and proliferation dissuasion, both generally and in the critical cases of Iran and North Korea.

As argued above, security considerations rather than disarmament actions drive countries' decisions on whether to acquire nuclear weapons. From that determination, it follows that the best way to dissuade countries from going nuclear and, more broadly, to reduce nuclear risks, is through a strategy that holds deterrence, arms control, and nonproliferation in balance and draws on both military and political instruments.

Widening the lens further, the United States and like-minded partners should consider ways in

which strategies to prevent nuclear proliferation and avoid a next use of nuclear weapons can be nested in the broader project to repair the global order and manage its increasingly multilateral form. It is instructive to recall that the greatest nuclear security gains of the first nuclear age – arms control agreements and reductions, limited proliferation, and the absence of a major-power war – materialized on account of US-Soviet (then Russian) cooperation. It is still too soon to know what form a second nuclear age will take, but it is almost certain to follow the trajectory of major-power relations. How the United States, China, and Russia compete for power and geopolitical influence will determine the pace of and possibilities for nuclear risk reduction. A return to zero-sum competition will naturally crowd out such possibilities. But those possibilities would multiply if the major powers also were to direct their energies toward options to reduce mutual suspicions and strengthen regional security and cooperation in Europe and Asia. As Henry Kissinger said in the early 1980s, “[W]e must have confidence in ourselves [that] we can solve both the arms control problem and...the political problem that is created by the deliberate creation of tensions in the world” (Riches 2016).

CONCLUSIONS

For all the political and academic ferment on the question of disarmament's effect on nonproliferation, the fact is that little more is known today than when the NPT entered into force half a century ago. Because so few states have acquired nuclear weapons, or even stepped close to the line, the empirical record is thin. Arms control may *contribute* to the goals of nonproliferation, but there is no evidence it is a *cause* of it. For this reason, many observers run to opposite ends of the line to argue either in favor of a disarmament- or deterrence-centered approach to nuclear weapon issues. Both fail to persuade, as suggested above. With some modesty, one might conclude there is no *a priori* pathway to safety in a world in which states possess nuclear arms, even if it at significantly reduced levels, and that the best option is to rely on a mix of strategies, even when elements are in tension with one another. After all, good, practicable strategies often involve trade-offs among objectives. ■

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XU TIANRAN AND MELISSA HANHAM

The Next 50 Years of Missile Proliferation

Since World War II, missile technologies have evolved at a rapid rate, and this trend is widely expected to continue. Whereas Nazi Germany's V-2 ballistic missiles were able to carry a one-ton warhead over a range of 320 kilometers, the Soviet Union was able to improve those capabilities in just 15 years for the R-7 intercontinental ballistic missile to 5.5 tons over 8,000 km. By the end of 1966, in a test, China had detonated a 12-kiloton live nuclear warhead on a medium-range DF-2A missile that was vastly superior to the German V-2 (China Academy of Engineering Physics 2014). Today, nuclear-capable missile technology is advancing and proliferating just as fast, if not faster.

More state and nonstate actors than ever before have built, bought, or stolen missile technology, and they will continue to do so in the coming decades. Furthermore, as new technologies increase the lethality, accuracy, reach, and survivability of existing systems, established military powers and new actors alike will strive to acquire them, potentially upsetting the status quo. Additionally, technologies such as computer modeling and additive manufacturing will accelerate the speed and decrease the cost at which new missiles can be tested, produced, and deployed.

This essay examines proliferation trends of nuclear-capable missiles over the past five decades

and emerging technologies in order to project how missiles might proliferate in the future. The authors explore how nuclear-capable missile proliferation transpired in the last 50 years and its implications for the next 50 years of proliferation using the story of the Scud. They then examine existing technology and how it is proliferating to new states and nonstate actors. Next, they examine emerging missile technology, which may change a state's strategic calculations. They conclude by examining the ways in which current trends affect the adoption of future missile technology and its impact on nuclear proliferation.

SCUD: THE MOST PROLIFERATED MISSILE OF ALL

In the past 50 years, the Soviet ballistic missile R-17/Scud has become one of the most popular ballistic missiles around the world because it has a relatively simple design and is easy to reproduce. It or its derivatives have proliferated to a number of countries such as Egypt, Iran, Iraq, Libya, Myanmar, North Korea, Nigeria, Pakistan, Peru, Syria, the United Arab Emirates, Yemen, and Vietnam (NTI 2015). Even some non-state actors possess this nuclear-capable, short-range ballistic missile.

Countries such as North Korea and Iran have reverse-engineered the original design and made significant improvements. For example, they replaced the steel body skin with a lighter aluminum alloy and replaced the original inertial guidance system with a more compact one. In North Korea's case, the airframe has been widened and lengthened to store more propellant. The North Korean extended-range Scud is estimated to be able to deliver a warhead of 500 kilograms to a distance of about 1,000 km (Schiller and Schmucker 2016), while the Qiam, Iran's modernized Scud, has a 645 kg warhead and a maximum range of 800 km, according to Iranian state media (Press TV 2018). Iran has proliferated the Qiam missile to the Houthi in Yemen and Syria. The Islamic State used these missiles to attack the US Ain al-Asad air base in Iraq in January 2020 with surprising accuracy (Roblin 2020). Although Iran does not possess nuclear warheads for its missiles, it could in the future.

A much more capable ballistic missile utilizing Scud technology that may continue to proliferate is North Korea's Hwasong-7/Rodong. The Hwasong-7 engine has a design that is very similar to that of the R-17/SCUD's engine, but it is bigger and offers about twice the thrust. As a result, the Hwasong-7/Rodong missile's performance almost doubled that of the Scud. After obtaining the original Scud from Egypt, North Korea scaled up the Scud and passed on the Hwasong-7 designs to Pakistan and Iran in the 1990s (Bermudez 1999).

As of now, only three countries are users or manufacturers of the Hwasong-7-origin missiles: North Korea, Iran, and Pakistan. North Korea and Iran have been improving the missile in the past decades. Iran's Ghadr, a domestic Hwasong-7 variant, has an estimated range of close to 2,000 km (Missile Defense Project 2020), which is achieved primarily by increasing the propellant volume and reducing payload mass. North Korea merely adopted a compact guidance set but did not lengthen the Hwasong-7/Rodong's airframe. It is likely North Korea can mount a nuclear device on it. Pakistan's Ghauri version of the Hwasong-7 is currently in service with the Pakistan Army's Strategic Forces Command and is capable of carrying a nuclear warhead (Inter Services Public Relations Pakistan 2018).

By clustering four Hwasong-7 engines, North Korea and Iran have built powerful first-stage engines for their space launch vehicles. Even assuming Hwasong-7 technologies will not proliferate further, if similar engine-clustering is adopted, Scud-possessing countries with enough of an industrial base could in theory be able to build a midrange ballistic missile with performance close to that of the Soviet R-12. Alternatively, Iran and North Korea could choose to proliferate their systems as they did with the original reverse-engineered Scud.

It is also worth noting that despite the use of a lightweight aluminum alloy airframe, North Korea and Iran have displayed an ability to fuel the Scud and Hwasong-7 missiles in a horizontal position before transporting them to launchpads. The more common practice is to erect the empty missile first and then fuel it immediately before launch in order to reduce the risk of damage and accidents during transportation. Thus, fueling liquid-fuel

missiles before moving them out of their shelter could significantly reduce the amount of time for the missile systems to stay in the open. This makes them less vulnerable to surveillance and attack from adversaries and therefore more survivable.

The Scud is a perfect example of how a simple and reliable missile became the missile of choice for developing nations. If the international arms control community fails to take effective action, Scud will continue to proliferate to still more actors. Such a wave would be particularly concerning because these missiles have already been improved with lighter alloy airframes, improved guidance, and better survivability. They have also been clustered to form stages of dual-use space launch vehicles – that is, vehicles having military as well as civilian applications. This makes them an ongoing proliferation threat, particularly as the technology to develop them becomes cheaper and easier.

EXISTING MISSILE TECHNOLOGY AND IMPACT ON STATE AND NONSTATE ACTORS

In the next several decades, missile technologies currently limited to major military powers will proliferate broadly to state and nonstate actors. This will complicate the international security environment and lead to more complex proliferation networks.

Higher Performance Liquid-Fuel Missiles

North Korea and Saudi Arabia, like the long-standing military powers, possess a number of higher energy liquid-fuel missiles, namely North Korea's Hwasong-12/14/15 and the Chinese DF-3. Missiles with higher-energy liquid fuel can carry the same payload further or a heavier payload the same distance, making them an attractive step for states seeking nuclear weapons. North Korea is an excellent example of how missile capabilities became a useful indicator of future nuclear capabilities. Other countries can follow Pyongyang's path. September 2016 marked the public debut of North Korea's 80-ton thrust engine linked to its Hwasong-12 intermediate- and Hwasong-14/15 intercontinental-range ballistic missiles. This new powerful engine uses a more energetic fuel, allow-

ing North Korea to have intermediate-range and intercontinental ballistic missiles for the first time.

The US Department of the Treasury identified Iranian individuals involved with the North Korean development of an "80 ton engine," which is likely the same one that Pyongyang displayed in 2016 (US Department of the Treasury 2016). This current relationship between Iran and North Korea can be taken as an example of what future relationships between proliferating states might look like. This engine may have been collaboratively designed, though there is little evidence in the open-source literature to support such a theory.

Saudi Arabia is now the only user of the Chinese DF-3 missile, which is powered by a cluster of four YF-1 engines. Each YF-1 has thrust that is comparable to that of the Hwasong-7/Rodong, but it is more efficient with fuel. The challenge of making higher-performance liquid-fuel engines lies in overcoming difficulties presented by higher combustion temperature and chamber pressure, associated issues with cooling, and manufacturing of higher-energy propellant. Nevertheless, Scud-possessing countries with a sufficient industrial base may try to develop more-efficient engines in the coming years. If such highly efficient engines were to be proliferated, the ability of Scud-possessing countries to launch long-range attacks would be boosted significantly.

Solid-Fuel Ballistic Missiles

Compared with liquid-fuel engines, solid-fuel rocket motors are more economical and easier to handle once a state has cleared the hurdle of carefully designing and safely testing the motors. Under proper storage conditions, solid-fuel missiles can be stored for a long time with minimal requirements for maintenance, meaning they can circulate on road-mobile vehicles and be launched rapidly. Thus, solid-fuel missiles have become the primary means of delivery for the five nuclear weapon states recognized by the Nuclear Nonproliferation Treaty (China, France, Russia, the United Kingdom, and the United States) and now the other nuclear-possessing states (India, Israel, North Korea, and Pakistan) are following.

Pakistan, North Korea, and Iran have developed large, staged solid-fuel ballistic rockets. The North

Korean Pukguksong missiles have a diameter around 1.5 meters and can be launched from land-based platforms and submarines. Iran's Sejil missile is about 1.25 meters wide and is longer than the North Korean Pukguksong. The development status of these missiles remains uncertain.

Several Chinese entities have been put under sanctions for alleged missile technology transfers since 1991 (Wisconsin Project on Nuclear Arms Control 2008). In a recent incident, Indian authorities detained a Chinese ship on its way to Karachi,

Recent commercial developers of space launchers have introduced creative solutions to simplify the design of solid-fuel rockets.

Pakistan, on February 3, 2020, for allegedly declaring a false end-use for an industrial autoclave that, according to Indian authorities, can also be used in the manufacture of ballistic missiles (Gupta 2020). Separately, scholar Jeffrey Lewis claimed in 2014 that China, with the quiet approval of Washington, secretly sold DF-21 solid-fuel midrange missiles to Saudi Arabia in 2007 (Stein 2014).

Apart from obvious tactical advantages mentioned above, solid-fuel rocket motors have a simpler structure and far fewer parts than liquid-fuel engines. But developing and producing high-performance solid-fuel motors is challenging. Iran experienced a devastating explosion at al-Ghadir missile base at Bid Ganeh in 2011, though it is not known if this was due to accident or sabotage. Similarly, Iran experienced a suspicious explosion at the Shahid Bakeri Industrial Group, which makes solid-propellant rockets for the Khojir missile facility east of Tehran (Gambrell 2020). Regardless, both Iran and North Korea have moved ahead with robust testing of solid-fuel motors, making them potential new leaders in proliferation (Lewis and Schmerler 2018).¹

The Soviet two-stage, solid-fuel ballistic missile Temp-S/9K76, which entered service in 1967, can

deliver a warhead of some 500 kg over a 900 km range (Kirill 2016). As mentioned above, the same performance can be achieved by a Scud variant, which is about the same size as the Temp-S but has only one stage. Manufacturing large-diameter motors also requires mixing stations, casting stations, insulation, and machining facilities that are more sophisticated than the production line of smaller solid-fuel rockets. In addition, it is more complicated to reliably and accurately terminate thrust (to cut the power in time to achieve accuracy) of solid-fuel motors. Controlling attitude

in pitch, yaw, and roll for a solid-fuel rocket is more challenging than for a liquid-fuel engine. However, recent commercial developers of space

launchers have introduced creative solutions to simplify the design of solid-fuel rockets. For example, the Chinese KZ-1A has a liquid upper stage (Integrated Propulsion and Attitude Control System) that controls the attitude of the first three solid-fuel motor stages by lateral jet and fine-tunes the trajectory for accurate orbital insertion so that each solid stage spares its own thrust termination system and attitude control unit (except the first stage, whose aerodynamic control surfaces will take over lateral jet when the rocket reaches a certain speed). Another Chinese four-stage solid-fuel rocket, the Smart Dragon-1, uses a combination of aerodynamic control surfaces on the first stage and a lateral jet control system located in the nose cone and around the fourth-stage nozzle to control the attitude of all four solid-fuel stages with fixed nozzles (Gao and Gu 2019).

Such trends in the rapidly growing space launch service industry might encourage some countries with a weaker industrial base to pursue long-range solid-fuel ballistic missiles despite previous hurdles. Still more difficult from a regulatory perspective is the fact that space commerce will contribute to a quantitatively and qualitatively more difficult dual-use trade to control.

1. Iran's new site is at Shahrud, where the solid-fuel storage facilities can be seen with thick dirt berms to guard against future explosions. The motors are tested horizontally inside a nearby giant crater (Fisher 2018). North Korea is expanding an already large facility near Hamhung, where it similarly has built berms around storage facilities and tested motors at horizontal test stands nearby (Lewis and Schmerler 2018).

From a purely developmental point of view, more states will acquire the ability to produce larger solid-fuel motors with a width of more than one meter in the coming 50 years. Through staging technologies, capabilities for medium, intermediate, and even intercontinental range can be achieved. Export controls on dual-use civilian and commercial items are already weak, and as these technologies rapidly evolve, the law will likely continue to limp behind.

Subsonic Cruise Missiles

Subsonic cruise missiles are like mini-planes, as they rely on wings for lift and an air-breathing engine to produce thrust. They can stealthily penetrate an air defense network by flying below the radar line of sight and path planning. Some have a range of over 2,000 km. Some of these cruise missiles are also capable of carrying nuclear weapons. Inertial guidance units and satellite positioning systems are becoming more accessible to all state and nonstate players. As a result, nuclear-weapon states no longer have a monopoly on subsonic cruise missiles. Modern manufacturing methods such as 3D printing have helped to simplify the production process for turbojet or turbofan engines and lower their cost. For example, Taiwan's National Chung-Shan Institute of Science and Technology has developed a 3D-printed cruise missile engine that can be manufactured in army workshops in 40 to 50 hours (Hong 2019).

India, Iran, Pakistan, South Korea, and Taiwan have developed and deployed their own subsonic cruise missile systems. The 2019 attack on the Saudi oil facilities at Abqaiq and Khurais, while not nuclear, proved that rudimentary cruise missiles and drones manufactured by a country with a relatively weak industrial base can exhibit dangerous capabilities when it comes to avoiding detection (Brumfiel 2019).

With the increased availability of satellite positioning providers and novel production methods, production costs will drop and the effectiveness of the delivery system will increase. As a result, new countries and even nonstate actors will likely invest in land attack cruise missiles.

New Actors Interested in Existing Technologies

Interest in pursuing missile capabilities is closely associated with the strategic intentions and threat

environment of state and nonstate players. Generally speaking, those that are more likely to engage in armed conflict are more willing to pursue better capabilities as offensive and deterrent measures.

Regional tension in the Middle East, Eastern Europe, South Asia, Northeast Asia, the East China Sea and the South China Sea could continue to encourage a number of states and territories – for example, China, Japan, Malaysia, North Korea, the Philippines, South Korea, Taiwan, and Vietnam – to develop the means to conduct missile strikes. It is not difficult to envision scenarios in which missiles might be used: a possible armed conflict across the Taiwan Strait could spiral into a full-blown war; there is no clear sign of mitigation or resolution for multiple conflicts in the Middle East; the possibilities of armed conflict between Russia and neighboring countries such as Ukraine will continue. Thus, it is likely that countries and territories will invest in some of the existing technologies mentioned above to enhance their missile strike abilities. Still more worrisome is that technologies such as the Scud, already deemed a poor state's weapon, can increasingly migrate to substate groups in Southeast Asia, Eastern Europe, the Middle East, South Asia, Africa, and Latin America through proliferation.

EMERGING MISSILE TECHNOLOGY TRENDS

The proliferation of existing missile technologies to states and nonstate groups will pose new security challenges, but missile technologies will also evolve. The United States, Russia, China, and some regional powers will continue to invest in emerging technologies as they seek to continue to boost their capability to penetrate enemy defense systems.

Loitering Munitions

Recent regional conflicts have witnessed the use of so-called loitering munitions, which can remain in the air for a period of time, allowing the operator to look for and choose targets. The basic concept of the loitering munition is to put a warhead on an unmanned aerial vehicle, also known as a drone, that is flown into a target. These drones have the characteristics of both subsonic

cruise missiles and surveillance drones. This kind of hybrid is called a “cruise drone missile” (巡飞弹) in China (CCTV 2020). Thus, some modern cruise missiles, including the nuclear-capable ones, can also perform the role of loitering munitions.

Currently, most loitering munitions are small drones powered by rotary engines or electric motors. Most of them are easy to build and have a small payload. Due to their simplicity, there is little doubt that the loitering munitions will continue to proliferate into the hands of state and nonstate actors. Their

Modern supersonic cruise missiles were first used as anti-ship missiles, but their role has expanded to land attack.

designs will focus on further reducing radar and infrared signature, increasing the ability to plan an autonomous flight path, and further cutting costs. It is also possible that heavier, nuclear-capable loitering munitions will be developed in the future.

Supersonic Cruise Missiles

Supersonic land-attack cruise missiles are becoming more prevalent. These supersonic weapons are mostly powered by a ramjet engine, which enables them to reach a maximum speed of about Mach 3.

Unlike typical subsonic cruise missiles, which rely on wings and relatively dense atmosphere to provide lift, the ramjet-powered high-speed missile is best suited to fly at high altitudes to reduce aerodynamic drag and increase range. Yet there are costs to pursuing this capability. A ground-based missile defense network could see the rapidly approaching targets from afar. Compared to subsonic missiles, the heat signature of supersonic cruise missiles is also much more obvious to infrared sensors of air defense systems. On the other hand, the time to initiate an interception of such a fast-flying target is shorter. A supersonic cruise missile capable of agile maneuver could make the interception even more challenging.

Modern supersonic cruise missiles were first used as anti-ship missiles, but their role has expanded to land attack. The French nuclear-armed air-

launched cruise missiles ASMP and ASMPA, which entered service in 1987 and 2009, respectively, are among the earliest dedicated land-attack supersonic cruise missiles. In French nuclear doctrine, these are “pre-strategic” weapons serving as the last “warning shot” before the full-scale use of strategic nuclear weapons (*Bulletin of the Atomic Scientists* 1990).

Taiwan is reportedly pursuing such weapons. Its Yun Feng cruise missile is said to be based on the Hsiung Feng-III supersonic anti-ship missile and has a range of around 1,500 km. According to local media, production of the first batch of 20 missiles was approved in 2018 (Zhu 2018). Other systems include the Russian Bastion-P and the Indian Brahmos missiles. Their land-attack versions are also based on the original anti-ship versions.

China officially unveiled its massive DF-100 supersonic land attack cruise missile in its 2019 military parade. This missile may also have an anti-ship variant. Countries are increasingly likely to put nuclear payloads on such systems; doing so will deeply affect strategic calculations of the future.

Hypersonic Weapons

A hypersonic weapon is an aerial vehicle that travels at speed of Mach 5 or above and can perform maneuvers during flight. Hypersonic weapons are even faster than supersonic cruise missiles. Yet it is a common misunderstanding that they necessarily travel faster than ballistic missiles. The term “hypersonic” is used mainly to describe missiles that are capable of high-speed evasive maneuvers in flight, which complicates the task of missile interceptors deployed against them.

Major nuclear powers, such as China, Russia, and the United States are investing in hypersonic weapons. Russia declared its Vanguard strategic hypersonic glide vehicle (HGV), which is placed on top of existing silo-based liquid-fuel intercontinental ballistic missiles (ICBMs), to have entered active duty in December 2019. China has deployed its DF-17 midrange ballistic missile, which adopts an HGV as its payload. It is reported that the Van-

guard is an unpowered HGV, while the Russian Navy's Tsirkon missile is a hypersonic cruise missile that is powered by a scramjet (supersonic combustion ramjet). The missile reportedly travels at a top speed of Mach 9 with a range of about 1,000 km. It is reported that 10 more tests will be conducted in 2020-2021 before Tsirkon is to be delivered to the Russian Navy (TASS 2020). The United States is currently developing multiple

As some delivery systems can carry both conventional and nuclear payloads, states that are under attack will be faced with the increasing problem of determining which delivery devices are carrying conventional payloads and which are carrying nuclear warheads.

hypersonic missiles with a variety of capabilities and missions, including through the Navy, the Air Force, the Army, and the Defense Advanced Research Projects Agency (Sayler 2020). While the United States argues that its hypersonic missiles are not intended to be nuclear-capable, there is little to convince adversaries that they will not be.

This issue of discrimination is a problem not only for hypersonic missiles, but for all new delivery systems. As some delivery systems can carry both conventional and nuclear payloads, states that are under attack will be faced with the increasing problem of determining which delivery devices are carrying conventional payloads and which are carrying nuclear warheads. These calculations, which must be made in a matter of a few minutes, may push risk calculations to err on the side of an aggressive offensive response.

Today only a handful of countries are capable of developing long-range hypersonic weapons that can deliver a nuclear payload. In the coming decades, however, it is possible that more players, even countries with weak aerospace industries, will enter this field. North Korea has tested the KN-23 and KN-24 short-range ballistic missiles multiple times. Both are boost-glide weapons with a quasi-ballistic trajectory and can maneuver in flight. Such technologies and relevant experiences can be very helpful for the development of longer-range HGV weapons.

Nuclear-Powered Cruise Missiles

In response to missile defense systems, Russia is developing the nuclear-powered, nuclear-armed 9M730 cruise missile. Little is known about this missile, but the cruise missile can theoretically penetrate missile defenses by taking advantage of its purported "unlimited range" (BBC 2019) like a never-resting loitering munition. This is not a new idea or technology. The United States studied

such concepts and gave them up in 1964. Russia's test failure in August 2019 demonstrates that it can also result in environmental catastrophe in case of an accident of its nuclear engine. It remains

doubtful that other state or non-state actors will develop similar weapons (Axe 2019).

CHALLENGES TO CURBING PROLIFERATION

Today's emerging technologies will improve the range, payload, accuracy, and survivability of missiles. In addition, missile design, testing, and production will be faster, cheaper, and easier. High-performance computers and modeling software make development of new designs easier and reduce testing. It has become theoretically possible for every state or nonstate actor with access to a reasonable education system and industrial base to pursue missile technologies that were available only to well established military powers in the last 50 years.

The adoption of composite materials and novel manufacturing technologies such as more-advanced additive manufacturing capabilities offer faster and cheaper ways to make lighter airframes. Design information is also moving to digital formats, creating new challenges in combating espionage, smuggling and export control violations.

Today, even some start-up companies are able to build very capable solid- or liquid-fuel space launch

vehicles that can easily be converted into intermediate-range or intercontinental ballistic missiles. Some commercial liquid-fuel launchers use liquid oxygen as the oxidizer. This increases the handling requirements and limits combat readiness because these rockets need to be fueled immediately before launch. However, the majority of first-generation ballistic missiles, such as the German V-2, Soviet R-5, Chinese DF-2A, and US Redstone, used liquid oxygen as the oxidizer. Liquid oxygen could be ideal for emerging actors that want to keep open the option of military uses, as it not only offers higher efficiency but also helps promote the civilian-use-only image of their projects.

Meanwhile, more and more commercial-use receivers for satellite positioning systems and off-the-shelf commercial inertial guidance components can be put to military use, making the missiles more accurate. Would-be missile possessors these days rarely smuggle missiles in whole. To avoid customs inspections, they ship small parts that are hard to identify, raw materials, commercial machine tools, and goods whose military applications are not easily recognizable to customs officials and licensing organizations due to the volume of legitimate trade or a lack of knowledge on emerging technologies.

Export Controls

Today represents a powerful moment for missile proliferation. The commercial space industry is moving into territory that previously belonged only to states. Additive manufacturing is moving many states' most secret knowledge into a digital format, which, if stolen, is very easy to transport across a border. Laws and norms have traditionally lagged behind scientific and technological achievements. This is particularly true in missile proliferation, where the dual-use nature of aerospace technology has put considerable pressure on export controls.

Unfortunately, the entity charged with checking missile-related exports, the Missile Technology Control Regime (MTCR), is not well positioned to do the work that needs to be done. It is a voluntary

group of 35 states that does not include China, Pakistan, North Korea, or many of the countries that, due to their location, may offer launch services for space commerce in the next 50 years. The regime has been working hard to update the list of items in its Equipment, Software and Technology Annex to move away from completed delivery systems and toward components, a shift that is in line with the way missile proliferation has changed in the last 30 years. However, it is a never-ending task for which successes will become more and more difficult as the definition of "basic scientific research" will evolve rapidly in the next 50 years and the items that the regime seeks to control become more intangible (MTCR 2019).²

Impact on Nuclear Proliferation

Missile technology and nuclear weapon technology are distinct in their specific scientific details but linked in their policy impact. In the past 50 years, all states that have produced nuclear weapons also have produced the missiles to deliver them. Today, commercial launch services are available in the United States, Russia, China, and elsewhere. It is likely that rocket manufacturing, like other manufacturing sectors, will move to territories with the most favorable commercial terms. Thus, while dual-use rocket technology is likely to see rapid growth, it will not be tied to a state or nonstate actor's desire to produce a nuclear weapon.

Missile proliferation may have an impact on how existing nuclear possessors choose to deploy their nuclear weapons and signal their intent. States with more powerful missiles can afford to have a simpler, heavier warhead. At the same time, nuclear proliferation will likely have a strong effect on missiles. As nuclear warheads are designed to be more compact or have more powerful yields or both, states will seek missiles that are more survivable, accurate, and capable of overcoming missile defense systems. Since the Cold War, states have been researching advanced missile technology to serve these three purposes, and they are likely to continue to do so. North Korea is an example: measurements of the Hwasong-15 ICBM show space for multiple independent reentry vehicles

2. According to the MTCR, "basic scientific research" means "experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena and observable facts, not primarily directed towards a specific practical aim or objective."

(MIRVs). North Korea has yet to demonstrate MIRVs, but with such a vehicle, researchers will be watching for them (Hanham 2019).

States will increasingly face discrimination problems as missile technology improves and nonstate actors continue to acquire more-advanced missiles. States will need not only to determine who is launching the missile, but also to quickly establish if the missile is carrying a nuclear warhead. Still more cumbersome is what happens when a nonstate actor launches what will likely be a conventional missile from a state that has nuclear weapons. With missile technology development unchecked, we will begin to enter a time in which

To prepare for the coming trends, the MTCR should include China, Pakistan, and other emerging missile powers.

nonstate actors in Pakistan, or perhaps someday Iran, could spoof a nuclear weapon launch, simply because they have similar capabilities in conventional missiles. Conversely, nuclear weapon possessors may even see an advantage in attributing an attack to a nonstate actor to divert blame.

CONCLUSIONS

Missile proliferation history indicates that state and nonstate players will pursue missile technologies either as offensive or defensive measures based on their own perception of threats. The main goal for states will be keeping their missiles survivable and capable of overcoming missile defenses.

Simple and reliable missile technologies are also the most popular choices for non-state actors. For those future malicious actors seeking to cause a nuclear exchange, there may be a desire for

advanced missiles that cause a discrimination dilemma. The combination of emerging technologies with actors that have the desire to pursue missile capabilities as a result of heightened regional tensions is likely to prompt further development and proliferation of missiles and more widespread use of them in future conflicts. The lack of proactive and cooperative risk reduction measures could result in an intentional or accidental initiation of an exchange of missiles, possibly carrying nuclear weapons.

To prepare for the coming trends, the MTCR should include China, Pakistan, and other emerging missile powers. Trade with missile proliferators and nonstate missile possessors should be rigorously controlled to curb further proliferation of missile technologies. The states in question should establish and strengthen their national export control regimes, comply with international regulations on export of dual-use technologies, and

educate their universities and companies about risks of export violations. However, while strict control regimes might be able to slow down proliferation to a certain degree, they cannot stop proliferation in the long run, given the continuing process of global industrialization and increasingly open access to technologies.

Policymakers must prepare for a world with more uncertainty and more risk. For example, a clear line needs to be drawn between conventional and nuclear-armed missiles to reduce the risk of nuclear exchanges resulting from misinterpretation of intentions during a conventional armed conflict. Under such circumstances, ensuring that decision-makers have access to high-quality information that enables them to make the best decisions in the face of escalating conflict is the key to avoiding armed conflict and even a nuclear exchange in response to error, uncertainty, or misdirection. ■

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LAURA GREGO

Missile Defense and Nuclear Weapons: Charting a Course to Security

In his February 2019 remarks at the Pentagon to unveil his administration's "Missile Defense Review" (MDR), President Donald Trump outlined an expansive vision for missile defense: "Our goal is simple: to ensure that we can detect and destroy any missile launched against the United States – anywhere, anytime, anyplace" (Trump 2019). This caused some confusion and consternation domestically, as it contradicted the MDR itself and long-standing US policy that missile defense was intended to defend the US homeland from the threat of long-range missiles from Iran or North Korea but not from the larger and more sophisticated missile arsenals of major nuclear powers Russia and China. The latter goal has been recognized as technically unachievable, and the

effort to attain it would be extremely expensive and strategically destabilizing. The statement also provided fodder for long-held suspicions in Russia and China that US missile defense systems were really intended for them.

While not official policy, Trump's statement echoes a belief that, at least in the United States, has never quite gone away – that missile defenses could be an escape from the horror of vulnerability to nuclear weapons. This belief has persisted, despite decades of work and hundreds of billions of dollars spent in unsuccessful pursuit of such defenses. In one version of this belief, missile defenses would, as envisioned by President Ronald Reagan, make nuclear weapons "impotent and obsolete"

(Reagan 1983). But that is not the universal view. Pursuit of highly effective missile defenses may also reflect the desire of states to escape their own nuclear vulnerability without necessarily giving up the ability to threaten others or doing the hard work to eliminate the weapons entirely. A central argument of this essay, however, is that pursuit of missile defenses for unilateral benefits is likely to confound efforts to chart a path to a stable future free of nuclear threats.

States have been trying to master missile defenses as long as they have been building missiles. It took years of offensive and defensive nuclear competition for the United States and Soviet Union to arrive at a shared understanding of just how interrelated offense and defense were. Eventually the two countries recognized that unconstrained pursuit of missile defenses was both encouraging the arms race, with adversaries building more missiles in order to overwhelm defenses, and creating an incentive to strike first if a crisis seemed imminent because missile defenses might negate an adversary's ability to retaliate. Once this interrelationship became clear, the subsequently negotiat-

If the future is to truly be free of nuclear weapons, states should consider carefully how missile defenses might shape incentives to acquire, stockpile, or threaten to use nuclear weapons.

ed Anti-Ballistic Missile (ABM) Treaty, which limited the United States and Russia to defense of a small geographical area and curbed research and development activities, became the cornerstone of the arms control framework. The nuclear reduction agreements that followed the ABM treaty allowed these nuclear powers to trim their total inventory from a high of more than 60,000 weapons in 1986 to fewer than 10,000 three decades later (Kris-tensen and Norris, n.d.).

If the future is to truly be free of nuclear weapons, states should consider carefully how missile defenses might shape incentives to acquire, stockpile, or threaten to use nuclear weapons. Equally important is to evaluate with clear eyes the value that missile defenses can bring.

To do so, this essay will examine the role missile defense has historically played, what its current technical capabilities are and what they might realistically be in the future, and how current plans are shaping strategic choices.

WHY MISSILE DEFENSES?

Missile defenses range from relatively simple battlefield systems designed to defend against short-range rockets and artillery shells to complex global systems to counter nuclear-armed long-range missiles. However, the systems most likely to substantially affect nuclear futures are those designed to defend entire countries from intercontinental-range missiles, systems referred to here as strategic missile defenses. (The line between strategic and nonstrategic missile defense systems is not always clear. Regional systems, designed to defend a smaller geographical area from shorter-range missiles, may, in the right geographic location and supported properly by sensors, have the ability to target long-range missiles over a

relatively large area, and so may have strategic capability. Even so, the problem is relatively well bounded.)

Strategic missile defense is an

enormously complex and technically challenging task. Intercontinental-range ballistic missiles can be launched with little to no notice, spend three to five minutes in active launch and then coast through space for 30 to 40 minutes at hypersonic speeds before arriving at their target, thousands of miles away. The coasting, midcourse phase provides a longer (but still challenging) timeline for the defense to destroy the incoming missile, but affords the offense the opportunity to use numerous countermeasures to make defense difficult or impossible. For example, the offensive missile may be accompanied through the emptiness of space by lightweight lookalike decoys, forcing the defense to exhaust its resources against harmless objects. Or the offense could detonate some of its nuclear weapons in space

or near the atmosphere to interfere with the defense's sensors and thus its ability to target subsequent incoming missiles.¹

Avoiding these show-stopping obstacles by instead targeting missiles during their active launch, the "boost phase," comes with its own significant challenges. Chief among them is the very short time frame. The missile launch must be detected and defeated within a few minutes, requiring the defense to be geographically close to the launching missile and highly effective, as there will not likely be an opportunity for multiple attempts.

Early on, during the massive nuclear arms buildup in the 1960s, it became clear from a technical perspective that the effective defense of an entire nation against large, sophisticated arsenals would not be achievable. (Nor would it be clearly desirable from a stability perspective.) The major powers turned to more-modest goals for the defense. The Soviet Union built and Russia still fields nuclear-armed interceptors designed to defend Moscow.² The United States developed but abandoned almost immediately nuclear-armed systems designed to defend some intercontinental ballistic missile (ICBM) silos and subsequently refocused in the late 1960s to defending the United States from the nascent Chinese ICBM arsenal.³

When President Reagan's vision for the Strategic Defense Initiative in the 1980s revisited the idea of a shield-like defense of the United States from the massive Soviet arsenal, the unworkability immediately became clear. In the 1990s, the United States returned to defending against small numbers of relatively unsophisticated missiles from nonpeer potential adversaries – this time Iraq, Iran, and North Korea. This has been the explicit goal for US strategic defense in the last two decades.

EXISTING AND PROPOSED DEFENSES

Currently, the sole fielded system for defending the United States from potential North Korean or Iranian ICBMs is the Ground-based Midcourse Defense (GMD) system, with a core of 44 interceptors based in Alaska and California. This system began development in the 1990s; it was hastened into the field starting in 2002, when the Bush administration withdrew from the ABM Treaty. Its "hit-to-kill" interceptor uses a powerful missile to launch a file-cabinet-sized kill vehicle toward a projected intercept point. The kill vehicle is meant to maneuver itself into a collision with the incoming warhead (or decoy) to destroy it with the force of impact. The system has been plagued by failure, and nearly 20 years after it was initially fielded, has yet to demonstrate a real-world defensive capability against even this limited threat.⁴ The system is slated to be expanded to include an additional 20 or more interceptors. This expansion is likely to take at least a decade because the interceptors are undergoing a full redesign and there are no spares available.

To shore up the system in the meantime, the United States is considering repurposing some of its regional and theater-based missile defense systems to assist in defending US territory. This includes the Aegis Ballistic Missile Defense (BMD) ship- and shore-based regional missile defense system, currently in use in by NATO in Europe and by the United States and Japan in East Asia. In the new conception, the Aegis system's new and more capable interceptor, the SM-3 IIA, would be launched from ground-based facilities in the United States or from ships patrolling the country's coasts.

However, while using the Aegis BMD system to support the struggling GMD system might seem a rational step, this is almost certain to substan-

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1. Such countermeasures have been well known for decades (Bethe and Garwin 1968). Subsequent reviews of existing systems indicate that little progress has been made in addressing these problems (National Research Council 2012).
 2. While public information is relatively scarce, analysts indicate that the Soviet-era system designed to defend Moscow and the surrounding areas from a limited missile attack, the A-135 system, is still in place and still relies on nuclear-tipped interceptors (Kristensen and Korda 2020).
 3. In his 1967 speech on "Anti-China Missile Defense and US Nuclear Strategy," Defense Secretary Robert McNamara explained the pivot away from the impossible task of defending against Soviet missiles and toward defending against China. He predicted that China would have a modest ICBM force in the next decade and might be prone to "irrational behavior."
 4. The GMD system has undergone 19 intercept tests in 20 years; it failed to destroy its target in nine of them. Three of the eight tests of the currently fielded types of interceptors have failed. (UD GAO 2020, 60). The test conditions have not yet reflected real world conditions, including countermeasures of the type an adversary is likely to use.

tially affect the US-Russia-China strategic balance. The Aegis BMD system, if successfully integrated, would dramatically increase the US strategic missile defense capability, as current plans call for the production of hundreds of SM-3 IIA interceptors deployed on scores of Aegis BMD-equipped ships. However, the GMD and Aegis systems have not demonstrated the technical capability to overcome long-known countermeasures, and their effectiveness will be limited.

Despite the fundamental limitations of midcourse defenses; the public nature of missile defense tests, which have indicated a slow rate of prog-

While the United States has not pursued space-based missile defense in earnest for decades, the effort never has been completely set aside.

ress; and US reassurances that its strategic missile defense systems are designed for “rogue nation” threats, the sheer size of the US defensive capability is a significant concern for near-peer missile states. A core concern, for Beijing particularly, is that the US system looks oversized and requires too much money for a defense against a rudimentary North Korean threat (Zhao 2020a). Similarly, Russia voices skepticism about the European Phased Adaptive Approach regional missile defense system fielded by NATO to counter Iranian missiles, arguing that it may be out of proportion to the actual threat posed by Iranian nuclear and missile programs. Because any future land-based ICBMs headed toward the United States from North Korea or Iran would travel through northern, near-polar latitudes on paths similar to the ones that Chinese or Russian land-based missiles would use, midcourse defenses designed for North Korea or Iran will have few characteristics that could distinguish them from those that could defend against Chinese or Russian missiles.

Chinese analyst Wu Riqiang sums up the suspicion about US missile defenses in this way: “[T]he U.S.

development of missile defense probably seeks to achieve two goals: it would first use North Korea as the excuse to quietly develop missile defense technologies and integrate different systems; after the technologies become mature it would then enlarge the scope of deployment to neutralize the Chinese and even the Russian nuclear retaliation capabilities” (Zhao 2020a, 33).

Theoretically, a missile defense system could be designed to defend against North Korean missiles but have essentially no capability against China or Russia, such as interceptors hosted on drones loitering outside of North Korean airspace or ships

off the North Korean coast that would target North Korean missiles during their boost phase. These systems have attracted little to no interest from the

Pentagon, at least in part because it has not been clear they could be built with existing technology.⁵

While the United States has not pursued space-based missile defense in earnest for decades, the effort never has been completely set aside. It is a perennial topic in Congress. Space-based boost phase missile defenses are bound to be extremely expensive; the National Research Council, the operating arm of the National Academies in Washington, estimated that an “austere capability” to defend against one or a few North Korean missiles would require at least 600 satellites and cost \$300 billion (National Research Council 2012). With technological advances in materials and miniaturization of components and a decrease in launch costs as commercial competitors enter the market, these systems will become less expensive. But the numbers are never on the defense’s side because for at least one interceptor to be within striking distance of the launching missile, many interceptors must be in orbit, as satellites in low-altitude orbits move rapidly with respect to the earth’s surface. Additionally, these systems can be evaded or overwhelmed relatively cheaply or simply.

5. Two landmark reports, one from the American Physical Society in 2004 and one from the National Research Council in 2012, found that boost phase defenses against the expected North Korean threat were impractical or unachievable (Barton et al. 2004; National Research Council 2012). Other open-source analysis has suggested it may be possible in certain circumstances (Garwin and Postol 2017).

Despite this, space-based missile defenses have consistently been a central concern for both China and Russia. This may be because by their nature, they are global defenses, less able to be tailored to launches from a particular geographical area than most other missile defense systems. Another problem is that space-based missile defense systems could be used as potent anti-satellite weapons, not only against nearby low-altitude satellites but also those valuable satellites at longer distances (Grego 2011).

Amplifying concerns about missile defense systems are advances in intelligence and surveillance to support targeting of silo-based and mobile ICBMs and in conventional precision strike systems that could target an adversary's command-and-control systems (Glaser and Fetter 2016). Such technologies could support a strategy of effectively striking first and using a moderately effective missile defense to defend against whatever missiles are left, thus escaping mutual vulnerability.

China and Russia have invested many fewer resources than the United States in strategically capable missile defenses. China has been developing and testing hit-to-kill interceptors that could be used against either satellites or ballistic mis-

China and Russia have invested many fewer resources than the United States in strategically capable missile defenses.

siles, but it has not fielded the sensors required to support them as a strategic missile defense. This may indicate that its current goal is instead to defend small regions, to simply understand the technology well enough to design its missiles to evade US defenses, or to use the technology primarily as an anti-satellite weapon.⁶ Russia has reportedly been modernizing its A-135 Moscow missile defense. It has several systems for air de-

fense and area ballistic missile defense, including the S-500 ballistic missile defense system, which is expected to be deployed in 2020 (US DIA 2017), and a new hit-to-kill interceptor system that may serve as missile defense or an anti-satellite weapon (or both). None of them, however, appears to have the range or sensor support to be strategic defenses.⁷

MISSILE DEFENSE AND ARMS CONTROL

Whether or not these proposed and fielded strategic missile defense systems are even close to reaching the goals set out for them, the possibility that they might one day realize their potential has led to missile defense playing a considerable role in nuclear postures and having an impact on the prospects for limiting nuclear weapons and delivery systems.

In the early decades of the Cold War, the Soviet Union and the United States each pursued ballistic missile defense as a means to counter the other's increasing inventory of ICBMs. It eventually became clear that any attempt to evade or mitigate vulnerability to nuclear weapons by defending against them was futile, as the adversary could simply build more missiles or design them to carry more warheads. Indeed, the pursuit of such defenses would almost certainly ensure the adversary would do just that, and so limits on

missile defenses would be necessary to achieve limits on offensive missiles. The culmination of this logic, the landmark 1972 ABM Treaty, permitted the negotiation of nuclear arms control treaties in the following decades, starting with the 1972 Strategic Arms Limitation Talks Interim Agreement (SALT I) – the first legal constraints placed on US and Soviet offensive and defensive strategic weapons – and continued through SALT II in the 1970s

6. Open-source analysts discuss the tests of the Dong Neng-3 hit-to-kill midcourse interceptor (Weeden and Samson 2020), but China's missile defense systems get little mention in public US intelligence reports, such as the Pentagon's annual report to Congress (US DoD 2019).
7. As with China's missile defense programs, little information is available in government intelligence assessments about Russian missile defense systems that are in development. Some information is available in open-source analysis, such as Weeden and Samson 2020.

and the Strategic Arms Reduction Treaty (START I) and START II in the 1990s.

The US withdrawal from the ABM Treaty in 2002 destroyed this foundation. The day after the US withdrawal, Moscow announced it would no longer be bound by its START II commitments (Arms Control Association 2019), as one of the conditions for Russian ratification of START II was that the United States ratify the negotiated 1997 agreements on ABM Treaty succession, demarcation, and confidence building.⁸ While the next nuclear arms reduction treaty, the Strategic Offensive Reductions Treaty (SORT), lowered the permissible number of deployed weapons, important START II provisions, including the prohibition of multiple independently targetable reentry vehicles (MIRVs) on ICBMs, were lost.

The United States and Russia were able to negotiate one more nuclear arms reduction treaty, the New Strategic Arms Reduction Treaty (New START), in 2010. In the treaty's preamble, the two states acknowledged that while the current missile defense systems "do not undermine the viability and effectiveness of the strategic offensive arms of the Parties," "the interrelationship between strategic offensive arms and strategic defensive arms... will become more important as strategic nuclear arms are reduced." As analyst Greg Thielmann notes, the United States and Russia did not necessarily mean the same thing when they referred to the increased importance of the interrelationship (Thielmann 2020). The position of both the Obama and the Trump administrations is that missile defenses are stabilizing, as they reduce the viability of an adversary's first strike. Russia's view is that missile defenses become more destabilizing if the two sides have small numbers of offensive missiles, as they reduce the certainty of second-strike retaliation. Russia has repeatedly stated that including missile defense in discussions is a prerequisite for the next round of nuclear reductions, while

US policy is that it will not accept legal limits on missile defenses.

The Chinese nuclear arsenal is about one-seventh the size of the US or Russian arsenal, and despite invitations (and threats) by the United States,⁹ Chinese officials have stated very clearly that they are not interested in joining the United States and Russia in a nuclear arms reduction treaty at this time. Indeed, if the menu includes only nuclear reductions, this is likely to hold true for quite some time. However, security concerns among the United States, Russia, and China are broader than simply creating or retaining parity in nuclear arms. US missile defense systems are a core concern for Beijing¹⁰ (as are conventional precision strike weapons and space weapons) and a commitment to discussing them may be the key to bringing China into strategic discussions and arms control negotiations.

MISSILE DEFENSE AND NUCLEAR POSTURES

Without the treaty limitations that once bounded this problem, missile defenses play an important role in nuclear states' decisions about the size and composition of their nuclear arsenals. Russia, China, and the United States are all modernizing their nuclear arsenals: Russia is in the midst of a modernization program that includes replacing its Soviet-era missiles with newer ones; China has been increasing the quality and quantity of its nuclear forces; and the United States is embarking on its own revamping of its triad of nuclear delivery systems.

Currently, Russia and the United States are each limited by New START to 1,550 warheads on 800 deployed and nondeployed strategic launchers. Currently, Russia fields approximately 812 warheads on 302 land-based ICBMs and 560

8. The successor agreement would have formalized the status of the former Soviet republics of Belarus, Kazakhstan, Russia, and Ukraine as parties to the treaty. The demarcation agreement would have clarified the difference between theater and strategic missile defense systems. The confidence-building agreements would have required an exchange of information between the parties to the treaty about theater missile defense systems covered by the demarcation agreement and notification before testing them.

9. Marshall Billingslea, the US special presidential envoy for arms control, stated that the United States "know[s] how to spend the adversary into oblivion" in an arms race (Hudson Institute 2020).

10. Analyst Tong Zhao states that "missile defense generates more Chinese suspicion about the U.S. military's strategic intentions toward China than anything else" (Zhao 2020b).

warheads on its nuclear-armed submarines (Kristensen and Korda 2020). In the absence of New START constraints, Russia and the United States could rapidly upload more warheads onto their existing ICBM forces.

Despite this enforced parity, it appears that Russia assesses US missile defense capabilities as a challenge to its ability to credibly threaten nuclear retaliation. Moscow has been explicit about this concern in official policy statements, including its

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recent listing of “military risks” that must be “neutralized by implementation of nuclear deterrence” (Putin 2020). The document calls out in particular the development of space-based missile defense. Russia appears to object not just to strategic defenses, but also to regional defenses located on its periphery, as evidenced by Russian threats to use nuclear weapons against NATO missile defense installations.¹¹ This may be less connected to any capability of these systems to target Russian strategic missiles (which the NATO system does not have) than to the intrinsic ability of the launch tubes in the system to launch cruise missiles and intermediate-range missiles as well as missile defense interceptors.

In the wake of the ABM Treaty's dissolution, Russia initiated the development of six new nuclear delivery systems including a nuclear-armed, nuclear-powered cruise missile; a nuclear-armed underwater drone; and maneuvering hypersonic missiles. A common feature of these systems is that they are designed to evade or penetrate strategic missile defenses, a fact that lends credence to Russian statements that these programs were initiated

specifically to respond to the US withdrawal from missile defense constraints and to hedge against US progress in fielding these systems (Putin 2018).

While these new delivery systems do not alter the essential strategic calculus – Russia's ballistic missiles were already able to evade or overwhelm existing and proposed US missile defenses – they do present a more complicated set of technologies for both countries to manage. Although Russia states that it is prepared to include two of

these systems – the Avangard maneuvering hypersonic missiles, which are launched from ICBMs, and the Sarmat “heavy” ICBM¹² – under existing New START

rules for counting missiles (Tass 2019), the other systems would have to be addressed separately in any future agreements.

Missile defense is a more immediate consideration for China. Because China fields so many fewer nuclear weapons than the United States (or Russia), US missile defense systems are already a considered a major challenge to Beijing's ability to retain an assured second-strike capability and thus are likely to be a driving factor for its nuclear planning (Zhao 2020a). Missile defense is not the only external factor, of course. US nuclear doctrine and strategic posture more generally are also key concerns. For example, the United States does not explicitly accept mutual vulnerability with China, and, unlike China, it has not adopted a policy of “no first use” of nuclear weapons. The capability of the United States to conduct a nuclear or conventional first strike against Chinese nuclear weapons or command-and-control facilities has grown in effectiveness, and the Trump MDR highlights the deliberate integration of offensive and defensive strategies. China fears that US missile defenses could effectively intercept any Chinese nuclear

11. For example, in 2015, Russia's ambassador to Denmark warned in an opinion piece that Denmark's ships faced Russian nuclear retaliation if Denmark joined the “American-controlled” NATO missile defense system in Europe (Local 2015).

12. The Avangard hypersonic glide vehicle would be launched from an ICBM and then maneuver through the atmosphere toward its distant target. Current ballistic missile defense sensors and interceptors are not designed to counter these kinds of missiles. The Sarmat launcher can reportedly carry up to 10 MIRVs (Kristensen and Korda). Since at least one hit-to-kill missile defense interceptor would be needed to target each MIRV, this can rapidly create a bigger burden on the defense than the offense.

forces left after a first strike or may fear that the United States believes this to be true and so may have an incentive, however small, to strike first.

Currently, China fields approximately 116 land-based ICBMs and submarine-launched ballistic missiles that could reach the United States (Kristensen and Korda 2019). While China deploys a small number of nuclear-armed submarines, these subs are unlikely to get close enough to the US coast to use their missiles on the continental United States before being detected and intercepted (Glaser and Fetter 2016). Until

There is no evidence to suggest that the US pursuit of the GMD system has had any dissuasive effect on North Korea or Iran.

and unless China moves to a launch-on-warning posture, it also would not count on its silo-based ICBM force surviving a first US strike. Thus, the credibility of China's retaliatory capability rests mainly on its relatively small mobile ICBM force, around 48 missiles. Because of increasingly capable US space-based intelligence, surveillance, and reconnaissance systems, China must also consider that not all of these missiles would survive a US first strike that tried to eliminate them (Glaser and Fetter 2016). So while US strategic missile defense systems are nominally sized to counter a small number of North Korean missiles, they will also have significant capability against the relatively small number of Chinese retaliatory missiles expected to survive a US first strike.

This risk to its deterrent is held by Chinese analysts to be the most important external driver of China's efforts to modernize its arsenal (Zhao 2020b). As with Russia, many of the technical choices China is making support this assessment, including the pursuit of technologies designed to evade or overwhelm missile defenses, including equipping their ICBMs with MIRVs and penetration aids (US DoD 2015).

As US investments in strategic missile defenses continue and especially if the technologies, sizes, and locations of the defenses make them

relevant to defeating Russian and Chinese ICBMs, Russia and China may fear the United States may one day believe it has a credible first-strike capability. This fear, and the dynamic of Russia and China modernizing their arsenals and building more-sophisticated systems to evade or overwhelm missile defenses will be a central issue for the coming decades.

For its part, the United States seems prepared to participate in this arms race. The Trump MDR frames the Chinese and Russian development of hypersonic glide and cruise missiles and other systems designed to overcome ballistic missile defenses as emerging threats against which the United States needs to build new defenses, rather than steps taken to hedge against

an unconstrained US missile defense program. Without intervention, this path leads to a cyclical, expensive, and dangerous buildup of offense and defense.

MISSILE DEFENSE AND PROLIFERATION

Many factors will inform an emerging missile state's decision on whether it will pursue an ICBM capability, including its expectations about whether such a capability can contribute to meeting its strategic goals and what the costs would be. The state may have a fairly low bar for such a program. Its goal might be met by simply demonstrating a credible ability to deliver a single long-range nuclear weapon to its potential adversary's territory if it believes that this capability would be intolerable to its adversary. In such a case, a marginally effective missile defense system, or even one with unknown effectiveness, may have little effect on the cost-benefit calculation. Or it could even create an incentive to build more or more-sophisticated missiles. There is no evidence to suggest that the US pursuit of the GMD system has had any dissuasive effect on North Korea or Iran. The bulk of North Korean long-range missile testing has taken place after the GMD's initial deployment in 2002.

To alter this calculation, the missile defense system would need to be very effective. More to the point, the emerging missile state would need to perceive it to be so, based on observable evidence. This has been a challenge in the current best example, the US GMD system. Despite an essentially unconstrained budget (more than \$45 billion and counting), the system has not demonstrated a credible ability to defend in a real-world scenario, in particular, one that includes the types of countermeasures a dedicated adversary would have available. Because North Korea's is a relatively small peninsular country, it has been suggested that a focused boost phase missile defense system based on ships or aircraft in international waters or airspace might be a more effective solution. As mentioned above, it has not been clear that such a system would be supported by existing technology.

FUTURE TRENDS

It is of course quite challenging to guess how technology will evolve beyond a decade or two. The competition between missile defenses and a well-prepared offense advantages the offense. That is unlikely to change in the future. It has long been the assessment of the intelligence community that states capable of building ICBMs should be able to build effective countermeasures.¹³ A country with an offensive capability also would have the advantage of being able to monitor its adversary building and testing a missile defense system because the attributes and locations of system components, such as radars and missile silos, are observable and tests are difficult to conceal. The first country could then adjust its planning in response to its observation of its adversary's progress.

While China and Russia have long been assessed to have developed effective missile defense countermeasures, in the coming years, they may gain more confidence in their ability to overcome US defenses as they continue to gain experience with their own midcourse defense technology.

However, it is not clear this would allay Chinese and Russian fears about US missile defenses. The nature of military planning is to hedge against an adversary's future advances, and the conservative path for Russian and Chinese planners may well give weight to a simple interceptor-to-missile ratio, assuming that the United States will eventually make a technical breakthrough to mitigate its missile defense's vulnerability to countermeasures. And technical assessments are only part of the mix; political judgments and industrial interests also will have a voice.

It is also conceivable that technical advances will eventually permit the United States to field geographically limited systems that could provide defense against North Korean missiles sufficiently capable that Washington would then consider circumscribing the development of the GMD and Aegis systems. While entrenched bureaucratic and economic interests are likely to provide a huge barrier to the United States setting aside existing programs, a deepening economic crisis or pushback by civil society against excessive military spending may force hard choices. That might be enough to keep the United States from developing new systems such as space-based interceptors. Although technological advances are likely to make space-based missile defense systems, including both sensors and interceptors, more economical, they will still be expensive to scale up. If current trends continue, anti-satellite weapons will continue to proliferate and become more sophisticated (unless constrained by agreement), and it is unlikely that a controversial system such as a space-based missile defense will operate uncontested, making such an investment even more unattractive.

It also seems unlikely that the United States would abandon its missile defense programs because the North Korean threat was assessed to be too mature to counter. It is more likely that these missile defense systems would then be refocused on a different threat in the way that the United States pivoted from defending against the Soviet arsenal to the emerging Chinese missile threat and then

13. The 1999 US National Intelligence Estimate assessed that Russia and China had already developed numerous countermeasures and that emerging missile states could deploy penetration aids and countermeasures by the time they flight-tested their missiles (Walpole 1999).

to other emerging missile states. In the same vein, a significant advance in the Iranian missile program with an unambiguous focus on ICBM development may provide additional incentives for the United States to expand its program.

CONCLUSIONS

Given its history, the United States will find it difficult to let go of the alluring possibility that vulnerability to nuclear weapons can be addressed by complex technical solutions. If current trends hold, strategic missile defense programs will continue to be well-funded for this reason and because of entrenched political and industrial interests. But the enormous investments will likely yield incremental rather than decisive improvements. The limited capabilities of the systems will not bring expected advantages, but China and Russia will find it difficult not to respond. (Entrenched political and industrial interests are important for these states as well.)

There are a few paths that might enable a breakaway from this offense-defense dynamic. Because so much of this cycle is predicated on perception or misperception of capability and intent, it is possible that a rigorous appraisal by these states, individually or jointly, of the technical prospects and strategic effects of existing and proposed missile defense systems could help break the cycle of nuclear buildup and soften the ground for nuclear reductions. There is a long history of efforts in the United States by national academies, professional societies, and other nongovernmental analysts to provide unclassified analysis that can support a robust public conversation. For example, the aforementioned 2012 National Academies study (National Research Council 2012), drawing on work by the American Physical Society in 2004 (Barton et al. 2004), laid out clearly the challenges and costs of boost

phase missile defense systems, and a 2000 study organized by the Union of Concerned Scientists and the Massachusetts Institute of Technology (Sessler et al. 2000) established clearly that countermeasures to midcourse missile defenses would be a formidable obstacle to success of such systems. When the conditions are right, such efforts have helped shape the debate and decisions. Analysis by trusted technical experts could set clear boundaries on what role strategic missile defense is likely to play in US security.

As Russia and China gain their own experience in developing missile defense systems, their own technical appraisals could help avoid unnecessary reaction to a limited US capability. And, as suggested by Tong Zhao, independent experts from the United States and China could conduct an open-source joint study of the feasibility of constructing a defense against North Korean long-range missiles that minimizes the effects on China (Zhao 2020b). Such a study could identify the most useful possibilities, or it could establish that such a system is difficult or impossible to construct. That might at least mitigate Chinese suspicions about US programs.

Additionally, the United States could focus its efforts solely on those systems that can be most clearly distinguished as regional systems. This may be by unilateral choice or preferably by negotiated constraint, as part of a new round of nuclear reductions.

Strategic missile defense, despite decades of effort and billions of dollars spent, has yet to provide a reliable defense against a limited missile threat, much less contend with what a sophisticated adversary might field. A simpler and cheaper approach to reducing vulnerability to nuclear weapons is to accept limits on strategic defenses of dubious value to secure significant limitations on offensive weapons. ■

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ROBERT S. WILSON

More to See and More to Hide: Forecasting the Effect of Space Technology on Nuclear Weapon Issues

Space is changing dramatically. With advances in technology and investments in capital, the technical barriers and financial costs for space operations have never been lower. Improvements in manufacturing have enabled the miniaturization of space systems: whereas satellites were previously large and custom-made, they are increasingly getting smaller and being produced in high volumes on assembly lines. As a result, satellites are cheaper, and dozens can now fit on a single rocket. Launch costs have fallen substantially. And rockets have become reusable.

This new environment is creating a democratization of space, allowing new players to participate. New companies, such as SpaceX, have

emerged and are proposing megaconstellations of satellites that, if realized, would fundamentally transform the scale of activity in space. About 2,700 active satellites are currently in orbit and about 9,000 have been launched into orbit over the entire history of the space age. Reports of planned activity indicate that more than 50,000 satellites could be launched by 2030 (Mosher 2020; Peterson, Sorge, and Ailor 2018). And the new space players are not limited to private companies. As of 2019, more than 60 countries have a national space budget, about 70 countries own or operate satellites in orbit, and nine countries – plus the European Space Agency – can independently launch a satellite into orbit (UCS 2019; US Defense Intelligence Agency 2019).

Changes to the space environment – and the changes that will further affect the space environment over the next five decades – could have profound implications for nuclear weapon issues. Increasing levels of activity in space have generated large amounts of data on military activities. For instance, space-based imagery can be used to identify force deployments and weapon sites. This enhanced visibility also applies in space: more countries and companies are developing the

Imagery from commercial remote-sensing satellites has created opportunities for open-source analysis that did not previously exist.

capabilities to see space assets, including those in high orbits. Among other impacts, this trend toward transparency will affect approaches for tracking nuclear capabilities and satellites essential for nuclear operations. States have historically gone to great lengths to shroud in secrecy their nuclear weapon programs and, in some cases, the whereabouts of their nuclear-armed delivery systems and the capabilities necessary to operate nuclear weapon systems – such as nuclear command, control, and communications satellites. Increasing transparency of these nuclear activities and capabilities might force nations, including the United States, to hide or protect their capabilities in different ways, such as building redundant systems. Depending on future technological breakthroughs, this trend of increased transparency could bring both opportunities and risks for global security. It could disincentivize proliferation through greater visibility of nuclear activities and forces, but it could also undermine strategic stability and cause states to react in ways that generate greater uncertainty. The nonproliferation and broader foreign policy community should take note of this trend toward transparency because it forecasts risks and opportunities related to nuclear weapon issues in the decades to come.

TRANSPARENCY ON EARTH

The advance and spread of space technologies is generating more transparency on activities on

Earth, which poses significant implications for nuclear-weapon issues.

At the dawn of the space age, the only satellites that could capture satellite-based imagery were controlled by the United States and the Soviet Union, which often classified the imagery and rarely released it to the public. In the decades after, governments, including these major powers, lost their exclusive grip on satellite surveillance.

In April 1986, after Moscow quieted rumors of a leak at its Chernobyl nuclear facility, news outlets broadcast imagery of the disaster taken from a US civilian

satellite and from a French commercial satellite (Nova 2007). The coverage signaled that “the age of total government monopoly on high-tech surveillance was over” (Kaspar 2001).

Three and a half decades after the Chernobyl incident, the number of reconnaissance and remote-sensing satellites has jumped considerably. According to a 2018 report from the Air Force, 38 countries have intelligence, surveillance, reconnaissance, and remote-sensing satellites, and 666 such systems are in orbit. The report notes that a decade ago, non-US reconnaissance and remote-sensing satellites totaled nearly 100 – a number that tripled by the middle of 2018 (National Air and Space Intelligence Center 2018). Further, more and more companies are operating satellites that offer imagery products for modest charges and, in some cases, free of charge. Using Google Maps, for example, anyone can access overhead images of a city, street, or building. The new space environment has transformed the quantity, availability, and quality of satellite-based imagery of activity on Earth. Nongovernmental customers are accessing imagery that used to be reserved for major governments, and major governments are leveraging promising new technologies and new sources of information.

Imagery from commercial remote-sensing satellites has created opportunities for open-source analysis that did not previously exist. The imagery is usually generated electro-optically (pictures

from a camera, essentially) or with radar (pictures created by bouncing radio waves off a target). Planet, a remote-sensing-satellite company focused on electro-optical imagery, achieved a roughly 150-satellite architecture in 2018 that has enabled it to produce an image of the entire Earth each day (Schingler 2017). Capella Space offers radar remote sensing that can produce high spatial resolution through all weather conditions, day and night (Capella Space). Maxar is developing its next generation of satellites that will reportedly be able to revisit some locations on Earth up to 40 times per day (Morin and Wilson 2020). With these types of resources, nongovernmental actors can conduct analysis of military activity that was formerly reserved to governments. Nonproliferation experts outside of government, for instance, can now use commercial satellite imagery to identify weapon sites, track maritime activity, and monitor missile movements. In 2019, major news outlets reported on nuclear or missile activity in North Korea, Iran, and Saudi Arabia in which nongovernmental experts – using satellite imagery – served as the primary source (Brumfiel and Welna 2020; *Guardian* 2019; Associated Press 2019). A 2019

Creating an operational hyperspectral satellite system with meaningful spatial and spectral resolution has proven to be a challenge because it requires significant power, data processing, and analysis resources.

Aerospace Corporation report notes that trends in remote-sensing satellites, among other factors, are pushing toward a “[Geospatial Intelligence] Singularity,” a scenario in which ubiquitous intelligence is available to the general public in real time (Koller 2019).

The benefits in new remote-sensing systems are not limited to nongovernmental customers. Governments are also leveraging the explosion of imagery data from private companies; the US National Geospatial-Intelligence Agency, for example, signed a five-year cooperative research agreement with Planet in 2018 (Marcus 2018). Countries without their own remote-sensing systems could look to commercial providers for

their needs. Governments could also try to exploit commercial technologies and models for their own systems (Morin and Wilson 2020).

Remote-sensing imagery is becoming not just more widespread and more available, but also more sophisticated. One example is hyperspectral imagery, the next big development in remote sensing. Unlike conventional optical or radar sensors, hyperspectral sensors can use spectrometry to facilitate the determination of chemical composition. The June 2019 issue of the *IEEE Geoscience & Remote Sensing Magazine* says, “Hyperspectral captures chemical composition of materials, able to simultaneously capture the spectral and spatial content with excellent spectral and spatial resolution.” Materials have diagnostic signatures that can be detected. The journal adds that “[t]he detailed spectral information thus captured allows for detailed examination of the scene, especially with regard to identifying particular materials in the scene by their unique spectral ‘fingerprints.’” An analysis by Los Alamos National Laboratory says that hyperspectral imaging data supports a variety of materially focused analyses including classifica-

tion, change detection, anomaly detection, and target detection (Ziemann and Theiler 2016). Such sensors can identify elements at a mining operation, distinguish different gases in plumes, and discriminate camouflage from

its surroundings. For example, the imagery could, in principle, easily pick out a camouflage canopy covering military equipment or materiel.

Creating an operational hyperspectral satellite system with meaningful spatial and spectral resolution has proven to be a challenge because it requires significant power, data processing, and analysis resources. However, steady progress in the development of technological solutions to resolve these constraints has resulted in a number of viable systems now in the planning stage in both the United States and Europe (Tratt 2020). At least for the next 5-10 years, the number of satellites carrying high-resolution hyperspectral imagers is likely to remain limited. Although some of these

will be US government systems, the European Space Agency and several companies are also planning to deploy hyperspectral sensors (Green et al. 2019; Strese and Maresi 2019; Keith 2019). For example, in the commercial sector, HyperSat LLC, a US company, and Montreal-based North-Star Earth & Space have both announced plans for hyperspectral satellite constellations. HyperSat LLC states that it will use an orbiting spectrometer that will allow it to identify the signatures of objects, materials, and processes (HyperSat, n.d.; Werner 2018).

POTENTIAL IMPLICATIONS FOR NUCLEAR WEAPON ISSUES

With more and better remote-sensing satellites comes more transparency regarding military activity. A 2018 US Defense Intelligence Agency report on space threats says that remote-sensing capabilities will continue “reducing the ability of all countries to remain undetected while performing sensitive testing and evaluation activities or military exercises and operations.” According to another 2018 report, of the 666 intelligence, surveillance, reconnaissance, and remote-sensing satellites in orbit, 353 are US systems, 122 are Chinese, and 23 are Russian. For China, for example, the report notes that these satellites can be used to monitor US forces and maintain awareness of regional rivals, such as India and Japan, and potential regional flashpoints, such as the Korean Peninsula, Taiwan, and the East and South China Seas (National Air and Space Intelligence Center 2018).

This increased transparency presents opportunities and risks related to nuclear weapons. It can be beneficial for nonproliferation by making it harder for aspiring nuclear-armed states to hide their programs and for current nuclear-armed states to proliferate without the rest of the world knowing. More actors being able to detect illicit activities may disincentivize a country from conducting those illicit activities. But that increased transparency could also expose hidden nuclear weapon systems, which could weaken strategic stability – meant here as the condition in which countries are confident their adversaries would

not be able to undermine their nuclear deterrent (Podvig 2012). If increased transparency makes a country feel as if its weapons are no longer secure, that country could respond in unpredictable and destabilizing ways.

Tracking proliferation in non-nuclear-weapon states. The history of nuclear weapon proliferation and testing is partly a history of states taking steps to conceal illicit activities from one another. Prior to its nuclear weapon test in 1974, Indian leaders maintained that their country’s nuclear program was only for peaceful purposes, and they prepared for the test in secrecy. For its subsequent tests, in 1998, India also reportedly avoided test preparations that would be readily detectable by satellites and kept personnel out of view of passes by US satellites (Nuclear Weapon Archive 2001; US Central Intelligence Agency 1965; Best 1998). News reports of the 1998 Indian tests note that US satellites were covering the test site only every three days (Risen, Meyers, and Weiner 1998). Current and future developments in remote-sensing satellites would make it harder for states to hide their preparations in the same way.

In identifying nuclear weapon programs, hyperspectral systems could be particularly valuable. As a notional example of how hyperspectral sensing could be applied, Jeffrey Lewis, an expert on proliferation and satellite imagery, discussed a uranium processing plant where the by-products are released into a nearby pond: “At the low end of hyperspectral technology, you can see water turbidity, which can give you a sense of whether water is flowing in ponds and in what direction. At the high end, you can identify specific chemicals in that water. Once that happens, your ability to identify industrial processes at facilities is pretty strong” (Lewis 2020).

Nonproliferation experts have also cited the potential that hyperspectral sensors could have in verifying suspected uranium mines and mills in North Korea (Hanham et al. 2018). In 2015, NATO, the European Defence Agency, and the US Department of Defense identified detection of weapons of mass destruction as one of the most promising military applications of hyperspectral technologies. In one case study on chemical weapons, hyperspectral sensors were able to de-

tect and classify chemical and hazardous materials (Shimoni, Haelterman, and Perneel 2019).

The plethora of systems and wide availability of constant global satellite surveillance could also lessen the likelihood that an actor could operate nuclear-weapon facilities and prepare for tests without anyone else noticing. If one state does not catch the activity, another state or interested party might. In an environment in which coverage may be ubiquitous and critical materials may be detectable, concealment becomes harder.

Tracking vertical proliferation in current nuclear-armed states. Just as it has in the past, satellite imagery will likely continue to play an important role in providing visibility into existing nuclear-weapon programs. Since the 1970s, government-controlled satellites have been recognized as a “national technical means” in that they can help verify US and Russian compliance with arms control treaties by, among other things, collecting detailed imagery of intercontinental ballistic missiles and aircraft. Verifying arms levels and capabilities can give states confidence that their rival is not seeking to

The value in satellites collecting information on strategic systems, force levels, and weapon movements could deepen if US and Russian arms control goes away.

overwhelm their capabilities or surprise them with an attack. US President Jimmy Carter noted in 1978 that “[p]hotoreconnaissance satellites have become an important stabilizing factor in world affairs in the monitoring of arms control agreements. They make an immense contribution to the security of all nations” (Carter 1978). Onsite inspections have served as the predominant method for checking compliance, but the use of satellites has been recognized as an important verification tool (Gleason 2020).¹

The value in satellites collecting information on strategic systems, force levels, and weapon

movements could deepen if US and Russian arms control goes away. The New Strategic Arms Reduction Treaty (New START) is the last remaining treaty between the United States and Russia that ensures both countries can conduct onsite inspections on each other’s deployed warheads and delivery systems. Absent an extension, New START would expire in February 2021. In this potential scenario, more and better remote-sensing satellites could be crucial for providing insight into the countries’ nuclear activities, information that could be available to governments and publics alike. Interested citizens and nongovernmental organizations would know whether governments were proliferating vertically – and if so, how. Other countries would have information on the world’s two largest nuclear arsenals, those of Russia and the United States. The two countries would have some understanding of each other’s nuclear developments and forces so that they could maintain strategic parity and have some assurances that the other was not preparing a nuclear strike. Of course, satellite imagery will not provide all the benefits inherent in arms control, but, in the absence of arms control, such imagery could be more important than ever (Manzo 2019).

The role of satellites in providing insight into nuclear forces extends beyond Russia and the United States. China

could use satellite imagery to look for vertical proliferation in India. And India could do the same for China, as could Pakistan for India and India for Pakistan. For these countries, as for Russia and the United States, satellite imagery can play a stabilizing role. Without the transparency they provide, worst-case planning could result.

Exposing hidden weapon systems. Although increased transparency can be a stabilizing influence among major nuclear-weapon states, enhanced visibility could also expose hidden weapon systems, worrying states that their nuclear

1. The term “national technical means” includes more than just satellites; it also encompasses sensors based on the ground, on aircraft, or even underwater. However, arms control experts consider satellites the most important type of national technical means.

deterrent might be vulnerable to attack from other states. This is less of a concern for Russia and the United States, given the size of their arsenals. China and other nuclear-armed states, however, could perceive trends in growing transparency as compromising their nuclear deterrent and thus compromising strategic stability. Increasing the numbers and quality of remote-sensing satellites could make nuclear-armed states reconsider the importance they assign to practices such as moving their nuclear forces to avoid detection.

It is worth stressing that such a development, if ever realized, is unlikely to happen anytime soon. Even in the next several years, remote-sensing

A critical unknown in projecting the long-term effect of remote-sensing satellites is whether satellites and their data will largely remain physically protected. If that were to fundamentally change, the implications would be much different.

satellites may not be able to sufficiently detect and track hidden and mobile weapons. And even if they could, detection and tracking would need to be coupled with other military developments, such as better data systems and prompt strike capabilities, to credibly threaten a country's nuclear deterrent. Much depends on how this trend of increasing transparency evolves – and the technologies undergirding it and developing alongside it. It is not implausible, however, that future developments in satellite capabilities – particularly within countries with advanced missile systems, such as the United States, Russia, and China – could lead some nuclear-armed states to believe that evasion and mobility may not ensure survivability in the future as effectively as they have in the past.

How states might respond. When presented with the new circumstances created by better remote-sensing satellites, states could accept the transparency and perhaps modify their behavior, or they could take aim against the transparency – the information from the satellites and the satellites themselves.

It is possible that states, in the face of increased transparency, would be deterred from engaging in illicit proliferation behavior precisely because many – rival states, private companies, publics – have the tools to track such activities. With greater public access to information, it might be harder to discredit revelations about clandestine activities. States pursuing nuclear weapons and current nuclear-armed states considering proliferation could decide, in the face of ubiquitous sensors, that the perceived gains are not worth the likely costs.

Alternatively, states may take countermeasures to negate the advantages of overhead capabilities.

Among other approaches, states could seek to weaken the credibility of satellite data. In a paper on the applications of remote sensing for arms control, Melissa Hanham and Jeffrey Lewis point to misinformation as an effective approach for an actor not wanting to be imaged: “Another tactic that has

been employed with great success is simply to flood media with false or confusing imagery. In a charged political environment, it may not matter if there is ‘proof’ in a satellite image if another image can be offered” (Hanham and Lewis, n.d.). States could try to hide their activities by moving them underground; however, advancing satellite imagery that can penetrate belowground may lessen the efficacy of such measures (Alzeyadi, Hu, and Yu 2019). States could also seek to degrade the satellites capabilities themselves. The Aerospace Corporation paper on Geospatial Intelligence Singularity suggests military forces may seek out active measures, such as jamming sensors, jamming communication links, and using lasers against sensors to mitigate the risks of detection.

A critical unknown in projecting the long-term effect of remote-sensing satellites is whether satellites and their data will largely remain physically protected. If that were to fundamentally change, the implications would be much different.

TRANSPARENCY OF SPACE

Advances in space technology are not limited to improvements in seeing activity on Earth. Countries and companies are pursuing capabilities that enable more accessible mapping of the space environment, called space situational awareness, and concepts that require close operations between satellites, called proximity operations. These capabilities and concepts are generating more transparency of space, which – just like on Earth – has significant implications for nuclear-weapon issues.

Space situational awareness is an important and growing area. Capabilities in this area include ground-based radars, telescopes, and space-based sensors. Until recently, the United States was the only country in the world – outside, perhaps, Russia – to develop high-fidelity space situational awareness information (Lal et al. 2018). While the US capabilities continue to represent the gold standard, now more than 18 countries have or are pursuing space situational awareness systems that can help identify and track orbital objects. Companies have also developed space situational awareness products for paying customers. LeoLabs, for example, in October 2019 established a space radar in New Zealand that will allow it to track objects as small as two centimeters in low Earth orbit (LeoLabs 2019).

While the US capabilities continue to represent the gold standard, now more than 18 countries have or are pursuing space situational awareness systems that can help identify and track orbital objects.

ExoAnalytics can track objects in geosynchronous orbit (some 20,000 miles above the atmosphere) and maneuvers (when an object moves into a different orbit). The evolution in transparency on Earth is similar to the evolution of awareness of space. A recent report published by the Institute for Defense Analyses (Lal et al. 2018) concludes, “The world is on a path-of-no-return for the proliferation of [space situational awareness] capabilities, a trend that has significant implications for transparency in space (e.g., more actors will be increasingly able to track others’ activities in space).”

In addition to helping manage space traffic, avoid collisions, and prevent debris, better mapping of the space operational environment can assist proximity operations. Proximity operations and imaging of satellites could support operational concepts that include debris tracking and removal, end-of-life disposal, and on-orbit inspection, repair, refueling, and repositioning. These concepts could be extremely important in an environment with 50,000-plus systems. But they also pose risks to critical satellites.

In early 2020, both the threat and opportunity of space proximity operations were displayed. In February, a Northrop Grumman satellite docked on an Intelsat satellite to provide life extension services. This was the first time a commercial satellite had ever docked with another commercial satellite (Henry 2020). Also in February, media reports indicated that a Russian satellite had been making orbital maneuvers near a US government satellite. General John Raymond, the commander of the US Space Force, called this Russian activity unacceptable (Erwin 2020). Experts have suggested that Russia’s activity could have been a pretext to take imagery and capture detailed information of the US satellite (Gohd 2020). As reported by James A. Vedda and Peter L. Hays, taking images of space objects – non-Earth imaging, as it is often called – has made maintaining secrecy of specific systems

more challenging: “In space surveillance and imaging, the diffusion of observation technology and know-how has curtailed the ability to maintain

secrecy in areas once thought to be invisible to public view” (Vedda and Hays 2018).

Commercial proximity operations are still in their infancy; however, in the next decades, they could become much more prevalent, as could proximity operations among smaller states. The availability of these operations coupled with growing space situational awareness capabilities reveals a clear trend: space is becoming more transparent for major powers, smaller countries, and publics – in short, for everyone.

POTENTIAL IMPLICATIONS FOR NUCLEAR WEAPON ISSUES

Imagery and data on the satellite operational environment could also help states identify, catalog, and track critical satellites. And if they can be identified and tracked, they can be targeted. In a moment of irony, Secretary of the Air Force Heather Wilson commented in 2018 that “We built a glass house before the invention of stones” when she discussed the emerging threats to critical US space systems (Cooper and Roberts). Just in 2020, Russia has tested direct-ascent anti-satellite weapons and a space-based co-orbital weapon (U.S. Space Command 2020). Although a war in space has never occurred, the domain is becoming increasingly tense.

Among the most critical satellites are those essential to nuclear command, control, and communications. This category includes satellites that

NC3 satellites used to be protected in part by their obscurity in high orbit: potential adversaries did not have the means to track and collect detailed information on these systems.

provide protected communications capabilities, such as US Advanced Extremely High Frequency and UK Skynet satellites, and early warning of adversaries’ missile launches, such as the US Space Based Infrared System and Russia’s Kupol satellites (Air Force Space Command 2017; Allison 2018; Air Force Space Command 2017; Dahlgren 2019). Future vulnerability of such systems could weaken strategic stability. From a threat perspective, the effect of growing transparency is not all bad, however. Increasing transparency could allow more actors to identify and attribute malign behavior in space. Much like transparency of military activities on Earth, increasing transparency of the space operational environment and of individual satellite systems presents opportunities and risks.

Tracking NC3 satellites. Much like its nuclear forces, a country’s nuclear command, control, and

communications (NC3) is a fundamental element of its deterrent. “When it comes to nuclear modernization, NC3 is the least expensive, yet perhaps the most critical,” says a 2019 report from the Mitchell Institute and MITRE. “Possession of an effective and robust NC3 system,” the report states, “is essential for deterrence since its existence will convince potential adversaries that any attempted surprise nuclear aggression will fail and will be met with a devastating response” (Deptula, LaPlante, and Haddick 2019). Nuclear scholar Paul Bracken notes the growing recognition of the importance of NC3: “An interesting feature of the global nuclear command and control system that is now developing is the recognition that the information regime around nuclear weapons is increasingly critical. It is critical for deterrence and for other aspects of nuclear governance” (Bracken 2020).

NC3 satellites used to be protected in part by their obscurity in high orbit: potential adversaries

did not have the means to track and collect detailed information on these systems. With space becoming more transparent, hiding may no longer be an effective

approach for protecting critical capabilities. In a speech in April 2020, Christopher Ford, a senior official in the US State Department, said that China is “exploring capabilities to attack satellites in orbits such as those of our NC3 systems” (Ford 2020). If space situational awareness, proximity operations, and threat technologies mature in a way that causes states to see their NC3 systems as becoming increasingly vulnerable, the states could lose confidence in their overall nuclear deterrent. Strategic stability could suffer.

Tracking malign activity. Just as more transparency could enable an actor to conduct malign activity in space, it also could enable other actors to see and attribute that malign activity. In the example of Russian satellites trailing a US government satellite, the initial news coverage of the Russian satellites’ abnormal activity was based on the work of amateur satellite trackers

(Grush 2020). In the future, with more and better information available on the satellite operational environment, a state may not be able to surreptitiously attack another satellite without being noticed. Such detection and attribution could lessen the likelihood that the country would engage in the attack in the first place.

How states might respond. Increasing transparency of the space environment and evolving threats have prompted proposals on how states should best respond. In the United States, for example, the government in 2019 established the Space Development Agency to develop a large network of satellites. Instead of relying on a small number of large and complex systems, this approach would emphasize a high number of small and modular systems. The new agency is planning to launch dozens of satellites in 2022. Derek Tournear, the agency's director, has said that the eventual architecture could entail thousands of satellites and that this architecture would provide "resiliency via numbers." Based on today's architecture, an attack on US satellites that resulted in the loss of a couple of critical systems could be crippling; an attack that led to the loss of a few satellites in an architecture of thousands of satellites may produce little effect (Vergun 2019; Strout 2019).

Other countries may also multiply their satellites in orbit. Or they could pursue systems to threaten constellations. Russia and China could try to emulate the United States or adopt asymmetric approaches to mitigate the US advantages, focusing on countering a disaggregated architecture or pursuing new ways of making satellites systems vulnerable. Smaller states may observe these actions and reactions and respond themselves.

CONCLUSIONS

Since the beginning of the Space Age, space technologies have played an important role in exposing nuclear activities and capabilities. In 1960, a satellite that was part of the US Corona photoreconnaissance program, which was intended to identify missile launch sites and production facilities, dropped a canister of film through the atmosphere that was successfully recovered, delivering intelligence photos taken over Soviet territory (US Central Intelligence Agency 2015; US Department of Defense, n.d.).

The deepening and widening of transparency, both on Earth and in space, has a few implications in the nuclear weapons sphere. Proliferators will find it less easy to hide clandestine activities, but they may be able to draw upon space technology as well. States with established nuclear weapons programs could find a more transparent environment challenging and uncomfortable. The trend toward increasing reliance on space-based assets for command and control, particularly if conventional and nuclear forces overlap, could create instabilities. At the same time, space-based assets will continue to be critical in verifying arms control agreements to reduce nuclear weapons.

In contrast to the current nuclear weapons status quo, the space environment in the next few decades will be crowded and noisy, with few obvious advantages to the traditional big players. With a certain degree of foresight and caution, states agreed long ago not to deploy nuclear weapons in space. Looking ahead, they may need to consider steps to minimize the global risks and maximize the opportunities that emerge from interplay of developments in space and nuclear weapons. ■

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DAVID SANTORO

Steep Hill Ahead: US-Russia-China Relations and Their Impact on Nonproliferation

The United States and Russia (the Soviet Union, until 1991) have had a long-standing interest in nonproliferation and, although it came quite a few years later, nuclear security. Both countries played a leading role in helping establish the 1968 Nuclear Nonproliferation Treaty (NPT), and are, along with the United Kingdom, NPT depositary governments. Both countries were also the primary architects of the 1980 Convention on the Physical Protection of Nuclear Material (CPPNM). Cooperation between Washington and Moscow on nonproliferation and nuclear security flourished even during some of the most frigid moments of the Cold War. It expanded further thereafter, when the bilateral relationship began to improve.

China, for its part, was disinterested in this agenda of work for many years, arguing that it was nothing but a tool for the two superpowers to maintain hegemony. In the early 1990s, however, Beijing slowly began to consider that nonproliferation and nuclear security were, by and large, in its national interest. As a result, Beijing became increasingly active in these areas.

US-Russia-China cooperation on nonproliferation and nuclear security is essential because the three countries are the world's major powers and, along with the United Kingdom and France, permanent members – known collectively as the P5 – of the United Nations Security Council. That status gives them veto power over the decisions made in the

council and therefore considerable influence on global governance and the management of crises, including proliferation crises. Cooperation among the three countries is also important because they are significant sources of sensitive equipment, materials, and technology, and, at least in the cases of Russia and China, also traditionally close to many countries of proliferation concern, such as North Korea and Iran.

This essay examines the evolution of US-Russia-China relations since the end of the Cold War and assesses the impact that these relations have had on nonproliferation and nuclear security. The essay also reflects on the future of the trilateral relationship and the implications for the nonproliferation and nuclear security agendas.

GREAT EXPECTATIONS: THE UNITED STATES, RUSSIA, AND CHINA IN THE 1990S

The end of the Cold War brought with it an end to both ideological competition and three-way balancing moves among Washington, Moscow, and Beijing. It gave rise to hopes that strategic cooperation among the three countries would replace strategic competition as the key organizing principle of their relations. Initially, these hopes appeared to be well-founded. The first few years of the post-Cold War world were productive. The United States, Russia, and China made substantial progress toward improving their relations in the political, economic, and security realms and, by the mid-1990s, they seemed on track to make much more. It seemed that the “new world order,” a term US President George H. W. Bush had used in 1990 to describe promising post-Cold War developments, was paying dividends and had more in store (Bush 1990). At the turn of the century, there were great expectations for cooperation among the three countries.

Such cooperation extended into the nuclear domain. The United States and Russia pushed nuclear weapons out of the forefront of their relationship. Those two countries, which had engaged in an intense nuclear arms race and built massive arsenals during the Cold War, embarked on an ambitious arms control journey in the 1990s. To

be sure, that journey had begun in the 1970s with the conclusion of the Strategic Arms Limitation Talks Agreement and the Anti-Ballistic Missile (ABM) Treaty in 1972. Fifteen years later came the Intermediate-Range Nuclear Forces (INF) Treaty. The progress the two countries made in the 1990s was even more significant, however. Washington and Moscow agreed to important reductions in their strategic nuclear arsenals through the 1991 Strategic Arms Reduction Treaty, and, that same year, they concluded reciprocal reductions in sub-strategic weapons through the Presidential Nuclear Initiatives. They also negotiated subsequent treaties that focused on offensive strategic nuclear weapons. Washington and Moscow also cooperated to repatriate to Russia the nuclear weapons scattered in Belarus, Kazakhstan, and Ukraine, and they engaged in important work on nuclear (and biological and chemical) security, notably through the US-led Cooperative Threat Reduction (CTR) program.

Because the nuclear arsenal it had developed was significantly smaller than those of the United States and Russia, China chose not to engage in arms control. In the 1990s, however, Beijing began to endorse many of the multilateral nonproliferation and disarmament regimes, which it had until then rejected. In 1992, for instance, China acceded to the NPT, indicating that Beijing would now take nonproliferation seriously. China also became more active in helping create and promote many other similar regimes of restraint: the 1993 Chemical Weapons Convention (CWC); the 1996 Comprehensive Nuclear-Test-Ban Treaty (CTBT); and the 1997 Model Additional Protocol, a template for more-intrusive nuclear safeguards.

The United States, Russia, and China also began to coordinate their responses and cooperate to deal with hard proliferation challenges. They did so in the case of Iraq after the 1991 Persian Gulf War, when they worked together to set up the UN Special Commission to inspect Iraqi weapon facilities. The three countries also began to coordinate their actions to address the emerging North Korean nuclear problem. Such coordination and cooperation proved significant given their P5 membership.

Promising developments notwithstanding, several uncertainties remained. One issue was that contin-

ued progress depended on successful transitions in Russia and China, with the former moving away from Soviet-style rule and the latter confirming the opening to the world it had initiated in the late 1970s while also undertaking internal reforms. Despite difficult political developments in both countries and the outbreak of major crises, such as the Chechen War in Russia's case and the Tiananmen Square Massacre in China, Moscow and

It gradually became clear that Russia and China did not see eye to eye with the United States over the management of Iraq's weapon stockpiles and that they disapproved of US choices for steps to manage the North Korean nuclear and missile problem, which they deemed too confrontational.

With the terrorist attacks against the United States of September 11, 2001, the international

strategic landscape changed fundamentally. In the wake of the attacks, the United States demanded that countries, including Russia and China, choose sides in the "war on terror." The

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Beijing seemed to be on a positive trajectory. But there was a possibility of a downturn in trilateral cooperation if such transitions faltered and failed. It was unclear whether US-Russia-China relations would remain smooth or if trilateral nuclear cooperation would continue and deepen.

While nuclear weapons no longer were as prominent a part of their relationships, the three countries continued to rely heavily on these weapons, including to deal with each other. Each of the three countries still sought to deter the other two. Moreover, and significantly, by the end of the 1990s the United States and Russia had been immersed in a long-running debate about the role of nuclear weapons in their overall security postures. China, for its part, was modernizing and expanding its small arsenal without giving details about its current and future scope and scale, or the place nuclear weapons would have in its security posture.

In the late 1990s, growing disagreements also emerged between the three countries over their approaches to nonproliferation and nuclear secu-

United States also embarked on a fundamental rethinking of its relations with the major powers in the context of what it had defined as a "new strategic framework" (Bush and Putin 2002). A key part of that rethinking was to improve great-power relations and adapt US forces to respond to the possibility that "rogue" states and terrorist groups could acquire nuclear weapons. That rethinking was characterized by the pursuit of a new strategic force structure, the withdrawal from the ABM Treaty, an open-ended acquisition of missile defense systems, and additional nuclear reductions with Russia codified in the 2003 Strategic Offensive Reductions Treaty (SORT).¹

The goal of the new strategic framework was to strengthen stability with Russia – and China, although to a much lesser extent – to allow a greater focus on two urgent problems. The first was "rogue states" – that is, states with nuclear-weapon ambitions. In particular, US President George W. Bush dubbed Iraq, Iran, and North Korea the "axis of evil." The second problem was nuclear terrorism (Bush 2002). A related goal, quite logically,

1. The proposed new force structure revised the traditional triad of intercontinental ballistic missiles, submarine-launched ballistic missiles, and heavy bombers to add nonnuclear strike capabilities, missile defense, and a revitalized defense infrastructure. The concept was addressed in the 2001 Nuclear Posture Review. The US Department of Defense did not release the text of full report; the DOD release of the opening summary can be found at <https://archive.defense.gov/news/Jan2002/d20020109npr.pdf>. DOD officials provided additional details at a briefing on January 9, 2002 (US DOD 2002) and in congressional testimony. The Federation of American Scientists obtained and released excerpts of the report beyond the opening summary (FAS 2002).

was to deter the rogues and prevent them from developing nuclear weapons as well as to secure vulnerable nuclear and other sensitive materials and technology to ensure that they did not fall into the hands of terrorists. Such an approach made nonproliferation and nuclear security a priority and identified it as an area of common interest for Washington, Moscow, and Beijing, as well as others, and for which the leadership and cooperation of the three countries was essential.

In a 2002 study reflecting on possible futures for US-Russia-China strategic relations in that context, Brad Roberts, a noted scholar and former practitioner, identified four options (Roberts 2002, 38-42). One described a bright future characterized by the continuation of US-Russia nuclear reductions, with China acting in ways that allowed the process to continue smoothly; a decreasing role for nuclear weapons in US, Russian, and Chinese security postures; and the development of a US-Russia-China partnership allowing for effective global governance and management of hard problems, such as proliferation and nuclear terrorism. Another possibility was the emergence of frictions in the trilateral relationship, but none strong enough to derail the effort to construct the nuclear peace envisioned in the new strategic framework. In that future, US-Russia-China cooperation on nonproliferation and nuclear security would continue to flourish.

The third scenario involved a failure to bring about nuclear peace, yet without leading to US-Russia-China competition. In that future, Roberts imagined a country successfully developing nuclear weapons or other weapons of mass destruction (WMD) and possibly using them in a regional war, leading Washington, Moscow, Beijing (or some combination) to refurbish their nuclear arsenals and causing major upheavals in their relations. The emerging partnership would not break down completely, however; the three countries would collaborate to reestablish peace and security. The final possibility described a future in which the hope for a US-Russia-China partnership would be replaced by competition. In that future, Roberts envisaged either a three-way competition, a situation creating an odd man out (characterized either by Russia-China cooperation against the United States or US-Russia cooperation against China), or a situation in which the United States chose to

achieve clear nuclear superiority over both Russia and China. Roberts suggested that this future would create significant proliferation pressures in various regions and could even lead to WMD use.

How have US-Russia-China interactions evolved since the United States announced the new strategic framework nearly two decades ago? How have they evolved in comparison to Roberts' forecasts? What has been the impact on nonproliferation and nuclear security? The rest of this essay explores these questions.

A TURN FOR THE WORSE: THE UNITED STATES, RUSSIA, AND CHINA IN THE EARLY 21ST CENTURY

During the first two decades of the 21st century, US-Russia-China relations gradually deteriorated and, in the mid-2010s, took a sharp turn for the worse. In other words, the post-Cold War expectations for strategic cooperation among the three countries were not fulfilled. By the mid- to late 2010s, trilateral relations had reached a low point, which has had a negative impact on nonproliferation and nuclear security.

US-Russia Relations

By the early 2000s, it became clear that Russian President Vladimir Putin was actively undermining nascent democracy in Russia and that he had a different idea on how the country should be governed (McFaul 2000). Putin also became confrontational toward the United States and the West, arguing that they had taken advantage of Russia's weaknesses and encroached on its interests and "near abroad" by intervening in the former Yugoslavia, enlarging the North Atlantic Treaty Organization (NATO) up to Russia's borders, and allegedly backing mass protests in Georgia and Ukraine. The United States and Russia still managed to conclude SORT, but problems remained. Moscow did not hide its dissatisfaction with Washington over the US decision to withdraw from the ABM Treaty, expressing skepticism about the US claim that its missile defense systems were intended solely for protection against the rogue states. Russia, in other words, feared that the United States was after "absolute security" – the ability to prevail over Russia, rather than simply defend against it.

The United States attempted in vain to reset the US-Russia relationship in the late 2000s. A key reason was what Moscow perceived to be NATO's aggressive action in Libya in 2011. Still, the reset helped deliver the New Strategic Arms Reduction Treaty (New START), a 2010 agreement that further reduced US and Russian strategic nuclear weapons but did not resolve many of Russia's concerns, notably about missile defense. So when, in 2013, Washington proposed that the United States and Russia conclude a new, more ambitious agreement, Moscow declined. Russia indicated that it was not opposed to continuing the arms control process, but that it wanted the next agreement to include nuclear weapons, missile defense, strategic conventional weapons, and space and counterspace weapons. Moscow also insisted that the next agreement should extend to the other three NPT-recognized nuclear-weapon states. The United States rejected that approach: It sought a narrower agreement and did not want constraints on missile defense, which it deemed necessary to protect against the rogue states. Washington tried to address Russian concerns about missile defense, but it was unsuccessful.

US-Russia relations then entered a downward spiral following Russia's annexation of Crimea in 2014 and intervention in eastern Ukraine, which Putin justified as protection of Russian interests against US/Western overreach. Russia's interference in

In addition to doubting the strength and veracity of China's no-first-use policy, the United States feared that Beijing might decide to change its traditional approach and build an arsenal big enough to compete with the US and Russian arsenals.

the 2016 US presidential election, its intervention in Syria, and its attempted assassination of a UK national and his daughter by using chemical weapons further deepened the crisis. Putin's post-Crimea promise to "snap back hard" if threatened brought nuclear weapons back into the foreground of US-Russia relations, especially when four years later, in 2018, the Russian president unveiled two novel strategic nuclear weapons (Putin 2014a; Putin 2018). For many US policymak-

ers and analysts, these developments confirmed the wisdom of the US decision to rethink nuclear deterrence and, in the context of launching its modernization program to advance two new nuclear weapons of its own (US DOD 2018b). The United States also decided to withdraw from the INF and Open Skies Treaties, arguing that Moscow was violating both, and it suggested on multiple occasions that it might not renew New START past its 2021 expiration date. By 2020, therefore, the US-Russia arms control partnership was falling apart, and renewed competition between Washington and Moscow was on the horizon.

US-China Relations

Throughout the 2000s, there was hope among the US national security community and beyond that China would transform into a power that followed international rules and norms, endorsed market forces, and implemented democratic reforms. By the early 2010s, however, concerns emerged in Washington and elsewhere as Beijing became increasingly critical of the international order and began to assert itself, notably in Asia. Another concern was that instead of endorsing market forces, Beijing had begun to expand its mercantilist practices (by, for instance, offering large state-supported subsidies for Chinese industry to outmatch overseas competition), and that the Chinese Communist Party, especially under Xi Jinping's rule, had become more repressive and

nationalistic. The goal seemingly was to achieve the "China Dream" of national rejuvenation and help China regain its rightful place in the world after the "century

of humiliation" (when China was subjugated by Western powers between 1839 and 1949).

Moreover, Washington became worried because Beijing ramped up the modernization, diversification, and expansion of its nuclear and conventional strategic forces, notably its short- and intermediate-range systems. The United States and Russia, meanwhile, had eliminated intermediate-range systems under the INF Treaty. Partic-

ularly worrisome was that Beijing continued to refuse to reveal the size and shape of its nuclear arsenal or the goal of its modernization program. In addition to doubting the strength and veracity of China's no-first-use policy, the United States feared that Beijing might decide to change its traditional approach and build an arsenal big enough to compete with the US and Russian arsenals. Another fear was that Beijing might stick with a small nuclear arsenal but enhance it sufficiently

Beijing became especially concerned because Washington refused to adopt a no-first-use policy and acknowledge that the United States and China were mutually vulnerable. To Chinese officials, that suggested that the US military still considered a US disarming strike against China to be an option.

to allow more aggressive action at lower ends of the conflict spectrum. Concerns also ran high because, besides refusing to be transparent about its activities, China rejected nuclear dialogue (and arms control) despite repeated US invitations to engage in official talks; Beijing's approach was – and remains – that China has only a few hundred nuclear warheads, whereas the United States and Russia have thousands and, therefore, that leadership on arms control should come from Washington and Moscow.

Beijing argued that its developments were purely defensive, that it maintained a nuclear strategy based on self-defense and a no-first-use policy, and that its modernization efforts were consistent with its tradition of minimum deterrence – that is, that they were aimed solely at developing a small force and ensuring that this force remained reliable and survivable. Beijing stressed that these efforts were essential in the context of the improvement in US missile defense systems and the US refocus on Asia. China had the same worries as Russia – that it might become the target of US military developments because the United States seemingly sought absolute security. Beijing became especially concerned because Washington refused to adopt a no-first-use policy and acknowledge that the United States and China

were mutually vulnerable. To Chinese officials, that suggested that the US military still considered a US disarming strike against China to be an option.

The relationship deteriorated further in the mid-2010s, when the United States identified China as a major competitor and began to push back against Beijing (US White House 2017; US DoD 2018b). In the context of Beijing's sweeping military reforms (launched in 2015) and uncertainty

about the impact of these reforms on Chinese nuclear strategy and weapons programs, the United States began to indicate a willingness to engage in nuclear competition with China. A primary

motivation was to compensate for Washington's diminishing conventional advantage vis-à-vis Beijing (Saunders, Ding, Scobell, Yang, and Wuthnow 2019). That is why, according to US administration officials, the US decisions to develop two new nuclear capabilities and withdraw from the INF Treaty were made with China as well as Russia in mind (Colby 2018). By 2020, therefore, the US-China relationship appeared ripe for rivalry, with, for the first time, the prospect of nuclear weapons being brought into the foreground of that relationship.

Russia-China Relations

Despite fundamental differences between the two countries, cooperation between Russia and China deepened after the end of the Cold War. The purpose of that partnership eventually became obvious: to counterbalance and confront the United States.

Bilateral cooperation has progressed uninterrupted since the 1990s. In 1994, Moscow and Beijing concluded a mutual no-first-use agreement. In 1996, Moscow and Beijing upgraded their relationship to a strategic partnership and, in 2001, they signed the Treaty of Good-Neighborliness and Friendly Cooperation. Then, in 2011, they signed a comprehensive strategic partnership, which helped further expand cooperation. By

2019, cooperation had deepened so much that Putin described Russia-China relations as “almost an alliance-type relationship” (Putin 2019).

Such cooperation took several forms. Russia exported military hardware to China, including modern air and missile defense systems, such as the S-400, and began assisting Beijing in developing early-warning systems. Russia and China also participated in each other’s military exercises, and the two countries conducted combined drills. Moreover, Moscow and Beijing pursued low-level confidence-building measures, notably by concluding a ballistic missile launch notification agreement (2009). They also coordinated their opposition to many US policies, especially on missile defense. In June 2019, for instance, they issued a joint statement on “global strategic stability,” the second of its kind (the first was in 2016), in which they criticized “[s]ome individual powers [for pursuing] unilateralism and bullying” and they identified themselves as the “stability anchor” for world peace (Putin and Xi 2019).

Nonetheless, deterrence was alive and well between Russia and China, although neither side acknowledged it. As in the US-China relationship, the stronger power (Russia) did not publicly acknowledge that it was worried about, let alone mutually vulnerable with, its weaker counterpart (China). Yet Moscow was concerned. Russia’s 2014 Military Doctrine, for instance, explained that Russian nuclear weapons helped prevent “an outbreak of nuclear military conflicts involving the use of conventional arms (large-scale or regional war)” (Putin 2014b). As two Russian analysts pointed out, the term “regional war” could only mean a conflict with China because war with the United States/NATO would be larger than regional (Arbatov and Dvorkin 2013, 12-13). Moreover, in calling for arms control multilateralization, Moscow made clear that it was concerned that Beijing might build up its nuclear arsenal as US-Russia reductions continued. Similarly, while evidence is lacking, China must be worried about its much stronger northern nuclear neighbor. Some of its short- and intermediate-range missiles probably continued to target Russia, as they did during the Cold War.

In sum, in just under 20 years, US-Russia-China relations deteriorated considerably, so much so that by 2020 it was the darkest prognosis of Brad

Roberts’s 2002 study that best described the strategic situation. The hope for a US-Russia-China partnership was replaced by US-Russia-China competition, and that competition now included both three-way counterbalancing moves and an odd man out, the United States. That is why Washington came to present Moscow and Beijing with two options: unconstrained nuclear competition or the conclusion of a trilateral arms control agreement (Trump 2018).

IMPACT ON NONPROLIFERATION AND NUCLEAR SECURITY

The difficulties in US-Russia-China strategic relations that began to surface in the 2000s did not, at first, negatively impact work on nonproliferation and nuclear security. On the contrary, until the mid-2010s, Washington, Moscow, and Beijing made significant progress in both of these areas despite their difficulties. That progress ended in the mid-2010s and, in some cases, later began to be reversed as US-Russia-China relations greatly worsened.

Progress until the Mid-2010s

In the 2000s, Russia and especially China considerably ramped up their actions to combat proliferation, notably by increasing their commitments to controlling sensitive exports. That is why there was a significant decline during that decade in the number of times that Russian and Chinese entities were placed under US proliferation sanctions. (Previously, Russian and Chinese entities had frequently appeared on these lists because Washington had had much tougher policies against proliferation than Moscow and Beijing.) China made a public commitment in 2000 not to assist “in any way, any country in the development of ballistic missiles that can be used to deliver nuclear weapons” (Chinese Ministry of Foreign Affairs 2000). In that spirit, Beijing began to align its export guidelines with the guidelines of the various multilateral export controls groups and, as a result, it was granted membership of the Nuclear Suppliers Group in 2004. These Chinese commitments were noteworthy in light of China’s record of assisting states with nuclear and missile programs.

US-Russia cooperation on nonproliferation and nuclear security also expanded and deepened considerably in the 2000s, notably, though not exclusively, through CTR and other similar programs. In 2000, for instance, the two countries signed the Plutonium Management and Disposition Agreement (PMDA), committing them to disposing of no less than 34 metric tons each of their surplus weapon-grade plutonium; an amended version of the agreement was signed in 2010 and it went into effect the following year. Washington and Moscow also negotiated agreements on nuclear trade and civilian research, allowing them to strengthen bilateral cooperation in those areas as well as to bolster their ability to fight nuclear proliferation and reduce the risks of nuclear terrorism.

Work on these issues flourished in the US-China context too. In the lead-up to the 2008 Beijing Olympic Games, in particular, Washington and Beijing enhanced their nuclear security cooperation. In 2011, the two countries signed a memorandum of understanding to pursue and expand such cooperation, which led to the establishment of a nuclear security center of excellence in Beijing, jointly built by the United States and China. The mission of the center, which opened its doors in 2016, was to carry out training of nuclear security professionals. As in the US-Russia context, US-China civilian nuclear cooperation expanded considerably in the 2000s, and Washington and Beijing negotiated a new nuclear cooperation agreement to replace their 1985 accord when it expired in 2015.

Moreover, the United States, Russia, and China joined forces to strengthen the multilateral nonproliferation and nuclear security regimes. They initially did little to shore up the NPT, BTWC, and CWC; the 2005 NPT Review Conference, for instance, notoriously ended in failure. But the three countries (and others) worked hard to create new regimes and tools to fight nuclear proliferation and nuclear terrorism. In 2004, the UN Security Council adopted Resolution 1540, which required all UN member states to develop and enforce appropriate legal and regulatory

measures against WMD proliferation. Then, in 2005, several countries successfully concluded an amendment to the CPPNM to strengthen the convention and negotiated a new treaty, the International Convention for the Suppression of Acts of Nuclear Terrorism.

These efforts, which depended heavily on US, Russian, and, to a lesser extent, Chinese leadership and cooperation, were complemented by various new ad hoc initiatives. Among them were the G8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, launched in 2002, which multilateralized efforts to reduce the threat of WMD terrorism worldwide;² the Hague Code of Conduct against Ballistic Missile Proliferation, also established in 2002, which sought to regulate access to ballistic missiles that can deliver WMD; the 2003 Proliferation Security Initiative, which aimed to stop WMD trafficking to and from states and nonstate actors of proliferation concern; and, in 2006, the Global Initiative to Combat Nuclear Terrorism, a US- and Russian-led partnership of countries working to improve capacity to prevent, detect, and respond to a nuclear terrorist event. In 2010, the United States also launched the nuclear security summits, a world summit process aimed at providing high-level attention and support to the efforts meant to prevent nuclear terrorism worldwide.

Note that all these initiatives included the participation of, and leadership from, the United States and Russia. Yet while participating in the Global Initiative to Combat Nuclear Terrorism and the nuclear security summits, China was not involved in the G8 Global Partnership (because it is not a G8 member), and Beijing also chose not to join the Hague Code of Conduct and the Proliferation Security Initiative.

Finally, and significantly, the 2000s witnessed considerable progress in the management of proliferation crises, largely thanks to growing cooperation among Washington, Moscow, and Beijing. For the first time, the three capitals engaged in intense negotiations with other key stakehold-

2. The "G8" refers to the group of eight industrialized countries – Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States – that decided at its 2002 summit in Canada to create the partnership. In 1997, the group, then known as the G7, invited Russia to join its annual meetings. Russia was a member until 2014, when the group ousted it because of Moscow's annexation of Crimea.

ers to tackle the Iranian and North Korean proliferation problems. In the case of Iran, the three countries joined France, Germany, and the United Kingdom to form a negotiating group known as the P5+1. The group sought to negotiate a deal in which Iran would accept constraints on its nuclear program in exchange for the lifting of economic sanctions. In the North Korean case, China, Russia, and the United States joined with Japan and South Korea, along with the North, in the so-called six-party talks. Note that while the United States

For starters, the United States began to doubt the Russian and Chinese commitment to nonproliferation and, in particular, to controlling sensitive exports.

played a central role in both negotiating processes, Russia assumed a greater role than China in negotiations with Iran and China was more active than Russia in negotiations with North Korea.

While often at odds about how to respond to these proliferation problems, the three capitals still managed, with others, to find common ground on a number of initiatives, including on the imposition of sanctions against both Tehran and Pyongyang. To be sure, these efforts failed to prevent North Korea from developing a nuclear arsenal, but they did impose limits on Iran's nuclear program, notably with the conclusion in 2015 of the Joint Comprehensive Plan of Action (JCPOA). In the same vein, while Russia shielded Syria, its ally, from condemnation and scrutiny in the wake of Israel's 2007 destruction of the planned plutonium production reactor supplied by North Korea, work by Russia and the United States to account for, inspect, and eliminate Syria's chemical weapons after Damascus's large-scale use of such weapons in 2013 stood, at least back then, as a clear nonproliferation success story.

Downturn in the Mid-2010s

US-Russia-China nonproliferation and nuclear security cooperation came to a near stop and even reversed course in some areas starting in the mid-2010s, as US-Russia-China strategic relations went from bad to worse.

For starters, the United States began to doubt the Russian and Chinese commitment to nonproliferation and, in particular, to controlling sensitive exports. During the mid-2010s, there was a sharp rise in US proliferation sanctions placed on Russian and Chinese entities because sensitive transfers from Russia and China continued, and seemingly even rose again. While China's nuclear export behavior improved after it joined the Nuclear Suppliers Group in 2004, Beijing still engaged in nuclear cooperation with

Pakistan in violation of the group's guidelines; Beijing and Islamabad signed a nuclear cooperation agreement in 2010, partly to placate Pakistan in the wake of the US-India nuclear deal. Washington also became concerned by Moscow's

– and increasingly Beijing's – practices with regard to civilian nuclear cooperation with other countries because both capitals proved much less demanding than Washington in terms of the nonproliferation conditions and assurances required of cooperation partners. For instance, Washington, unlike Moscow and Beijing, strongly discouraged its partners from acquiring the capability to enrich uranium or to separate plutonium from spent fuel through reprocessing.

US-Russia cooperation on nonproliferation and nuclear security was brought to a standstill in just a few years. In 2012, the Russian Ministry of Foreign Affairs had already indicated that it would not renew the framework for implementing CTR efforts in Russia, set to expire the following year. Despite subsequent efforts on both sides to salvage the program, Moscow terminated it in late 2014 in the context of rising hostilities with Washington following Russia's annexation of Crimea. A year earlier, Moscow had also suspended its participation in the PMDA over implementation disagreements with Washington. Then, in 2016, Russia suspended some nuclear activities with the United States, leaving in place the framework nuclear cooperation agreement.

Similar developments took place in the US-China context a few years later. Cooperation receded

on many fronts, particularly in civilian nuclear cooperation. The United States argued that cooperation with China had to stop because of Beijing's policy of "military-civil fusion," under which it had put in place laws and regulations to facilitate military diversion and exploitation of any technology accessible to anyone within China's jurisdiction (Ford 2019).

Trouble also emerged in multilateral fora. More recently, NPT meetings became the theater of open conflict between the United States and Russia. As two analysts put it, "As delegates to the April-May [2018] meeting of the NPT review process, we witnessed first-hand the furious volley of rights-of-reply in which the Russian and American delegations engaged" (Potter and Bid-

The management of proliferation crises became increasingly difficult as US-Russia-China relations deteriorated.

good 2018). As a result, no progress was made to improve the NPT although the five nuclear-weapon states had agreed in 2009 to take significant steps to advance the disarmament agenda. The only deliverable that the five countries could highlight was the conclusion of a "Glossary of Key Nuclear Terms," a product led by China that many believed fell short of expectations. While they had always been latent, issues with BTWC and CWC compliance and implementation also became more pronounced. The United States began to raise concerns about Russian and Chinese compliance with the BTWC and asserted that Russia was not in compliance with the CWC. In 2018, the United Kingdom also accused Russia of assassinating a former Russian spy, Sergei Skripal, and his daughter on UK territory by using a chemical agent. That series of events further soured relations between the major powers.

Other regimes began to suffer, too. Implementation of UN Security Council Resolution 1540 lagged, for instance. Moreover, Russia's indefinite suspension from the G8 following its annexation of Crimea in 2014 meant that it could no longer participate in G8 Global Partnership efforts. Partly

in retaliation, Russia opted to cease its participation in the nuclear security summit process; Moscow was not a participant in the 2016 event, the last of four biennial meetings of world leaders on that issue.

Finally, the management of proliferation crises became increasingly difficult as US-Russia-China relations deteriorated. Important differences emerged between Washington on the one hand and Moscow and Beijing on the other. The United States gave proliferation issues high priority; it showed a willingness to use sanctions and even debated the use of force to address them, as in the cases of North Korea and Iran. Russia and China proved much less concerned by such crises and wanted to address problems exclusively through diplomatic engagement. These differences in approach became so big that they seemingly drove the United States to give up on Russian and Chinese cooperation to address proliferation crises; until recently, Washington had always

considered that Moscow and Beijing were part of the solution to the Iranian and North Korean problems. Under President Donald Trump, the United States unilaterally withdrew from the JCPOA (because Trump administration considered it flawed) and engaged in a "maximum pressure" campaign against Iran. After threatening war against North Korea, Washington opted to pursue a fruitless bilateral diplomatic initiative with Pyongyang.

Accordingly, by 2020, there was no attempt to foster major-power cooperation to address proliferation crises. Distrust had become so widespread in US-Russia-China relations that even cooperation to deal with hard cases such as North Korea and Iran proved a bridge too far. Worse, Russia, for instance, did not make efforts to hide that it was now actively protecting some proliferators. Following the conclusion of the 2013 US-Russia agreement that dismantled Syria's declared arsenal of chemical weapons, Moscow took steps to shield Damascus from further actions by the international community, even after another chemical attack took place in Syria in 2017.

CONCLUSIONS

Nonproliferation and nuclear security are areas where the major powers have traditionally cooperated even when their relations were poor. That is no longer the case. Since the mid-2010s and the return of strategic competition, primarily between the United States and Russia and between the United States and China, cooperation on nonproliferation and nuclear security has stopped and, in some cases, suffered serious reversals. This is a trend that is likely to continue and could even worsen in the foreseeable future.

“Expect things to stay bad and maybe even get worse” is not a satisfactory conclusion, and it does nothing to guide policy. It does highlight at least two important implications, however.

First, the emerging strategic landscape is unique. Today’s competition between the major powers is likely to be vastly different from the one that took place during the Cold War, and it could be, in many ways, much more dangerous. Second, today’s major powers seem to have either forgotten or chosen to ignore that they have a shared interest in promoting nonproliferation and nuclear security. In other words, the United States, Russia, and China now seem to dismiss even the idea that they would benefit from cooperating on these fronts. Nor do they seem to acknowledge that such cooperation is essential given the power and influence that they have in the world, the fact that they have large economies and host industries that produce a plethora of sensitive materials and technologies, and the inherent transnational nature of the proliferation and nuclear terrorism threats. This is a new, concerning development.

While major-power competition is likely to remain the order of the day, it may be that Washington, Moscow, and Beijing eventually end up recognizing that such competition does

not preclude cooperation in some areas, notably nonproliferation and nuclear security. The late international relations professor Hedley Bull once said that “Arms control in its broadest sense comprises all those acts of military policy in which antagonistic states cooperate in the pursuit of common purposes even while they are struggling in the pursuit of conflictual ones” (Bull 1965, xiv). The same statement could apply to nonproliferation and nuclear security. In theory, the three major powers could continue to compete while also cooperating to address threats from proliferation and nuclear terrorism. The two endeavors are not, and should not be seen as, mutually exclusive, on the contrary. Fighting proliferation and nuclear terrorism threats should be a “common purpose”; that is how they were seen during the Cold War, and there is no reason why they should be seen differently today.

Unfortunately, there is no indication right now that today’s major powers will change course. If that remains the case, perhaps the baseline guiding principle should be the Hippocratic Oath “do not harm.” In other words, if the United States, Russia, and China continue to rule out cooperation on nonproliferation and nuclear security, they should at least ensure that the current situation does not get out of control. In practice, that means ensuring that the nonproliferation and nuclear security regimes do not break down and the hard proliferation challenges, notably North Korea and Iran, do not become unsolvable problems.

In any case, it may be that if the major powers abandon leadership, then the responsibility for managing these threats will fall on others, notably middle powers. Such countries, while less influential than the United States, Russia, and China, can still do much to address hard proliferation cases or shore up the international regimes that have helped prevent these cases from emerging in the first place. When leadership at the top is missing, the next level down must pick up the baton. ■

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ANKIT PANDA

Knocking Nuclear Weapons Off Their Pedestal: Emerging Technologies and the Future of Proliferation

For decades now, nuclear weapons have been almost universally regarded as a category apart from all other weapons. Despite fears of widespread nuclear proliferation in the early days of the Cold War, the world knows just nine nuclear possessors in 2020. As the 21st century continues, however, new technologies that may transform the nature of nuclear deterrence and stability are emerging. While many of these technologies interact with nuclear weapons in the realms of delivery systems (for example, hypersonic boost-glide vehicles) and command and control (for example, artificial intelligence), none are likely to knock nuclear weapons off their pedestal. In the coming decades, however, these

technologies may contribute to disincentives to nuclear proliferation, primarily by increasing the challenge for new nuclear aspirants in ensuring that their burgeoning nuclear forces will be survivable and, therefore, useful. To date, assuring survivability for nuclear forces has been mostly feasible, even for resource-poor nuclear possessors, but this might not be the case indefinitely – especially if revolutionary technical advances can be made in certain defensive technologies. This essay examines the pathways by which radical technical advances – even those that do not seem technically feasible, given current capabilities – might disincentivize future nuclear proliferation.

NUCLEAR WEAPONS ON THE PEDESTAL

Contrary to some accounts, the detonation of the Trinity “gadget” on July 16, 1945 did not immediately raise nuclear weapons above other forms of ordnance in the views of military planners – even as the Manhattan Project scientists who witnessed that initial detonation firsthand appreciated the devastating power of the plutonium implosion fission bomb. Though the initial use nuclear weapons against Imperial Japan in August 1945 conveyed that an import-

By the late 1950s, when the first intercontinental ballistic missile (ICBM) was deployed in the Soviet Union, it became apparent that any state on earth that had the appropriate ballistic missiles could in theory threaten another state with unacceptable levels of damage in a matter of minutes.

ant threshold had been crossed, military planners in the United States before the creation of the civilian-led Atomic Energy Commission treated early US nuclear weapons as an especially large iteration of conventional ordnance (Tannenwald 2005). It was only after the experience of multiple crises, Soviet nuclear breakout ending the US nuclear monopoly, and the “nuclear learning” of the early years of the Cold War between the two superpowers that many of the axioms concerning nuclear deterrence became established and better understood by practitioners. The nuclear taboo – a norm against the use of nuclear weapons – took hold more broadly by the end of the Cold War (Tannenwald 2007). Nuclear weapons have not been employed in conflict since 1945; the most recent case of a country testing a nuclear device for the first time was North Korea in 2006. Cold War-era nascent proliferators, some of whom ended their programs after the Nuclear Nonproliferation Treaty took effect in 1970, learned these lessons themselves, seeing nuclear weapons as a necessary component of their national defense policies until they were forced, primarily for political and diplomatic reasons,

to abandon their pursuit of the bomb (Kramer and Brannan 2004). Countries that succeeded in their efforts to acquire nuclear weapons – South Africa (before it disarmed), India, Pakistan, and North Korea – were undeterred from their course by the technical challenge. Other attempts – for instance, by South Korea and Taiwan during the Cold War – were ultimately thwarted by political interventions rather than the technical challenge.

Nuclear weapons had found themselves on a pedestal and appeared to proliferate quickly in the earlier years of the nuclear era. In technical terms, nuclear weapons radically revised earlier understandings of the relationship between the weight of ordnance and explosive yield: an impossibly impractical amount of conventional explosives would be necessary to achieve an effect comparable to that of even the earliest single-stage nuclear weapons, whose explosive yield was in the

thousands of tons of TNT equivalent. By the late 1950s, when the first intercontinental ballistic missile (ICBM) was deployed in the Soviet Union, it became apparent that any state on earth that had the appropriate ballistic missiles could in theory threaten another state with unacceptable levels of damage in a matter of minutes. Nuclear competition quickly spilled outside of the Cold War superpower dyad between the United States and Soviet Union as the United Kingdom (1952), France (1960), and China (1964) successfully developed nuclear weapons. As of 2020, nuclear weapons remain a special class of weaponry, with just nine known state possessors and a robust set of institutional, normative, and technical barriers to their proliferation in place.

A key question for the coming decades is whether any technical developments can displace the fundamental marriage between delivery vehicle and payload that made nuclear forces a central component of the national defense strategies of the powers that developed them and a few smaller states that turned out to be determined proliferators.

CAN A DEFENDER'S ADVANTAGE BE REALIZED?

Traditionally, possessors of nuclear offensive arms have been able to find acceptable levels of survivability – the ability of a sufficiently large part of one's nuclear forces to survive a nuclear or conventional attack – at moderate cost, even if political leaders have feared the effect of defensive systems. When an attacker's and defender's nuclear forces are sufficiently survivable, both are more likely to appreciate a condition of mutual vulnerability, which is stabilizing, depriving both of the incentive to use nuclear weapons against the other. While elegant in theory, this idealized notion of perfect strategic stability has not obtained in observed nuclear competitions. Despite the commonly repeated notion that the United States and the Soviet Union accepted some sort of stabilizing condition of "mutual assured destruction," the reality was that each side faced persistent insecurities throughout the Cold War as a result of concerns about the other side's qualitative and quantitative offensive advantages. Instead of accepting

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some level of strategic mutual vulnerability – which would have been stabilizing – both sides charted courses to develop defensive systems and planned counterforce targeting strategies to limit damage in case strategic deterrence were to fail. In the post-Cold War era, these instincts have persisted – especially in the United States, where advances in everything from sensor arrays to conventional precision strike systems to nuclear-force readiness have made avoiding vulnerability and challenging the survivability of the adversary's nuclear forces

appear more feasible (Lieber and Press 2006; Lieber and Press 2017).

North Korea's test of the Taepodong-1 technology demonstrator in 1998 spurred Washington and its allies to take strategic missile defense more seriously (Namatame 2012). This in turn led to the genesis of the Ground-Based Midcourse Defense (GMD) program by the Clinton administration's National Missile Defense program, which the George W. Bush administration then used as a pretext to exit the 1972 Anti-Ballistic Missile Treaty in 2002. US lawmakers supported the effort by approving the National Missile Defense Act of 1999. China and Russia, meanwhile, have responded to massive US investments in missile defense by focusing primarily on devising measures to defeat enemy missile defenses rather than developing their own missile defenses – partly out of a recognition that assuring the survivability of one's own forces is more feasible than threatening the survivability of the opposing forces. When Russian President Vladimir Putin, in a 2018 speech to the Russian Federal Assembly, described a panoply of exotic new delivery systems that the country's defense establishment

was exploring, he justified the effort in part by citing the US pursuit of missile defenses in the aftermath of the Bush administration's exit from the ABM Treaty (Putin 2018). Similarly, China's investments in multiple independently

targetable reentry vehicles and hypersonic boost-glide vehicles such as the DF-17 are driven by similar concerns.

In the years since its inception, US testing of the GMD system has yielded a lackluster record, with all publicly available evidence suggesting that the system has fallen well short of its design objectives (Grego, Lewis, and Wright 2016). US policymakers often refer to missile defense as a "shield," but GMD – the only strategic defensive system that is currently in operation and has

been demonstrated to be capable of intercepting ICBM-class targets – has fallen well short of meriting that description (Korda 2019). Nevertheless, Russia and China continue to take US investments in missile defense seriously – largely on the assumption that qualitative breakthroughs may yet be possible in ways that could revolutionize the offensive advantage that long-range nuclear-tipped ballistic missiles have long enjoyed. The divergence between actual capabilities and feared potential future capability was aptly

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demonstrated by China’s reaction to the deployment of a US AN/TPY-2 X-band radar alongside a Terminal High Altitude Area Defense (THAAD) system in South Korea, with Beijing fearing the effects of this radar on the ability of the United States to cue up Alaska-based ground-based interceptors (GBIs) for defense of the US homeland with earlier warning than would otherwise have been feasible (Ministry of Foreign Affairs of the People’s Republic of China 2016).¹

Future proliferators will likely make similar calculations with imperfect information about the performance of real missile defense systems. Even if a prospective proliferator has ample fissile material at hand, political and strategic incentives to develop nuclear weapons, and a willingness to face great international opprobrium and economic sanctions, development of nuclear weapons might not be worthwhile unless the country were reasonably confident that its new arsenal would be able to hold its adversaries at risk. The story of North Korean acquisition of a usable nuclear arsenal – from the criticality of the Yongbyon 5-megawatt (electric) gas-graphite reactor in 1986 to the first flight test of an ICBM in 2017 – might not be easily repeatable. North Korea’s 2017 ICBM tests demonstrated credibly to many observers that the US homeland could

be held at risk by North Korea’s nuclear weapons. In a future where the GMD system – or a successor – might exhibit a perfect or near-perfect test record, a proliferator like North Korea would find the effort of developing nuclear weapons and the means of delivery to be far too onerous.

For instance, if the US ability to intercept all ICBM reentry vehicles in their midcourse phase had been demonstrated with a high degree of reliability, North Korea’s offensive capabilities

would need to grow quantitatively to the point where its ICBMs could greatly outnumber available interceptors – a costly proposition.

Or, Pyongyang would need to consider investing in qualitatively different means of nuclear delivery, such as low-flying hypersonic boost-glide weapons that are impervious to interception in midcourse. A would-be nuclear-armed state with limited resources might find that assuring survivability would become a vanishing prospect, not least because its adversaries might possess dominant defensive systems and long-range precision conventional-strike weapons that could carry out preemptive strikes. Even as the prospect of nuclear explosive yields would remain alluring for such a state, the low probability of assuring delivery and the resulting inability to establish the credibility that underpins nuclear deterrence might serve to disincentivize proliferation in the first place. To be sure, no qualitative revolution in missile defense technologies is anticipated in the near future – only gradual refinement. As a result, the offense is likely to retain its traditional advantage – even as defenders remain reluctant to accept mutual vulnerability in the pursuit of absolute security. Even so, the record of how China, Russia, and North Korea interpret the challenge that US missile defense systems pose, notwithstanding the poor track record of these systems to date, suggests that states will continue to reason from worst-case assumptions – that is, they will assume the best of their adversaries’ defensive systems.

1. Chinese experts have described fears of the X-band TPY-2 radar potentially assisting American exoatmospheric kill vehicles in discriminating warheads from physical countermeasures in midcourse as well. In 2016, China rejected US invitations to technical briefings on the THAAD system.

DEFENSIVE CAPABILITIES IN SPACE AND PROLIFERATION

Space-based strategic defenses may also contribute to deterring new proliferators – particularly those seeking to hold at risk the territory of the United States and other resource-rich states. As of today, only the United States has expressed serious interest in developing space-based strategic defensive capabilities, but other countries, including Russia and China, could reasonably follow in the coming decades if technological breakthroughs increase the feasibility of deploying such systems. In addition to strategic missile defense systems, one area that could see greater investment is space-based defensive systems, where new sensors and interceptors may contribute to a greater capability to intercept ballistic missile reentry vehicles in flight. Like the strategic effects of more-capable missile defenses, these types of capabilities would be destabilizing by reducing the mutual vulnerability that underpins

A particular concern for both new proliferators and existing nuclear possessors will be the possibility of advances in undersea, surface-level, and space-based sensors, combined with AI-enabled persistent intelligence, surveillance, and reconnaissance, to target nuclear ballistic missile submarines (SSBNs), which historically have been the most survivable platform for nuclear weapons.

strategic stability. For newer proliferators, such capabilities may present further challenges to assuring the survivability of nuclear forces.

For resource- and knowledge-poor states, counterspace capabilities might not be a feasible undertaking. Direct-ascent, kinetic-kill anti-satellite weapons – exoatmospheric missiles that head straight from the earth’s surface to an overhead satellite target – remain a relatively niche capability in 2020, with known systems existing in China, India, and Russia. (The United States used an SM-3 missile defense interceptor against a decaying satellite in 2008, demonstrating an

anti-satellite capability.) Co-orbital counterspace systems, meanwhile, remain relatively rare. If a new proliferator’s ballistic missiles would be vulnerable to unreachable, persistent space-based defenses, the benefits of acquiring nuclear weapons in the first place would be greatly blunted. As with the possibility of new advances in missile defense technologies, the challenge of assuring survivability would be insurmountable without serious resource investments in counterspace capabilities or advanced penetration aids.

EMERGING TECHNOLOGIES AND ASSURING SURVIVABILITY

Even without any dramatic advances in missile defense technologies, new nuclear-armed states might be deterred in their pursuit of new capabilities by the incorporation of artificial intelligence (AI) systems into counterproliferation intelligence, surveillance, and reconnaissance activities.

Some of these technologies are already being used today, allowing, for example, human intelligence analysts to more quickly analyze vast quantities of raw information, including imagery. Greater advances in this area could make the detection of clandestine

nuclear activity more viable (Gartin 2019). As the Central Intelligence Agency’s chief learning officer has observed, “The explosion of data has increased the complexity of an analyst’s job, but likewise potentially increased the fidelity of many assessments” (Gartin 2019, 3). “We are awash in ones and zeroes that can be linked, analyzed, and leveraged, if we ask the right questions of the right data sets,” he adds. The gaps in intelligence and the resulting policy uncertainty that persisted in prior cases, including North Korea, Libya, and Iraq, might be reduced by allowing resource-rich states such as the United States the means to improve its monitoring of potential proliferators.

A particular concern for both new proliferators and existing nuclear possessors will be the possibility of advances in undersea, surface-level, and space-based sensors, combined with AI-enabled persistent intelligence, surveillance, and reconnaissance, to target nuclear ballistic missile submarines (SSBNs), which historically have been the most survivable platform for nuclear weapons. Submarine-hunting is not a new enterprise, and the Cold War featured extensive efforts by the United States and the Soviet Union to simultaneously increase the stealthiness of its own submarines while increasing the ability of its own sensors to track the other's SSBNs. Although the often-referenced dramatic notion of a "transparent ocean" remains far from being realized today, it may not be so indefinitely (Cote 2019). As with the possibility of ballistic missile defenses improving in revolutionary ways, something akin to a transparent ocean may be imaginable in the future. The first-order effects of this would be severe for the major nuclear powers that have relied on continuous at-sea deterrence, such as the United States, the United Kingdom, and France, but this would also deprive new proliferators of a reason to consider sea-based nuclear weapons as a means to increase survivability. This would be true even in the case that strategic ballistic missile defense remained of limited capability as they are today.

Advances in undersea acoustic sensor technology and unmanned underwater vehicles, including autonomous vehicles, could contribute to such a future. Similarly, if more and more sensors were available to collect data, advanced artificial intelligence could assist in the identification of signatures that may be associated with SSBN movements. For instance, a modern iteration of the Cold War-era "deep sound channel" concept, in which underwater acoustic anomalies were detected by US Sound Surveillance Systems (SOSUS), could be imagined with a more sophisticated array of sensors where data analysis could be assisted by artificial intelligence (Long and Green 2015). SOSUS alone was insufficient during the Cold War to come close to identifying the precise location of Soviet submarines, but a new version may be more successful. A future analog to SOSUS may be assisted by autonomous underwater and aerial vehicles and might locate enemy submarines. In doing so, it would depend not only strategic stability between

nuclear superpowers relying on SSBNs as the most survivable leg of their forces, but proliferation incentives for states that might have been tempted to pursue the bomb with an eventual plan for sea-based deployment. The survivability of SSBNs, however, remains great, and there are considerable reasons to remain skeptical of the notion of a truly transparent ocean ever materializing to the extent that sea-based nuclear forces would have their traditional survivability advantages fully blunted (Naughton and Brixey-Williams 2016).

OFFENSIVE CYBER TECHNOLOGIES: RISKS AND OPTIONS

Advances in offensive cyber technologies – both those existing today and those yet to come – may significantly complicate the task of countries seeking to acquire nuclear weapons. For instance, nation-states have exhibited some degree of success in interfering in the industrial processes that would be necessary for the production of fissile material and ballistic missile airframes by adversaries. The Stuxnet worm was effective at significantly hindering and damaging Iran's nuclear program at the Natanz Enrichment Complex amid concerns about weaponization activity, for instance (Farwell and Rohozinski 2011). Separately, South Korean sources have reported that North Korea's leadership ordered an investigation into the repeated failures of one of its intermediate-range ballistic missiles, the Musudan, in 2016 (Yonhap News Agency 2016). Public reporting on US efforts to use offensive cyber means to interfere with the missile production supply chains of countries such as North Korea in recent years suggests that the United States sees opportunities for disruption in this area (Panda 2018).

If these capabilities become more robust and vulnerabilities persist in the industrial processes used by potential proliferators, it may be fairly trivial for more-sophisticated countries to sabotage the production of delivery vehicles, for example. This would effectively increase the costs of proliferation; states seeking to develop long-range missiles as delivery vehicles for nuclear weapons would have to improve their cybersecurity or the reliability of their personnel. Where institution-

alized export control arrangements might fail to deter a determined proliferator, these types of real costs might come to play a more important role in how states think about the costs of setting up their nuclear forces.

Elsewhere, offensive cyber capabilities will continue to weigh on policymakers as an opportunity

The notion that the United States – or other nuclear possessors – would cross the nuclear threshold in response to a cyberattack remains incredible.

and threat. Following the clarification in the 2018 US Nuclear Posture Review that the United States would not rule out the use of nuclear weapons in response to “significant, non-nuclear strategic attacks,” many analysts have argued that cyberattacks do not meet this threshold (Office of the Secretary of Defense 2018; Mount and Stowe-Thurston 2018). The NPR is silent on the matter of cyberattacks specifically, but the nongovernmental expert community has interpreted concerns about cyber offensive capabilities to be implicit in this clarification of prior US declaratory policy.² The notion that the United States – or other nuclear possessors – would cross the nuclear threshold in response to a cyberattack remains incredible. Cyberattacks have the potential to cause economic losses and damage to infrastructure, but with few exceptions, such as attacks on healthcare facilities that may cause loss of life to patients in critical care, these types of capabilities cannot replicate the damaging effects of nuclear weapons. Strategically, cyberattacks will continue to have great appeal for states at all levels of resources and technical sophistication for their plausible deniability and subsequent high-reward, low-risk nature. But, as noted above, they do not serve the same purposes as nuclear weapons. Because the damage they inflict is not of the same scale, the

threatened use of cyber weapons does not have the same deterrent effect as a threat to use nuclear weapons. Similarly, it is not plausible to threaten to use nuclear weapons to respond to a cyberattack.

The one exception to the above assessment might be cyberattacks that intentionally target the nuclear command, control, and communications apparatus of a nuclear possessor, but such attacks are unlikely to be carried out by states that do not have nuclear weapons. In the cases in which an aggressor with no nuclear arsenal or a very limited one might

see strategic value in such an attack (such as Iran or North Korea against the United States), the strategic value of the attack would be moderate. This type of attack would be plausible only if the potential aggressor feared a “bolt-out-of-the-blue” nuclear attack early in a crisis and therefore sought to prevent that possibility by disrupting its enemy’s ability to launch such an attack.

WHAT IF DEFENSIVE TECHNOLOGIES REMAIN CONCENTRATED?

Many of the futures imagined in this essay rely on the development of advanced technologies. An embedded assumption, however, is that the country that would likely first develop or master these technologies, from artificial intelligence to ballistic missile defense to undersea acoustics to offensive cyber capabilities, would be a resource-rich superpower. Given this, the first-order effects of many of these developments would be deeply destabilizing. But this destabilizing effect might not be universal; it probably would not apply to states that are considering developing nuclear weapons because of a regional rivalry. For instance, historically, the decisions by India

2. A leaked draft of the 2018 Nuclear Posture Review included language saying that “the President will have an expanding range of limited and graduated options to credibly deter Russian nuclear and non-nuclear strategic attacks, which could now include attacks against U.S. [Nuclear Command, Control, and Communications], in space and cyber space.” This language – or a variant – did not find its way into the final document, but the leaked version may offer insights into policymaker considerations in the process of drafting the document. The original leaked predecisional NPR is available at: <https://fas.org/nuke/guide/usa/npr2018-draft.pdf#page=33>.

and Pakistan to pursue nuclear weapons when they did had little to do with the existence of sophisticated anti-ballistic-missile systems and radars in the Soviet Union and the United States.

Future proliferators may, however, have their fates entangled with the superpowers, who may choose to take an interest in their potential pursuit of the bomb for political or diplomatic reasons. For instance, Iran's interest in the bomb through 2003, the date through which the International Atomic Energy Agency had determined Tehran pursued "the development of a nuclear explosive device," had everything to do with Israel's possession of nuclear weapons and the pursuit of a deterrence – but Tehran still found itself in a highly contentious standoff with the United States, Israel's superpower patron, as a result (Quevenco 2015). In the United States, meanwhile, Iran, a country that possessed neither a nuclear weapon nor an ICBM, had been described by the Missile Defense Agency as one of the motivators behind the GMD program, which

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was officially and nominally designed to defend the US homeland against "limited" ballistic missile threats from Tehran and Pyongyang.

As a result, given the stakes of new 21st century proliferation, even if the futures described here materialize only for technologically sophisticated, resource-rich countries, they will have global effects. There are no "small" proliferators in the end. One way in which certain technologies might be more democratized to rich and poor countries alike is by way of the private sector. Already, high-quality, frequently updated commercial satellite imagery is available to private consumers worldwide. Nation-states with limited indigenous capabilities for satellite imagery could never have imagined having access to these sorts of resources during the Cold War, for instance, when the cutting edge in space-based imagery

was limited to a handful of states. Similarly, as countries such as North Korea have demonstrated, sophisticated cyber capabilities need not be the sole preserve of large, wealthy states (Kong, Lim, and Kim 2019). But even while these technologies might be accessible to potential new proliferators, they are unlikely to have a significant effect on the thinking of countries as they decide whether to develop nuclear weapons.

New technologies might deter new proliferators, but could potential proliferators find nonnuclear weapons to be a worthwhile defense investment instead of nuclear weapons? This appears unlikely. The logic that elevated nuclear weapons onto a pedestal during the Cold War relied on the ability of these weapons to impose indiscriminate and high costs on adversaries – with delivery being feasible over long ranges (Wohlstetter 1958). Emerging technologies may have the effect of making nonnuclear precision strikes more feasible on a global scale and making defense against nuclear attack more of a reality, despite decades

of overpromised and underdelivered progress on missile defenses. If any contemporary states were to decide to pursue the bomb, it would be because their

national leaders perceived nuclear weapons to be providing capabilities that other weapons could not provide.

CONCLUSIONS

As in recent decades, the main disincentives for nuclear proliferation will come from political, institutional, and normative sources. While several critical technologies will continue to advance, future proliferators generally will not be motivated by technical developments alone. On top of the already robust normative and political disincentives against nuclear proliferation, new proliferators will likely face tremendous difficulty in breaking out in total secrecy and, even if they succeed in building nuclear weapons, will find the pursuit of a surviv-

able nuclear force more challenging than their 20th-century predecessors. This will be doubly true for resource-poor proliferators seeking to deter superpowers, especially as the latter may have increasing access to sophisticated defensive technologies and even offensive cyber means to create complications for the former in the industrial supply chain for ballistic missile production and manufacturing.

It is possible, however, that despite projections that imagine significant leaps in capabilities for missile defense systems, space-based sensors, and other technologies, technical developments in these fields will be incremental because of resource constraints – even in rich countries – or a lack of ability to innovate to overcome the core

limitations that have kept these technologies from fulfilling their promise. In such an eventuality, these technologies will remain mostly irrelevant for the prospective proliferator's decision to pursue the bomb in the first place. Like North Korea, which saw fit to master a physics package and flight-test an ICBM capable of holding the United States at risk before worrying about qualitatively and quantitatively pursuing a more survivable nuclear force, states that decide nuclear weaponry is necessary may find that that immediate deterrent effects of these weapons are reason enough to pursue them. The primary inhibitors to proliferation, as a result, will continue to be the institutional and normative mechanisms of restraint that have largely prevailed over the last half century. ■

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David Santoro is vice president and director of nuclear policy programs at Pacific Forum, located in Honolulu, Hawaii. He specializes in strategic and deterrence issues, as well as nonproliferation and nuclear security, with a regional focus on Asia and Europe. Before joining Pacific Forum, Dr. Santoro worked on nuclear policy issues in France, Australia, Canada, and the United Kingdom. Santoro is coeditor, with Tanya Ogilvie-White, of *Slaying the Nuclear Dragon* (University of Georgia Press, 2012) and author of *Treating Weapons Proliferation* (Palgrave, 2010). His essays have been published in several monograph series and academic journals, such as *Nonproliferation Review*, *Proliferation Papers*, and *Survival*, and his op-eds have appeared in the *Bangkok Post*, *Bulletin of the Atomic Scientists*, *Japan Times*, *PacNet*, and *Wall Street Journal*, among others.

ADAM M. SCHEINMAN

Adam M. Scheinman is a career member of the Senior Executive Service and DOE Faculty Chair at the National War College as of June 2017. From September 2014 through January 2017, he served

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From 1999 to 2009, Ambassador Scheinman held a number of positions in the Department of Energy's National Nuclear Security Administration, including Assistant Deputy Administrator in the Office of Nonproliferation and International Security (a career SES position); Director in the Office of Export Control Policy and Cooperation in the Office of Arms Control and Nonproliferation; and Senior Advisor to the Assistant Secretary for Nonproliferation and National Security. From 1995 to 1999, he served as Foreign Affairs Analyst in the Office of International Policy and Analysis Division at the Department of Energy. From 1990 to 1995, he was a policy analyst and program coordinator for several non-governmental organizations that focus on arms control and nonproliferation matters. He is an alumnus of Cornell University (B.A. 1987) and the George Washington University's Elliot School of International Affairs (M.A. 1990). He, his wife and three children live in Falls Church, VA.

HENRY SOKOLSKI

Henry Sokolski is the executive director of the Nonproliferation Policy Education Center and teaches graduate-level classes on nuclear policy at the University of Utah and the Institute of World Politics. He is also a Senior Fellow for Nuclear Security Studies at the University of California at San Diego's School of Global Policy and Strategy.

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SHARON SQUASSONI

Sharon Squassoni is the principal investigator for the Nuclear Boundaries Initiative. She joined the research faculty at the Elliott School of International Affairs, George Washington University in 2018. An expert in nuclear nonproliferation and arms control, she directed the Proliferation Prevention Program at the Center for Strategic and International Studies from 2010 to 2017 and was a senior scholar at the Carnegie Endowment for International Peace from 2007 to 2010. Ms. Squassoni advised Congress as a senior specialist in weapons of mass destruction at the Congressional Research Service from 2002 to 2007 and served for eight years prior to that in the Department of State and in the Arms Control and Disarmament Agency. Ms. Squassoni is a distinguished graduate of the National War College, a member of the Science & Security Board of the Bulletin of the Atomic Scientists, a member of the board of the Center for Arms Control and Nonproliferation and on the advisory board of the PIR Center in Moscow.

WILLIAM TOBEY

William Tobey was Deputy Administrator for Defense Nuclear Nonproliferation at the National Nuclear Security Administration from 2006-2009. There, he managed the U.S. government's largest program to prevent nuclear proliferation and terrorism by detecting, securing, and disposing of dangerous nu-

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ROBERT S. WILSON

Robert S. Wilson is a policy analyst for the Center for Space Policy and Strategy at The Aerospace Corporation. In his role, he is responsible for leading work on international space; nuclear command, control, and communications; and missile issues. Wilson has authored papers on the impact of Brexit on UK space; Japan's shift toward space security; the future of space-based nuclear command, control, and communications; and space traffic management. He has led work for the Office of the Assistant Secretary of the Air Force for Acquisition and Integration, the Office of the Director of National Intelligence, and the Air Force Nuclear Weapons Center. As a result of his work, Wilson has testified to the House of Lords in a public hearing, discussed space issues in Track II dialogues in Moscow, guest lectured at universities, and presented on panels at think tanks in Washington, at U.S. Strategic Command, and at the Pacific Northwest National Laboratory.

Prior to joining Aerospace, Mr. Wilson served as a senior analyst in the U.S. Government Accountability Office, leading reports on nuclear command, control, and communications; strategic force structure; arms control; and U.S. nuclear forces in Europe. He has completed fellowships with the National Defense University's Program for Emerging Leaders, the Center for Strategic and International Studies Project on Nuclear Issues, the German Marshall Fund, and the Nonproliferation Policy Education Center.

JON B. WOLFSTHAL

Jon B. Wolfsthal is director of the Nuclear Crisis Group, an independent nonpartisan group of globally-recognized former military officials, diplomats, and security experts dedicated to preventing crises from escalating to the use of nuclear weapons. From 2014 to 2017, he served as special assistant to former U.S. President Barack Obama and as senior director for arms control and nonproliferation at the National Security Council. In that post, he was the most senior White House official, setting and implementing U.S. government policy on all aspects of arms control, nonproliferation, and nuclear policy. Prior to that, he served as the deputy director of the James Martin Center for Nonproliferation Studies at the Monterey Institute for International Studies.

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