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Edited by **Dr. Viatcheslav Kantor**
President of the International Luxembourg Forum on Preventing Nuclear Catastrophe

INTERNATIONAL LUXEMBOURG FORUM ON PREVENTING NUCLEAR CATASTROPHE
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International Luxembourg Forum
on Preventing Nuclear Catastrophe

PREVENTING THE EROSION OF STRATEGIC STABILITY

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This book follows a conference of the International Luxembourg Forum on Preventing Nuclear Catastrophe held with the intellectual support of the Carnegie Endowment for International Peace in Geneva in June 2018. Leading experts in nuclear security, arms reduction and nuclear non-proliferation from Russia, the United States and other countries came together to discuss the most important and pressing issues of strategic and regional stability. This book, prefaced by the President of the Luxembourg Forum, contains chapters on the dynamics of the strategic relationship between Russia and the United States, arms control, global nuclear weapons proliferation and its consequences for strategic stability, and the two leading nuclear powers' plans to upgrade their arsenals.

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“The Luxembourg Forum has had successful meetings for more than a decade, highlighting nuclear dangers to the world and making concrete and constructive proposals to lower those dangers. In particular, they have consistently pressed for constructive official dialogue between the USA and Russia in the nuclear field. During the early years, the Luxembourg Forum was one of a number of unofficial – Track 2 – dialogues underway, but during the last decade many of the other Track 2 dialogues have been discontinued, which is exactly the opposite of what should have happened. As the tensions between the USA and Russia increase, so does the danger of a nuclear catastrophe. And in the absence of any significant official dialogue on how to decrease those dangers, a much greater burden falls on Track 2 dialogue. While we would like to see a much more robust Track 2 dialogue in this critically important field, we are prepared to continue and strengthen the Luxembourg Forum to close this unfortunate gap in dialogue.”

William Perry

INTRODUCTION BY VIATCHESLAV KANTOR, PRESIDENT OF INTERNATIONAL LUXEMBOURG FORUM

The work of the International Luxembourg Forum is primarily intended to perform deeper scientific analysis of the state of strategic and regional stability in the world. It requires looking beyond the current, unprecedented turbulence of political and military relations between major coalitions and states. It means trying to rise above the tussle, to identify some regular patterns in a rapidly changing context which, despite a few seemingly positive local developments, is becoming increasingly tense and menacing.

Scientific analysis has always been part and parcel of the Luxembourg Forum. The Forum's experts are distinguished scholars: historians, political scientists, physicians, nuclear physicists, engineers. At the same time, we are all human beings, who react strongly to events as they occur in real time, as our regular annual conferences show. In our conference's declarations and proposals, we recommend, in response to current events relevant to our field of study, specific steps for strengthening the nuclear non-proliferation regime, reducing nuclear weapons, solving regional nuclear crises and other suchlike issues. To lock ourselves up, as the saying goes, in an ivory tower of thinkers and philosophers and not react to current events, is something we cannot do.

Perhaps, with this impending chaos, as some have described it, what is needed for an objective analysis of the causes behind the current, far-reaching changes and disagreements between America, Europe, Russia, the Asia-Pacific region and South Asia in the political, economic and military fields, is an ingenious researcher-philosopher who will see some logic and find the key to survival and sustainable development. But this will take time.

Time, however, is something we do not have. Over the last year alone we have witnessed a heightening of tensions between Russia, the United States and China, and an increase in military confrontation and rivalry in Eastern Europe, the Middle East, in the Western part of the Pacific Ocean and in the Arctic.

The general trend in the political and military affairs that fall within the Luxembourg Forum's remit is such that the situation is becoming increasingly fraught, threatening and hard to predict.

The nuclear weapons control regimes continue to weaken. The Intermediate-Range Nuclear Forces Treaty is in jeopardy, as Russia and the United States do not appear likely to settle their mutual grievances. The Strategic Arms Reductions Talks are still on hold, which is unprecedented in almost fifty years. Today the prospects for a new agreement between Russia and USA are non-existent. Even a five-year extension of New START, which is due to expire in 2021, is not being seriously discussed.

A new problem is the USA's withdrawal from the nuclear agreement with Iran. Our experts have aptly spelt out a whole range of flaws in the Joint Comprehensive Plan of Action (JCPOA), which was unanimously endorsed by the UN Security Council on July 20, 2015 and is intended to last ten years. It includes a fifteen-year obligation for Teheran to possess no more than 300 kg of uranium enriched up to 3,67% and to not produce highly enriched uranium or weapons-grade plutonium, amongst other things. But in ten years' time, unless there is another agreement, Iran could, as far as is known, create its first nuclear weapon in one or two years. The JCPOA does not prohibit further development of long-range ballistic missiles, which could threaten European and other countries' territory.

Those involved in the painstaking negotiations with Iran, which lasted eleven years, understood all this. They also understood that this deal was the best possible result they could achieve, given that without it Tehran might already have built nuclear weapons by now.

But if the deal breaks down following the decisions of the US administration, it would take Iran only a couple of years to build a nuclear warhead for its missiles. In this regard, information asserting that Teheran hoodwinked everyone by claiming that it was not developing nuclear weapons brings no fresh news. What matters is that now all Iran's actions are verified by IAEA staff, according to whom the terms of the nuclear agreement are being fully met.

But one thing is very important. It is quite understandable that US attitude to Iranian deal triggers the process, absolutely new process, of preparation of a new treaty, which will include delivery means of nuclear and non-nuclear warheads. This is possible positive result. Talks with Iran will again be extremely difficult, but we do not have any other alternative.

It is virtually impossible to predict right now what the prospects for a settlement of the nuclear crisis on the Korean peninsula will look like following contacts between the US, South Korean, and Japanese leaders. All that can be done for now is to check various possible scenarios, which Forum's experts regularly examine.

Crucial agreements such as the Comprehensive Nuclear-Test-Ban Treaty, Fissile Material Cut-Off Treaty, agreements on plutonium, on the safety and security of nuclear weapons and nuclear material are at a prolonged standstill.

Meanwhile, the USA and Russia are planning and carrying out a full-scale modernization of their strategic nuclear forces, enhancing their effectiveness in all the various ways in which they can be deployed in combat.

All that has a very damaging effect on the principles of strategic and regional stability and on the nuclear non-proliferation regime, which are both receding into the background, if not further, as leading states try to address new, global issues of contention between themselves. Nor are there any opportunities for renewed joint efforts aimed at curbing the threat of catastrophic nuclear terrorism. This threat has grown significantly as a consequence of there being more nuclear countries and of efforts to safeguard nuclear materials having been reduced.

This is constantly being recalled by well-known international political figures, scientists and experts, including William Perry, a member of the Forum's Supervisory Board, and General Eugene Habiger and his fellow American and Russian generals in the framework of the Elbe Group's regular meetings.

They insist that the question is not *whether* a terrorist attack will occur, but rather *when*. There is no need to wait for such a nuclear attack with all its catastrophic consequences to actually happen in order to understand this threat.

Especially given the fact that the general situation which, for a number of reasons, is marked by discord and rising animosity in society at large, is playing into the hands of ultra-leftist, ultra-right and terrorist movements which in turn increases the threat of terror attacks.

Therefore, one of the Forum's objectives is to try and convince political leaders as soon as possible of the need to work together, despite all their disagreements, in order to prevent such a catastrophe.

The Forum's experts recognize the usefulness of picking out some general and regular patterns connected to the dynamics unfolding in their sphere of interest. They have previously formulated conclusions and proposals on the role of sanctions in solving the Iranian and North Korean nuclear crises. The progressive stiffening of sanctions by the UN Security Council and individual states appear to have proved the most pivotal in bringing about a nuclear agreement with Iran and making Kim Jong Un amenable to a "sporting reconciliation" and then to state-level meetings.

The Forum's previous declarations already made the case that during such crises diplomatic efforts must be made in parallel to a full-scale sanctions regime. It continues to be the Forum's general conclusion and recommendation as to what should be done in the event of other but similar situations.

The result of the Forum's collaboration with various international organizations is the elaboration of a set of criteria for analyzing developments in the field of nuclear energy in states suspected of intending to create a nuclear weapon. These criteria allow IAEA staff to perform more detailed verifications right up to what is considered to be a red line beyond which the threat posed to the Treaty on the Non-Proliferation of Nuclear Weapons would warrant immediate intervention.

This book includes some of Forum's proposals and recommendations to key international organizations and the leaders of major states on how to enhance the nuclear non-proliferation regime in order to strengthen nuclear security and avert catastrophic consequences.

I. PRACTICE AND THEORY OF STRATEGIC STABILITY

1.1. A PEACEFUL KOREAN PENINSULA: REAL OR IMAGINARY?

William Perry[1]

On June 12, 2018 the eyes of the world will focus on Singapore, where Kim Jong Un and Donald Trump will be deciding the future of North Korea's nuclear arsenal which in turn will determine whether there would be a military conflict with North Korea.

We have faced that stark choice before; but this time there is a huge difference in what a military conflict would entail. Today a military conflict with Pyongyang could escalate into a nuclear catastrophe that could result in more than ten million casualties. North Korea has enough nuclear bombs, including some thermonuclear bombs, that they could destroy Seoul and Tokyo, while they themselves were being destroyed. And the outcome could be far worse if the conflict were to expand; to China, for example.

I will try to answer two questions. How did we get into this mess? And will the Singapore meeting get us out of it?

When I became the US Secretary of Defense in 1994, the first crisis I faced was North Korea. Pyongyang had announced its intent to produce plutonium by reprocessing spent fuel from its reactor, which would have given it enough plutonium to make six nuclear bombs. President Bill Clinton determined that it would be too dangerous to

1 William J. Perry – Professor at the Stanford University, Member of the Supervisory Board of the International Luxembourg Forum, PhD (USA).

allow North Korea to make plutonium, and authorized me to make a public statement saying that we would not permit them to do so.

North Korea responded by calling me a "war maniac." It appeared that Pyongyang was not going to back down, so I prepared an option, which I did not announce, for destroying their nuclear facility with cruise missiles armed with conventional warheads. And the State Department prepared an option, which they did announce, for sanctions that would have been very damaging to North Korea.

But Pyongyang threatened to engulf Seoul in a "sea of flames" if the sanctions were imposed. The threat could be bombast, but we knew that they were capable of carrying out that threat. North Korea had a huge deployment of artillery at the border that could indeed engulf Seoul in a sea of flames and lead to a second Korean War.

I proposed that before imposing the sanctions, we should augment our forces in Korea with another 20,000 troops, so if they did follow through on that threat, we could stop their troops before they reached Seoul.

In the meantime, President Clinton had authorized former President Jimmy Carter to go to Pyongyang to meet with Kim Il Sung. During the national security meeting considering my proposal for reinforcing American troops, President Clinton received a phone call from President Carter who reported that Kim Il Sung had agreed to stop production of plutonium and negotiate a diplomatic solution.

It is fair to say that this was a successful example of what is usually called "coercive diplomacy." Ambassador Gallucci was appointed to lead the American diplomatic team and in a few months he had negotiated the Agreed Framework.

I believed then as I do now, that this was an excellent agreement, but it was bitterly opposed by some members of the US Congress who led a continuing battle against it. The US, Japan, and South Korea fully complied with the "hard" agreements that entailed building two light water reactors for North Korea and supplying them with fuel oil until the reactors were operational.

But as a result of the intense opposition in Congress, President Clinton decided that it would be politically difficult to comply with the "soft" agreements – the actions designed to move towards a normalization of relations with North Korea.

Pyongyang fully complied with the "hard" agreements by shutting down the nuclear complex at Yongbyon, but they wanted a hedge; so they started an R&D program in highly enriched uranium at a covert facility. So neither side fully complied with the full intent of the Agreed Framework. The net of this was that the Agreed Framework did prevent North Korea from building the dozens of plutonium-based nuclear bombs they could have built at Yongbyon by the end of the decade, but it did not lead to normalization; and it did not prevent North Korea from getting a head start on a uranium-based nuclear bomb.

In 1999, a new crisis arose with North Korea over their test firing of a long-range missile. We saw the test firing as evidence that they must also be continuing work on the development of a nuclear bomb, since an ICBM does not make military sense unless it has a nuclear warhead. We soon found out that this continuing nuclear work was an R&D program for enriching uranium. We had a new crisis, with many calls for withdrawing from the Agreed Framework. By this time I was back at Stanford, but President Clinton asked me to come back into the government for a few months to be his special envoy to North Korea.

I agreed and added comparable envoys from Japan and South Korea. The three of us worked together as a team and in a few months had prepared a report that described a way forward. The report said that it was time to end our wishful thinking about North Korea. It called for coercive diplomacy; that is, a combination of incentives and disincentives ("carrots and sticks"). It laid out a rich package of incentives not previously offered to North Korea, including ending the Korean War and diplomatic recognition.

These last two we saw as key steps in normalization, which we believed was necessary to fully end the threat of war with North Korea.

In the latter half of 1999 I spent four days in Pyongyang negotiating an agreement with North Korea that would require it to give up its nuclear and long-range missile programs. I left Pyongyang believing that the North was very positive about our proposal.

During the next twelve months there were hopeful signs: a North-South summit meeting; the two Koreas' teams marching together in the 2000 Olympics. Then in October 2000 Kim Jong Il sent his senior military advisor to Washington to conclude that negotiation.

He stopped at Stanford to visit me on the way to Washington and we had very positive discussions. I then went with him to Washington and again the discussions were very positive. By the end of 2000 the deal was ready for signing by the heads of state.

But a month later, the Bush administration came to power and cut off all discussions with North Korea, thus walking away from this opportunity to stop North Korea's nuclear program.

I believe the Bush administration cut off discussions because they thought that if they could put enough economic pressure on North Korea the regime would collapse. But I think this reflected a lack of understanding about how tight and ruthless was the control of the North Korean regime over their people. In any event, that hoped-for collapse did not happen.

In 2003, the crisis began building up again and China stepped in to promote the six-party talks. The talks were hopeful, but those hopes were dashed when North Korea conducted its first nuclear test.

So while the talks were underway, North Korea was developing and testing both nuclear weapons and long-range missiles. Today they have a medium-sized arsenal of nuclear bombs, including thermonuclear bombs, and a large arsenal of ballistic missiles, including an ICBM that has been successfully tested. And they continue to build and test.

What can we learn from these previous negotiations with North Korea? I believe that the *first and the most fundamental lesson* is that North Korea, at a very high cost, has pursued a nuclear program to ensure the survival of their regime, that is maintaining the Kim dynasty. That was quite obvious to me during the four days I spent in Pyongyang in 1999.

North Korea believed that the US had the intent and the capability to overthrow their regime, and that a North Korean nuclear arsenal was the only sure way to deter us from carrying out that plan. One cannot learn everything about a regime in four days, but that lesson was absolutely clear to me.

A *second lesson* is that, in spite of their bluster and threats, they seek "normalization." Indeed, I have come to believe that there will be no peace and stability on the peninsula until normalization is achieved. The *third lesson* was that North Korean leaders are not "crazy."

They are despotic; they are ruthless; they are cruel to their own people; but they are not crazy. They have a rationale for their actions – to stay in power – and they have followed that rationale with consistency and shrewdness. I note that all other Stalinist regimes in the world have been overthrown since the end of the Cold War – North Korean is the last one standing.

So from their point of view, they are doing something right. The *fourth lesson* is that while they value economic incentives, and will bargain for them, they will never trade regime survivability for economic benefits, no matter how attractive.

Conversely, economic disincentives (sanctions) hurt North Korea, but by themselves will not cause them to give up their nuclear program. During our negotiations with Pyongyang my guiding principle was: "We must deal with North Korea as it is, not as we wish it to be." And those four lessons give us a clue as to how "it is."

Any agreement must deal with their security concerns and that cannot be achieved through economic incentives alone. Any agreement must address their desire for normalization. And any agreement made must be subject to a rigorous verification process that is included in the agreement.

And that will be very difficult in a country rightly called the "Hermit Kingdom." These are not non-starters, but they do call into question whether the US can quickly achieve its stated goal of full denuclearization, now that North Korea has a nuclear arsenal. That arsenal provides a deterrent to any military attack by the US, an attack that North Korean officials believe would be successful

Believing that, why would they give up the nuclear arsenal that deters such an attack? Or, to put it another way, what could we offer them that would persuade them to give up their nuclear arsenal and remain confident of staying in power? Would American security assurances do that? I offered them such assurances in 1999, and they were very interested.

But at that time, they did not have a nuclear arsenal, and could not be sure that they could succeed in building one. Thus they were not considering giving up a nuclear arsenal, but rather giving up the right to try to build one.

Perhaps we could strengthen the security assurances we offer them by getting the other participants in the six-party talks – China, Russia, Japan, and South Korea – to be co-signers of the security agreement.

Verification is critical in any arms control agreement, but particularly so with North Korea given its history of breaking agreements. And I do not know of any way of unilaterally verifying an agreement whereby North Korea gives up its nuclear arsenal. We do not know how many nuclear weapons they have operational or under construction. We do not know where all of their nuclear facilities are located.

And counting warheads is fundamentally difficult. The US nuclear treaties with the Soviet Union and Russia counted operational missiles which could be verified, and inferred the number of warheads which could not be directly verified.

To this day, the US does not know how many nuclear warheads Russia has in reserve or storage, and the error in the estimates could be in the thousands. It is hard to understand how we could unilaterally verify a treaty in which North Korea agreed to dismantle all of its nuclear weapons and not build more.

It will take a degree of intrusiveness well beyond previously discussed, and, just as importantly, it would take some progress on the road to normalization. So full disarmament will take some time, and in the meantime we could improve our security by reaching an immediate agreement with North Korea on a testing ban and a ban on any transfer of nuclear technology or components.

Such an agreement should be easy to negotiate and, once negotiated, relatively easy to verify. In the meantime, North Korea could begin the process of denuclearization while we began the process of instituting security assurances.

Denuclearization is likely to be a long and difficult process, and its ultimate success is tied to progress in normalization, which itself takes time. And while normalization with the US is important, normalization between the two Koreas must be taking place at the same time. Indeed, in some ways, the ongoing talks between the North and South, are perhaps more important than the US-North Korea talks.

The four things mentioned above are the same as in previous negotiations. But one important difference is the robust North-South dialogue, and that will be the key to bringing about normalization, which is the key to long-term peace and stability.

The other major difference is that the US president is a Republican. That means, if Donald Trump can get a peace agreement, he can get it supported in the Congress, unlike Bill Clinton, who could not get congressional support for the Agreed Framework.

That is what I would call *the Nixon effect*. If any Democratic president had tried to do what Richard Nixon did in China, he would have been rebuffed in the Congress. If President Trump can get an agreement, he will have *the Nixon effect* working for him.

I believe that between the US and South Korea we could set up a process that in the long term could lead to normalization and to a non-nuclear Korean Peninsula; and in the short term, would make us safer through the ban on testing and transfer, and the beginning of concrete steps towards disarmament and normalization.

So very useful results could be obtained from negotiations, but not the immediate and full denuclearization that some are expecting. The negotiations could result in failure if we enter them with unrealistic expectations.

But we could negotiate an agreement that would quite significantly improve security on the Korean Peninsula – and that would be a stepping stone to even stronger agreements. Peace and security on the Korean Peninsula could be real; but it will not be quick; and it will not be easy.

1.2. THE SCIENCE OF STRATEGIC STABILITY

***Roald Sagdeev*[1]**

The notion of strategic stability, which was very well understood and accepted on both sides of the Cold War divide, has almost disappeared from vocabulary of current nuclear powers leaders and actors. In recent speeches some of these leaders would talk mostly about nuclear balance or nuclear parity, avoiding the notion of strategic balance. There is a subtle, but very important difference between these two notions. I remember one of conversations with then the General Secretary Mikhail Gorbachev in the spring of 1986. He made a very brief remark indicating that he understood the difference between notions of nuclear parity and strategic stability. He put it in the following way: “Maintaining strategic stability does not require both sides to be equally armed.” It was indeed remarkable at the time when both nuclear superpowers just entered into very serious dialogues, which led to four important Reagan–Gorbachev summits and finally to the end of the Cold War.

Talking about importance of those summits, it is worth to note that the fourth summit in Moscow took place 30 years ago, in late May 1988. The summit went down in history not so much because of specific results coming out of negotiations, but rather thanks to the general spirit

1 Roald Sagdeev – Distinguished Professor of the Department of Physics at the University of Maryland, Member of the Supervisory Board of the International Luxembourg Forum, PhD (Russia/USA).

of what had been achieved during three previous summits. It was reflected in an interesting remark made by President Ronald Reagan when he was stepping on the stones of the Red Square. He declared that the Cold War between United States and Soviet Union had ended. The same day a reporter asked him about the relation between his statement on the end of the Cold War and a previous one which called the Soviet Union an "evil empire." Reagan responded: "You are talking about another time, another era." Those two statements were separated by only three years.

So now, thirty years after that famous summit in Moscow, unfortunately, it looks like we again are living in a different time and a different era with the Cold War coming back into our life. How has it happened? How did we get from what we had in the past to increasingly lower nuclear weapon levels and then to what we have today? It has been a long sequence of actions and events on both sides. The initial mistrust has later increased manifold.

Mistrust leads to misperception when one side tries to look at actions and declarations of the other side, and those are not even the actions or declarations *per se* which would eventually enter into military plans and actual arms race. These are exactly the misperceptions which are now playing a very important role. One could see it, for example, in recent actions and statements by President Vladimir Putin, particularly in his famous speech in Munich in 2007 in which he listed most of the Russian grievances of that period ten years ago.

Let us look closer at the origin of this type of mistrust and perceptions. The early 1980s were the time of major discussions of the ABM Treaty triggered by the idea of the Strategic Defense Initiative (SDI). Despite all the assurances of the American side that SDI had purely defensive purposes (even the weapons to be deployed in orbit), the Soviet military establishment took it with deep mistrust. The concern was that under the pretext of defense the United States were planning to deploy offensive arms.

That perception was about to trigger a response reaction in suggested military counteractions. I remember getting a phone call, as late as in 1984, from a prominent Soviet rocket scientist Academician Valentin Glushko. He said, "I am sending to you a draft document for a very important project to develop a new type of technology. I need you to sign it." I responded that I had not heard of it. He said, "But your collaborators were a part of the process." Essentially it was an elaborate plan to develop a new type of a maneuverable spacecraft which would be able to approach (maybe as close as at ten meters) potential SDI system in orbit to "sniff out" whether it might carry hydrogen warheads. It illustrates how far the mistrust and suspicion went at that time.

The draft document had signatures of all the key Soviet military technical figures. Almost everything was ready for the document to be presented to the government. There was a signature of Yulii Khariton, one of the fathers of the Soviet Union's nuclear weapons program, Anatoly Alexandrov, the president of the Academy of Sciences of the USSR and director of Kurchatov Institute of Atomic Energy. The only missing signature was mine as the director of the Space Research Institute. It took me about an hour and half to figure out every technological step of using a mass spectrometer to determine the composition of the potentially suspicious outgassing of a space vehicle, and what I found striking was an error by six orders of magnitude – the sensitivity of mass spectrometers of that time was overestimated. This is how the project was killed due to the simple finding.

Next year, 1985, witnessed a first summit in Geneva which did not immediately lead to an agreement but it was a first serious dialogue. I was lucky to participate almost in every summit between Ronald Reagan and Mikhail Gorbachev.

It is very important to remember that the concept of the ABM Treaty – to limit the danger of competition between defense and offense – originated on the American soil. Russians largely were taken by surprise at a famous meeting in Glassboro (USA) between US President Lyndon Johnson and Soviet Prime Minister Alexey Kosygin. President Johnson was the first to tell Mr. Kosygin that missile defense might lead to something very bad and to suggest that the two countries should agree on limiting such systems. The first reaction of Kosygin, who was completely unprepared to such a suggestion, was that "defense is moral, but offense is immoral." It took the Russian side some time to understand the rationale behind the idea of limiting missile defenses and eventually to sign the ABM Treaty. It is essential that Russian scientists played a key role in negotiating and discussing the concept in detail with their US counterparts.

The treaty was in fact a follow-on of a very early intervention of leading world scientists into the issues of arms control and elimination of nuclear weapons in particular during a series of Pugwash conferences. These major conferences were attended by the brightest scientists of that time and followed by a number of bilateral meetings between the US and Soviet scientists. Those involved either participated in military programs or were civilians who tried to gain in-depth knowledge of the issue. (Here I would like to commend the leadership of the Luxembourg Forum for promoting the idea of bringing scientists back to the table, so that science can play a role in generating and discussing new ideas in this area.)

Those meetings led to signing of the ABM Treaty. The *Nixon effect* played very important role not only in the president's Chinese initiative, but also in having agreements between Richard Nixon and Leonid Brezhnev ratified as the Republican Congress indeed supported those treaties.

For many years the ABM Treaty was a cornerstone of strategic stability, a guiding star for deterrence-based regime. It even survived a brief deviation by the United States intended to replace a narrow interpretation of the ABM Treaty by a broader one which would allow it to develop at least first stages of the Strategic Defense Initiative. Again, scientists played very important role in that episode with all the discussions of the limits on thresholds, certain parameters of "exotic" weapons, and so on.

However, in 2001 a disaster struck – the United States withdrew from the ABM Treaty. Trying to reassure Russia, President George W.

Bush even commented that “friends do not need treaties.” The question which remained unanswered was why then friends need treaty organizations? It is another important argument which has played a big role in a renewed arms race between the US and Russia which we are witnessing at the moment.

What kind of lessons we learned from history? We need a dialogue, a different type of a dialogue. Not simply an exchange of monologues, but a serious conversation, joint thinking, involvement of scientists and military experts. But if political leaders think that it is not enough to have scientists on board, I have another suggestion: in the era of grand expectations for artificial intelligence, maybe it can help us to build bridges between the two sides.

1.3 STRATEGIC STABILITY IN THE BROADER CONTEXT OF THE US–RUSSIAN RELATIONS

Andrew Weiss[1]

The ability of US and Russian experts to tackle hard issues in a constructive and forthright fashion gives one a sense of cautious optimism about what might be possible to restore some sense of direction and perhaps even momentum to the US–Russian relationship, which obviously is in very bad shape these days.

The disruptive effects of Donald Trump's *America First* policy are hard to overstate, and anyone who has been watching television coverage of preparations for the Trump-Kim summit meeting probably has a pretty good sense of that. But at the same time, the talks in Singapore are a good reminder of how there are a great many urgent real-world security challenges that are too important to ignore. We should all be hoping for success and progress in managing the very dangerous relationship between Washington and Pyongyang even as we seek to be realistic about what is in the realm of the possible.

That leaves us with a basic question. Can the United States and Russia achieve something similar? The optimist in me (and the former policy practitioner) says, "Sure, we have been through hard times, and there have always been people on both sides who are prepared to work through them with good faith and with creative ideas." The realist in

1 Andrew Weiss – James Family Chair and Vice President for Studies at the Carnegie Endowment for International Peace (USA).

me, though, says, "I am not so sure." We should be focusing most of our energies on what is most realistic and urgent – i.e., managing the fall-out and the dangerous implications of an increasingly competitive and adversarial relationship between the United States and Russia.

In assessing and looking over the state of that relationship, there is no disputing that the bilateral relationship between the United States and Russia is in tatters. There has been a near total breakdown across the relationship in all spheres. An incident in Syria on February 7 that involved a deadly confrontation between United States and Russian forces, broke through a key barrier that was respected throughout many of the worst days of the Cold War, that the United States and Russia should not be shooting at each other. Hopefully that incident is teaching various people a hard lesson, and that there will be no repeat.

There is a lack of reliable channels between the two governments right now. Apart from an important deconfliction mechanism that has been set up to prevent dangerous military incidents in Syria, it is very hard to see how this relationship is going to be managed at a time of increased pressure on both sides to show who is tough and to show that there is no backing down. Now that all things Russia-related have become neuralgic political issues in Washington, it is hard to imagine how the current US administration will have much room for maneuver or the practical ability to engineer a significant change in the policy framework that has been in place since the war in Ukraine began in 2014.

Economic sanctions and pressure have become the main tool for the United States to show its displeasure with Russian actions.

All of this contributes to a corrosive lack of trust on both sides, especially in the national security establishment. The political climate in both capitals is simply toxic.

Finally, there are divergent views about the international environment, global security challenges and what constitutes an agenda for the two sides to work on going forward.

So what can Presidents Putin and Trump do to change all of that? Well, there is no doubt that Donald Trump loves grand gestures, being disruptive, and shaking things up. As both a presidential candidate and now as president, he has remained fixated on trying to change the dynamic with Russia. Since his motivations for trying to accomplish this goal are a little bit hard to explain, it is unlikely that he is going to be terribly successful, not least because he has yet to demonstrate much mastery of or control over the policy apparatus that guides US policy on a day-to-day basis.

For his part, Vladimir Putin is a consummate realist who is always ready to get into discussions with less experienced foreign counterparts and to start wheeling and dealing at a moment's notice. He has been a mainstay on the international scene who has been reasserting Russia's global influence for the better part of 18 years.

But the actual agenda for the United States and Russia to focus on is not at all obvious. Yet the tensions, which in many ways are evocative of the worst days of the Cold War, are all-encompassing and pervasive. If we take a quick survey of the front-burner issues that preoccupy government figures on both sides, there is a tremendous overhang from the events of 2014, 2015, and 2016. It would be hard to overstate how dangerous that period has been and how corrosive it has been for US–Russian relations.

The strategic and security issues are obviously very complex. When it comes to regional issues, whether they are in East Asia or the Middle East, there is no escaping the impression that the situation is extremely complicated and worrying. Economic, trade, and commercial ties between our two countries are negligible at best.

And finally, and perhaps most tragically, people-to-people ties in various spheres such as the scientific-technological sphere and our joint efforts on space exploration, are at this point fading amid the waves of acrimony and mutual hostility in both countries.

The experts from both countries have to look at these issues in the spirit of cooperation and creativity, drawing upon a sincere desire to identify areas where the United States and Russia might yet be able to cooperate out of cold-blooded necessity.

II. US–RUSSIA: NUCLEAR MODERNIZATION – IMPLICATIONS FOR STRATEGIC STABILITY

2.1 NEW THREATS TO STRATEGIC STABILITY

Alexey Arbatov[1]

It is hard to come up with a notion that has been more widely used (and more widely abused) in political and military discussions of recent decades than "strategic stability." The multiple nuances range from an extremely broad interpretation to an extremely narrow one. In its broadest sense, the term is allegedly equivalent to "international security."

The narrow application relates to the state of military strategic relations between states, and arose as the nuclear balance and negotiations between the USSR and the USA were still evolving. Although the term is bandied about frequently for propaganda purposes, it does nevertheless convey a specific, agreed meaning, having served as the basis for a whole series of treaties between the two powers from the late 1980s on reducing strategic arms.

To judge from the agreed criteria of that construct, the strategic balance is more stable now than ever. Nonetheless, the paradox would seem to be that the two parties have drifted further and further apart over their understanding of strategic stability in just a few years, creating the real risk of an accelerating arms race and the collapse of the

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nuclear arms control system. Worse still, there is a decidedly greater chance of nuclear arms being used now than a quarter of a century ago, when the concept of strategic stability first emerged and true nuclear disarmament started.

The traditional meaning of stability

"Strategic stability" as a legal norm was devised for the first – and, regrettably for the last – time in June of 1990 in the US-Soviet Joint Statement,[2] and was defined as strategic relations that *"remove incentives for a nuclear first strike."* In order for such relations to develop, future treaties for the reduction of strategic offensive arms (START) had to incorporate a number of agreed upon elements:

- *The relationship between strategic offensive and defensive arms* (so that defense could not mitigate the other party's counter strike).
- *Reducing the concentration of warheads on strategic delivery vehicles* (so that a single delivery vehicle armed with several warheads could not strike several of the enemy's operationally deployed delivery vehicles armed with a large number of warheads).
- *Giving priority to highly survivable systems* (so they could not be destroyed by a pre-emptive strike before their launch).

The concept marked a revolutionary shift in traditional views. According to the 1990 Joint Statement's logic, if neither party is capable of waging a first strike that would substantially reduce the damage to be suffered from the other party's retaliation, then a first strike makes no sense. Specialists refer to such a state of play as "crisis stability." A military balance like that saps the incentive to pursue an arms race, particularly if approximate parity has been agreed for the important strategic force parameters. This is often referred to as "arms race stability."

That concept dates back to the 1960s, and is officially ascribed to

2 Joint Statement on Future Negotiations on Nuclear and Space Arms and Further Enhancing Strategic Stability. In *State visit by USSR President M.S. Gorbachev to the United States, 30 May-4 June 1990: Documents and materials*. Moscow: Politizdat, 1990. Pp. 197-199; Soviet-United States Joint Statement on Future Negotiations on Nuclear and Space Arms and Further Enhancing Strategic Stability, June 1, 1990. Available at: http://www.presidency.ucsb.edu/ws/?pid=18541.

the then US Secretary of Defense Robert McNamara. He came up with the idea of mutual deterrence between USA and the USSR in his historic 1967 San Francisco speech, claiming both nations had a reciprocal capability for inflicting unacceptable damage in a counter strike against whichever one of them was the aggressor, thus proposing an agreement be concluded first to limit and then to reduce offensive and defensive nuclear forces.[3]

Moscow endorsed that logic a few years later, and in 1972 it was brilliantly enshrined in the ABM Treaty and the provisional Agreement for the Limitation of Offensive Strategic Arms (SALT I). Agreement on "strategic stability" was reached during the talks on START I, which was signed in 1991, its intricate provisions and limitations embodying all of the principles behind the concept. Those principles went on to feature more or less prominently in 1993 START II, 1997 START III Framework Agreement, 1997 Agreed Statements on Anti-Ballistic Missile – Theatre Missile Defense (ABM-TMD) Demarcation, 2002 Moscow Treaty on Strategic Offensive Reductions (SORT), and 2010 New START (known in Russia as START III).

Over the last three decades Russia and the United States have reduced their nuclear arsenals 6- to 7-fold in terms of numbers of warheads and more than 30-fold in terms of total destructive power (in megatons).[4] The combined effect of all the arms agreements has been the strategic balance that now looks to be immeasurably more stable (according to the 1990 criteria) than in the run-up to the 1990s, before the signing of START I. The permissible ceilings on strategic arms were lowered nearly 6-fold for warheads, and nearly 3-fold for deployed delivery vehicles. The ratio of warheads to delivery vehicles shifted from 5:1 to 2:1. Highly survivable systems[5] that had accounted for 30-40%

3 McNamara R. *The Essence of Security: Reflections in Office*. New York: Harper and Row, 1968. Pp. 51-67.
4 Calculated from: *SIPRI Yearbook 2016: Armaments, Disarmament and International Security*. Oxford: Oxford University Press, 2016. Pp. 609-667; *SIPRI Yearbook 1990: World Armaments and Disarmament*. Oxford: Oxford University Press, 1990. Pp. 3-51.
5 Highly survivable systems refer to sea- and mobile land-based missiles forces, but not heavy bombers as they are not kept in a state of high alert, have a long flight time, and may not be able to penetrate the enemy's ballistic missile defense.

have since come to represent 60-70% of Russia's and the US's strategic nuclear forces.[6]

Realistic projections of a hypothetical nuclear exchange indicate that neither side is capable of hitting more than 50% of the other's forces, expending, in the process, more than 20% more capacity than it would destroy.[7] In other words, the attacking party would incapacitate itself, while the other side would retain more capacity than the aggressor from which to launch its choice of counter-attack.

Until quite recently, the State Armament Program for 2011-2020 (GPV-2020) had provided for modernizing Russian nuclear forces in a rational and timely manner, given the massive de-commissioning of systems introduced from 1980s through the 1990s. Overall, the GPV-2020 calls for 400 new strategic ballistic missiles and 8 submarines with missile launchers to be introduced into service.[8] The United States will follow suit over the next decade initiating a major cycle to upgrade their strategic triad.[9]

With few exceptions, both modernization programs comply with two out of the three principles of strategic stability that had been agreed in 1990, i.e. reducing the concentration of warheads on strategic delivery vehicles and giving priority to highly survivable systems.

However, the first principle – the relationship between strategic offensive and defensive arms – opened up a huge rift between the two parties, creating an impasse in the START talks and lending new impetus to the arms race.

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6 Calculated from: *SIPRI Yearbook 2016: Armaments, Disarmament and International Security*. Oxford: Oxford University Press, 2016. Pp. 609-667; *SIPRI Yearbook 1990: World Armaments and Disarmament*. Oxford: Oxford University Press, 1990. Pp. 14-16.

7 Dvorkin V. Offensive Arms Reduction. In *A Polycentristic Nuclear World: Challenges and New Opportunities*, ed. by A. Arbatov, V. Dvorkin. Moscow: Moscow Carnegie Center, Political Encyclopedia, 2017. Pp. 67-68.

8 Putin V. Being Strong: National Security Guarantees for Russia // Rossiiskaya Gazeta. 2012. 20 February. Available at: http://www.rg.ru/2012/02/20/putin-armiya.html.

9 Nuclear Posture Review 2018. US Department of Defense. February 2018. P. 48-50. Available at: https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

Missile defense

It is the United States that is responsible the exacerbated clash over missile defense systems. They withdrew from the 2002 ABM Treaty, even as they signed the Declaration with Russia committing them to develop a missile defense system jointly.[10] Nonetheless, without waiting for results to emerge from talks, they announced in 2004 that they were unilaterally deploying such a missile defense system in the US, the Czech Republic, and Poland, and were inviting Russia to join them. Moscow declined, claiming they should have an equal hand in cooperation and that Russia's specific missile defense concerns should be taken into account (although they had as yet to be spelled out in detail). All the same, Washington stubbornly plowed on with its program, riding the wave of public shock over the 9/11 terrorist attacks in 2001.

However strained the current differences may be between Russia and the US over missile defense issues, in objective, military technical terms, neither the US missile defense program nor the Russian aerospace defense program (VKO) appears capable of making any appreciable difference to either side's second-strike capability.

Despite that, if you follow the McNamara *reductio ad absurdum* logic, the US's unilateral withdrawal from the ABM Treaty in 2002 and the failed talks between the two powers on a jointly developed missile defense system from 2007 to 2011[11] did seriously destabilize their strategic relations. In his address on March 1, 2018, Putin declared: "However, in light of the plans to build a global anti-ballistic missile system, which are still being carried out today, all agreements signed within the framework of New START are now gradually being devaluated, because while the number of carriers and weapons is being reduced, one of the partners, namely, the US, is constantly increasing the number of its anti-ballistic missiles in an uncontrolled fashion, improving their quality,

10 Joint Declaration by President George W. Bush and President Vladimir V. Putin on the New Strategic Relationship between the United States of America and the Russian Federation. May 24, 2002. Available at: https://www.gpo.gov/fdsys/pkg/PPP-2002-book1/pdf/PPP-2002-book1-doc-pg869.pdf.

11 Statement in connection with the situation concerning the NATO countries' missile defense system in Europe. November 23, 2011. Available at: http://en.kremlin.ru/events/president/news/13637.

and creating new missile launching areas. If we do not do something, eventually this will result in the complete devaluation of Russia's nuclear potential."[12]

By way of a response to the American program, six state-of-the-art Russian weapons programs and projects were made public in the address. The first was the heavy Sarmat ICBM system, which openly had been years in the works (testing began in 2017) and is the next generation of the weapons systems that have been around for over half a century. The problem with heavy ICBMs was that their launch silos were already open to attack by US nuclear missiles (the MX or the Trident II variety) some 30 years ago, which is actually why Russia moved in the 1990s to mobile launch platforms. Permanently based heavy missiles can inflict a first strike (and draw a 900 megaton US retaliatory strike[13] – the equivalent of 60 Hiroshimas) or they can lift off on signal from space-based or land-based early warning systems (BMEWS) before enemy warheads impact. The second scenario would afford the president only scant minutes to take a decision – (an ICBM has a 30-minute flight time to target, a SLBM just 15 minutes) – and the chance of a false alarm or a technical error setting off a war could not be ruled out. (Blips have been known to occur in the past). Unlike current Russian strategic nuclear force modernization programs, the Sarmat system does not comply with two of the strategic stability principles agreed in 1990: reducing the concentration of warheads on strategic delivery vehicles; and giving priority to highly survivable systems (even though that is not, of course, in breach of any treaty).

The second system Putin speaks of in his address is the Burevestnik nuclear-powered and nuclear-armed cruise missile with an unlimited range. This would not appear to meet any obvious demand, since hundreds of Russian nuclear and non-nuclear cruise missiles can be fired by heavy bombers and multi-purpose nuclear submarines (also evading

12 Presidential Address to the Federal Assembly. March 1, 2018. Available at: http://www.kremlin.ru/events/president/news/56957.
13 Sivkov K. Disarmed and Very Dangerous // Voenno-promyshlennyi kur'er. 2017. 22-28 March. Pp. 1-4.

US missile defense systems) to hit targets via the short route across the northern seas.

The third project involves an Avangard strategic class of hypersonic glide vehicle, which started to be developed in the USSR during the mid-1980s as a response to President Ronald Reagan's Strategic Defense Initiative (SDI). In recent years the US has begun testing a virtually equivalent system as part of the Conventional Non-Nuclear Prompt Global Strike concept. Judging from the March 1 address, Russia would seem to have gained on and rapidly overtaken the US in that department, with an Avangard that can be fitted on RS-18 missiles (UR-100N UTTKh, or, in the Western designation, the SS-19 Stiletto) or the new heavy Sarmat ICBM.

Just like in the case of ballistic missiles, the launch of missile boost stages for hypersonic boost-glide systems can be picked up by satellites, but then the HGVs take a "dive" into the stratosphere and fly along erratic routes. Radar stations will only detect them 3-4 minutes before approach.[14] In sufficient numbers such nuclear-armed systems threaten to deliver a disarming strike at protected sites like enemy ICBM launch silos or command centers. Since satellites cannot track an HGV trajectory once it has been launched and radars cannot confirm the closing in of an HGV in time, ICBMs will have to be primed for launch on just the basis of an early warning BMEWS satellite signal. That would vastly increase the risk of a nuclear war being triggered by a false alarm or a technical error.[15]

Lastly, the fourth system – the nuclear-powered and heavily nuclear-armed Poseidon torpedo – boasts a very long range, as well as top speed and depth of submersion. (Formerly dubbed Status-6, it was intended to deliver a 100-megaton nuclear warhead[16]). This is another system to

14 Acton J. *Silver Bullet? Asking the Right Questions About Conventional Prompt Global Strike*. Washington: Carnegie Endowment for International Peace, 2013. Pp. 33-63.

15 In his book, former US Secretary of Defense William Perry describes a case of panic over a missile attack false alarm when a duty officer mistakenly uploaded a training program into the computer. See: Perry W. *My Journey at the Nuclear Brink*. Stanford: Stanford University Studies, 2015. Pp. 52-53.

16 Sivkov K. Op. cit.

have been conceived in the early 1980s to strike from underwater and circumvent the outer space SDI. What is not clear is why it should be needed now. There are already one and a half thousand nuclear-armed Russian ballistic missiles capable of reliably hitting every imaginable target within 30 minutes along a coast or deep within the interior of any adversary.

The remaining two systems to have been displayed at the Manezh were not part of the strategic forces. The Kinzhal hypersonic air-launched missile, with its 2,000 km range, can drive American aircraft carriers back outside the range of their carrier-based aircraft or can strike missile-defense bases in Romania and Poland (from where Russian ICBMs could not possibly be intercepted in any case). Mobile land-based laser complexes are probably capable of defending important sites from attack by non-nuclear cruise missiles or future hypersonic glide vehicles, as well as of "blinding" spy satellites and missile warning systems.

Generally speaking, all (with reservations perhaps about the Sarmat system) of the programs and projects made public in the Presidential address comply with the principles of strategic stability set out in the 1990 Joint Declaration. None of them violate existing nuclear arms treaties, yet all of them (with the exception of the traditionally nuclear-armed Sarmat ICBM) remain unregulated by New START and would require agreement on special measures of limitation in any negotiation on the next START treaty. Assuming one hopes to maintain a capability to break through the US missile defense, and to preserve strategic parity and stability, the announced program appears to be excessive. What it does do, though, is put Moscow at the forefront of military technology, leaving others to catch up. The chances are that the US will rise to the challenge with one or another response to upset the arms race stability achieved over the last three decades. In any case, the Pentagon has already announced it is fast-tracking its own Prompt Global Strike hypersonic weapon system, with tests to begin in 2019.[17]

17 The US is Accelerating Development of Its Own 'Invincible' Hypersonic Weapons // Defense One. 2018. 2 March. Available at: https://www.defenseone.com/technology/2018/03/united-states-accelerating-development-its-own-invincible-hypersonic-weapons/146355/.

High-precision weapons and the "nuclear threshold"

Non-nuclear long-range high-precision weapons (HPW), together with unmanned aerial vehicles, have changed the way local wars have been fought in the late 20th and early 21st centuries: e.g. Iraq, Yugoslavia, Libya, Syria. This was only made possible with the advent of new information-control systems (especially space-based), allowing for far more accurate munitions guidance, to within a few meters (with provision for probable deviation). In the end this started to affect strategic balance and stability.

The US currently has more than 6,000 Tomahawk[18] (BGM-109) sea-based cruise missiles (CM) with a range of about 1,800 km, while the Air Force has about 140 CMs (AGM-84) armed with conventional warheads, and has announced plans to commission a new, similar CM (AGM-158B JASSM-ER) with a greater range.

Russia is also expanding its own comparable systems. Slated for entry into service are the Kh-55SM and Kh-555 type air-launched missiles, as well as various modifications of sea-based Kalibr type 3M-54 and 3M-14 CMs, in addition to which new Kh-101 air-based CMs are being deployed. As of 2018 the number of high-precision cruise missiles had increased by more than 30-fold.[19] Those systems have demonstrated their effectiveness in Syria.

Land-based intermediate-range cruise missiles (500-5,500 km) are banned for both Russia and the US under the INF Treaty. Similar sea-based systems – either conventionally armed or nuclear-armed, are subject to no limitations at all, while air-based missiles for the same two states are only indirectly limited by New START in terms of the number of their strategic delivery vehicles, i.e. heavy bombers.

China, India, Iran and other countries are also working to develop longer range cruise missiles.

18 They are deployed on four modified Ohio class strategic submarines each accommodating 154 missiles (for a total of 616 cruise missiles), on 25 multifunction Virginia and Seawolf class submarines (500 cruise missiles), as well as on 22 Ticonderoga cruisers and 62 Arleigh Burke type destroyers (4,560 cruise missiles).

19 Presidential Address to the Federal Assembly…

Existing non-nuclear cruise missiles have a relatively limited range (under 2,000 km.), travel at subsonic speed, and take a long time to engage their target (about 2 hours). That explains why, for the foreseeable future, efforts are concentrating on the next generation of high-precision conventional weapons (HPW) that could strike at intercontinental distances (over 5,500 km) in a relatively short timeframe (under 60 min).

As part of the US Conventional Prompt Global Strike program mentioned earlier, a key project deals with developing the Alternate [Atmosphere] Re-entry System –- or ARS hypersonic missile glide vehicle, earlier designated as Advanced Hypersonic Weapon, or AHW. The system was originally devised for use with a boost phase drawing on long-range, ground-based ballistic missiles. At the moment, the new version is most likely to be installed on US submarine intermediate-range ballistic missiles. In the past, the AHW performed successfully in two test runs, including at a speed of about 6M and over a distance of more than 3,800 km (the design range was 6,000-8,000 km). Other tests are being run alongside the PGS program, though not as part of it, on the hypersonic air-launched X-51A Wave Rider cruise missile, with a range of 1,800 km and a speed of 5M, for mounting on heavy bombers.[20]

In Russia flight tests for the planned hypersonic boost glide vehicle (BGV) were carried out in 1991-1992 and 2001-2004. The Albatross missile system (subsequently known as Project 4202 or Yu-71) used an RS-18 type ICBM for boost (SS-19 in Western parlance). In the future, (as announced in President Putin's 2018 address) an Avangard BGV may be fitted with a conventional warhead on the new Sarmat heavy missile, scheduled to enter service around 2020.[21]

20 Telemetry Lost During Hypersonic Test Flight // Aviation Week. 2011. 12 August. Available at: http://aviationweek.com/awin/telemetry-lost-during-hypersonic-test-flight-0; Zaznobina E. The fastest rocket in the world // Uznai Vse. 2015. Available at: http://www.uznayvse.ru/interesting-facts/samaya-byistraya-raketa-v-mire.html.

21 Raigorodetskiy A. The Albatross ICBM project (USSR) // Dogs of War. 2011. Available at: http://www.dogswar.ru/oryjeinaia-ekzotika/raketnoe-oryjie/4945-proekt-mbr-qalbatros.html); Ramm A., Kornev D. The Albatross of the World Revolution – Part I // Voenno-promyshlennyi kur'er. 2015. 23 September. Available at: http://www.vpk-news.ru/articles/27160; Ramm A., Kornev D. Hyper-death on Its Way // Voenno-promyshlennyi kur'er. 2015. 25 March. Available at: http://www.vpk-news.ru/articles/24407.

Besides the two military superpowers, the People's Republic of China is also testing a hypersonic system designated WU-14, using stages of an old DF-5 liquid-fuel ICBM as boost, and probably aiming to arm it with a nuclear hypersonic glide vehicle to thwart US missile defense systems. In addition, China has tested a DF-21C intermediate-range ballistic missile with high-precision non-nuclear warheads for use against American aircraft carriers.

Mirroring China, India started up a hypersonic system program that, for the time being, is still only in the stage of conception.

The strategic impact of long-range, non-nuclear HPW can generally be seen as destabilizing, although opinions vary as to by how much. Most professionals, Russian included, consider subsonic cruise missiles ineffective in disarming secured underground sites such as ICBM launch silos and command centers.[22] What remains debatable is whether they will be accurate enough to strike protected sites (e.g. ICBM silos, command centers). Could they destroy mobile land-based systems, which would require continually updated guidance by satellite or from aerial vehicles over the final leg of their trajectory? And finally, what assurance is there that these costly systems would be deployed in sufficient numbers (by the hundreds) to pose a threat to Russian strategic deterrence forces?

Despite US denials of any plans for non-nuclear high-precision strikes against Russia's strategic forces, there is no doubting the vulnerability of unsecured strategic nuclear force sites even to existing subsonic non-nuclear cruise missiles. That means at risk are: early warning radars, BMD, and anti-aircraft systems, light ground shelters housing mobile ICBM launchers, submarine missile carriers at base, and heavy bombers at airfields, as well as centers for communication with satellites, submarine missile carriers, and long-range aircraft. Still more feasible are non-nuclear high-precision strikes against economic targets and infrastructure: e.g. power plants, oil refineries, transportation hubs,

22 Akhmerov D., Akhmerov E., Baleyev M. It Won't Happen Overnight // Voenno-promyshlennyi kur'er. 2015. 21 October. Available at: http://vpk-news.ru/articles/27617.

and communication centers.[23] Systems and plans for such strikes lie at the heart of the concept of non-nuclear (conventional) deterrence that has long been part of the US military doctrine.

The Russian Military Doctrine identifies the capabilities of US high-precision systems as a main threat to national security, and establishes as a top priority "air defense provisions for critical Russian Federation sites and preparedness to repel strikes launched in an aerospace system offensive."[24] In response to the threat, Russia is not only building its target-out or in-depth Aerospace Defense, but in recent years it has also been developing equivalent conventional deterrence offensive capabilities, as per the Russian Military Doctrine.[25]

The 2018 US Nuclear Posture Review would appear to have been swayed by Russian use of HPW in Syria, as, for the first time, it terms Russian conventional strike capability a threat to American population centers and economic infrastructure, information control systems and US nuclear forces sites, to which they are resolved to respond with nuclear weapons.[26]

Many of the present and future HPW systems and their delivery vehicles are dual purpose, and it will be impossible to know up until the moment of detonation whether they are being used in a nuclear attack. That applies to heavy and medium bombers, tactical assault aviation armed with missiles and air-launched bombs, as well as to ships and multifunction submarines carrying dual-purpose missile systems: e.g. sea-based Kalibr and Tomahawk cruise missiles,[27] and Kh-101/102 type air-launched cruise missiles. It remains to be determined whether the Russian

23 Einhorn R., Pifer S. Meeting US Deterrence Requirements: Towards a Sustainable National Consensus. Brookings Institution. September 2017. P. 20. Available at: https://www.brookings.edu/wp-content/uploads/2017/09/fp_20170920_deterrence_report.pdf.

24 The Military Doctrine of the Russian Federation. 2014. Available at: http://news.kremlin.ru/media/events/files/41d527556bec8deb3530.pdf.

25 Ibid.

26 Nuclear Posture Review 2018… P. 21.

27 In 2010, the US decided to decommission all nuclear Tomahawk sea-launched cruise missiles before 2013, yet the 2018 Nuclear Posture Review announced a decision to return nuclear SLCMs to service on multipurpose submarines.

hypersonic system will be conventionally armed or carry a nuclear warhead.[28]

One of the gravest new threats stems from the wide deployment of long-range, high-precision conventional systems and how they entangle with nuclear arms systems and their military objectives. This has become all the more palpable against the backdrop of current political and military tensions and the growing military confrontation between Russia and NATO. Projected scenarios of escalation towards a nuclear war somehow "outflank" the classic model of strategic stability which precluded any first (disarming) strike by either of the two parties.

Limited nuclear warfare

The US holds the "copyright" for the idea of limited nuclear warfare, just as it does for most all of other strategic concepts and nuclear arms systems. The Cold War beginning from the late 1950s saw this thinking take hold in various ways and undergo several stages of evolution.[29] Yet all of those schemes foundered due to the likelihood of a massive nuclear reprisal from the USSR, which rejected the very notion of limited nuclear warfare out of hand and was bolstering its own capacity for "devastating retaliation."[30]

However, in 2003 a new trend became discernible within official Russian Defense Ministry documents, as a new notion was advanced, namely that of "de-escalating aggression… by the threat of or actual launch of strikes on a varying scale using conventional and/or nuclear attack systems." Moreover, it presumed that it would be possible to "graduate the tactical employment of individual Strategic Deterrence Force components."[31] Succeeding documents and editions of the Russian

28 Ramm A., Kornev D. Hyper-death on Its Way…

29 Enthoven A.C., Smith K.W. How Much is Enough? Shaping the Defense Program 1961-1969. New York: Harper and Row Publishers, 1971. Pp. 175, 207; *New York Times*. 1974. 11 January. P. 6; *Newsweek*. 1974. 4 February. P. 23; Annual Defense Department Report FY 1975. Washington, DC: US Government Printing Office, 1974. Pp. 38, 40-41.

30 Sokolovsky V. *Military Strategy*. Moscow: Voyenizdat, 1968. Pp. 14–20; Tolubko V. *Missile Forces*. Moscow: Obshestvennye Nauki, 1977. P. 42.

31 *Current Objectives of the Russian Armed Forces Development*. Moscow: Defense Ministry, 2003. P. 42.

Military Doctrine contain no further reference to the proposition, but nor do they rule out that sort of action either, since they do not specify in what way Russia might "use nuclear arms… in the event of conventional armed aggression against the Russian Federation jeopardizing the very existence of the state."[32]

At a time when Russia and NATO are increasingly facing one another off militarily, with their armed forces active and deployed within immediate proximity of one another, any local conflict could rapidly lead to the use of tactical nuclear weapons. Imagine how much greater the risk of an abrupt escalation would be if intermediate-range nuclear arms were deployed, in the event the INF Treaty collapsed.

A recent series of publications by former and current military experts has periodically let the concept of selective nuclear strikes seep into the Russian specialized press. To cite an example, it is emphasized in one such publication that: "The limited nature of an initial nuclear action, aimed not at incensing the aggressor but at bringing it to its senses and causing it to cease its offensive and accept negotiation. Thus… initial nuclear action by the Russian Federation can be limited."[33]

The 2018 US Nuclear Posture Review is geared around that same idea. Its introduction points out that "Recent Russian statements on this evolving nuclear weapons doctrine appear to lower the threshold for Moscow's first-use of nuclear weapons. Russia demonstrates its perception of the advantage these systems provide through numerous exercises and statements. Correcting this mistaken Russian perception is a strategic imperative. To address these types of challenges and preserve deterrence stability, the United States will enhance the flexibility and range of its tailored deterrence options."[34]

As a means of limited nuclear engagement, plans call for arming part of the Trident II SLBMs with low-yield warheads and for creating

32 Military Doctrine of the Russian Federation 2014. Available at: http://news.kremlin.ru/media/events/files/41d527556bec8deb3530.pdf.

33 Akhmerov D., Akhmerov E., Baleyev M. Aerostat – Friend of Sarmat // Voenno-promyshlennyi kur'er. 2016. 12-18 October. No. 39. P. 6.

34 Nuclear Posture Review 2018… P. XII.

advanced, long-range, air-borne nuclear-armed cruise missiles (LRSO – long-range stand-off missiles), varying yield smart bombs (B61-12) for tactical and strategic aviation, and nuclear-armed SLCMs.[35] In Russia, besides tactical nuclear systems, a new Sarmat ICBM is being considered in the same context, with a nuclear hypersonic glide vehicle.[36]

There can be no doubt that selective nuclear strike concepts and systems substantially lower the nuclear threshold, together with non-nuclear HPW. Talk in Russia about selective strikes is more of a response to the US and NATO's concentrated non-nuclear "air and space aggression,"[37] whereas in the US such selective options are now being put forward as a reaction to Russia's "escalate to de-escalate" strategy. The danger is that with both of them developing plans and systems for limited nuclear strikes, any local (even random) brush between the two superpowers in Eastern Europe, the Baltic Sea or the Black Sea, the Arctic, or Syria, could be catapulted into a global armed conflict – yet another menace of strategic stability being "outflanked" in a way that could never have been foreseen a quarter century ago.

Outer space and cyberspace

Outer space was already becoming a military arena back in the 1950s and 1960s, originally for nuclear testing and ballistic missile transit, then for their interception by BMD systems. There was never any full onset of outer space militarization, though, if you discount a few series of experiments and the production of anti-satellite weapons systems (ASAT) that were subsequently retired from active service by the Soviet and US military.[38] For the time being, spacecraft are used to provide information and support command and control functions for armed forces

35 Ibid. P. XIV.

36 Akhmerov D., Akhmerov E., Baleyev M. Aerostat – Friend of Sarmat…

37 Dyemin A., et al. A Proper Response to a Serious Threat. Air and Space to Become the Main Sphere of Armed Combat // Voyenno-kosmicheskaya oborona. 2012. 13 August. Available at: http://www.vko.ru/strategiya/sereznoy-ugroze-adekvatnyy-otvet; Sukhanov S. ASD: A Mission, Not a Sytem // Voyenno-kosmicheskaya oborona. 2010. 29 March. Available at: http://www.vko.ru/koncepcii/vko-eto-zadacha-ne-sistema.

38 See: Dvorkin V. Space Weapons Programs. In *Outer Space: Weapons, Diplomacy, and Security*, ed. by A. Arbatov, V. Dvorkin. Washington: Carnegie Endowment for International Peace, 2010. Pp. 30-45.

on land, at sea, or in the air, as well as for land- and sea-based ballistic missiles and BMD systems. Nevertheless, given the increasing significance of outer space for military purposes, it may well become the new theater for the arms race and for the possible use of force.[39]

The US is currently developing an Airborne Laser system (ABL) based on air-launched BMD and anti-satellite systems. A modified sea-based anti-missile (anti-satellite) Aegis system is presently undergoing tests with Standard Missile 3 (such as were used in 2008 in a trial run to destroy a disused American satellite). Work is also underway on a multiple-use Space Maneuvering Vehicle (SMV) to carry out anti-satellite missions.[40]

An Russian Defense Ministry's official presented a review of retired Russian anti-satellite systems that could be brought back into service.[41] They include the IS-MU system, mounted on a strategic ICBM at the Baikonur launch site; a system to attack low-orbiting spacecraft, comprised of a MiG-31 aircraft with Kontakt interceptor missiles; early designs for the Naryad-VN and the Naryad-VR space missile systems based on RS-18 (SS-19) type operational missiles; and development of an airborne laser system. To counter low-orbiting spacecraft, anti-satellite capabilities are installed in S-400 and S-500 air-defense missile systems.[42] In the current State Armament Program 2027 (GPV-2027) the Nudol anti-satellite system is identified as a priority, based on the non-nuclear, mobile land-based missile capable of hitting a spacecraft orbiting at up to 700 km (also a feature of the new Moscow District A-235 BMD system). As one might gather, this system (code reference – 14Ts033) including an interceptor missile (labelled 14A042) is being

39 At present there are about 1420 satellites operating in space of which 576 belong to the US, 140 to Russia, 181 to China, and 41 to India. In total, military satellites account for about 40% of the overall number. See: UCS Satellite Database. Union of Concerned Scientists. August 11, 2016. Available at: http://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.WCHPuE2LSUk.

40 See: Dvorkin V. Space Weapons Programs… Pp. 30-45.

41 Russia is developing anti-satellite weapons in response to the US measures, Army General Vladimir Popovkin, Deputy Defense Minister responsible for disarmament, told journalists on Thursday // RIA Novosti. 2009. 5 March (as cited in Khoroshikh A. Re: Space Weapons Defense // Astroforum. 2009. 13 December. Available at: http://www.astronomy.ru/forum/index.php/topic,69231.msg1108417.html#msg1108417).

42 Ibid.

developed and tested by the Almaz-Antei Concern and the Novator Experimental Design Bureau.[43] A statement was also leaked to the press from a representative of a Defense Ministry scientific institute about an anti-satellite system being developed under the code name Rudolf, but no details were provided.[44]

China has no intention of lagging behind the two leading powers when it comes to producing its own space weapons as was amply demonstrated with the testing of an anti-satellite weapon in 2007 when an intermediate-range missile hit a Chinese weather satellite.

Russian and US strategic thinking seems to be increasingly bold in seizing upon outer space as the new, critical theater for military operations. However, that sphere was confined to global nuclear warfare in the past, whereas now it is also open to conflicts using conventional weapons. Assuming the US and NATO would have the upper hand in long-range high-precision weapons systems, that also means they would be particularly vulnerable due to their dependence on space information and control systems, something Russia could not fail to take advantage of.

A space arms race, which would also involve deployment of weapons in outer space, threatens to seriously destabilize the strategic state of play and increase the risk that an armed conflict could erupt into a nuclear war. So an attack against a missile launch warning spacecraft would most likely be perceived by Russia and the US as the start of a nuclear missile attack. The class of satellite concerned (i.e. the Russian US-K Oko series and the new satellites of the Unified Space System for Detection and Tactical Control [EKS][45] together with the US DSP and

43 Ramm A., Kornev D. Satellite Hunter // Voenno-promyshlennyi kur'er. 2016. 26 June. No. 25. P. 8.

44 A bet on Rudolf: an anti-satellite weapon will give the Russian Federation a huge advantage in a major conflict // Ekonomika segodnya. 2017. 30 November. Available at: https://rueconomics.ru/292171-stavka-na-rudolfa-antisputnikovoe-oruzhie-dast-rf-ogromnoe-preimushchestvo-pri-krupnom-konflikte.

45 Myasnikov V. The Unified Space System (EKS) will warn of a nuclear attack // Nezavisimoye voyennoye obozreniye. 2014. 17 October. Available at: http://nvo.ng.ru/armament/2014-10-17/1_shojgu.html; Gorina T. Russia without Oko: When will the new space early warning system start operating for missile attacks? // Moskovskii komsomolets. 2015. 11 February. Available at: http://www.mk.ru/politics/2015/02/11/rossiya-ostalas-bez-oka-kogda-zarabotaet-novaya-sistema-obnaruzheniya-raket.html.

SBIRS satellites) are deployed on a geo-stationary or highly elliptical orbit. Those satellites would stand to be at risk if longer-range anti-satellite weapons come into operation.

Other spacecraft in high orbit (like the Russian GLONASS, the US GPS/NAVSTAR, and communications satellites like MILSTAR, AEHF, and the Russian Molniya or Meridian series) serve not only general operation forces for the respective parties, but their strategic nuclear forces as well. Their elimination in a conventional armed conflict would also threaten to escalate war to the nuclear level. Accordingly, space weapons development presents an inherent two-fold threat to strategic stability, even though it does not directly impinge on the classic 1990 formula.

Given the highly classified nature of the subject, there is little specific one can say about the impact cyberwarfare could have in provoking a nuclear exchange. The likelihood is that highly insulated systems governing the use of nuclear weapons are hardly going to be vulnerable to cyberattack. At the same time, however, radio communications channels and spacecraft control systems would be relatively more exposed, particularly early warning satellites. Should they be disabled, or an (false) alarm of a missile attack be simulated, that could spark an unpremeditated nuclear war, particularly in the event that plans and systems persist for a ground-based launch-on-warning ICBM response.

What with the risk that a spontaneous nuclear exchange could be triggered, however, the major powers are scarcely about to commit such an act of sabotage. Terrorists or some crisis-ridden rogue state are the more obvious suspects. If such a risk is to be diminished, there will need to be cooperation between the major powers to articulate rules and procedures of conduct and information exchange, as well as to jointly determine the source of a cyber attack.

Multilateral stability

Speaking before the Russian National Research Nuclear University in January 2014, President Putin declared: “The Russian Federation is not alone in having nuclear weapons, other countries do too, many others, yet none of them are about to renounce these means of armed struggle. In the circumstances, it would be extremely strange for the Russian Federation to take that step, and, I would emphasize, to do so under present day conditions might entail rather enormous and grievous consequences for our country and for our people."[46] The same idea has cropped up repeatedly in other fora as well.

President Trump had much the same to say on the subject, although in a fairly convoluted way: "We are increasing arsenals of virtually every weapon… And, frankly, we have to do because others are doing it. If they stop, we will stop."[47]

Officially, Moscow has made an extended nuclear disarmament format one of the main conditions for work on the next START treaty. According to New START's compliance data exchange from February 2018, Russia has 1,440 warheads on deployed delivery vehicles, as compared with 1,390 for the US.[48] The warhead arsenal figures for the other seven nuclear states are as follows: the United Kingdom – 215, France – 300, the PRC – 260, India – 110, Pakistan – 120, Israel – 80, and the DPRK – 10.[49] Since the combined total for the other seven nuclear weapons states comes to about 1,000 nuclear warheads, there would seem at first to be every reason to require their limitation.

Nevertheless, the political position is not unassailable. Strictly speaking, a comparison would have to be made between equivalent classes and types of weapons systems. The bulk of third party arsenals do not qualify as strategic arms under New START, and a large portion of them are kept in storage. Were one to count all of Russia's and the US's comparable systems in storage – (as ready reserve for strategic and tactical nuclear delivery vehicles),[50] in addition to those mounted on

46 Excerpt from the stenograph of the meeting with students at the MEPhI National Research Nuclear University. Official website of the President the Russian Federation. January 22, 2014. Available at: http://kremlin.ru/events/president/transcripts/20098.

47 Morin R. Trump: US will cease building nuclear arsenal if other countries stop first // Politico. 2018. 2 February. Available at: https://www.politico.com/story/2018/02/12/trump-nuclear-arsenal-404491.

48 In fact, there are several hundred more, since New START counts heavy bombers as one delivery vehicle with one warhead. Both sides have roughly 60 bombers, capable in fact of delivering 12-16 long-range nuclear air-launched cruise missiles.

49 Calculated on the basis of data and updates of *SIPRI Yearbook 2016: Armaments, Disarmament and International Security*. Oxford: Oxford University Press, 2016.

50 Estimates are approximate and variable due to the "fluid" nature of warhead stock moving between different reserve categories at storage facilities and plants for dismantling and disposal.

deployed strategic missiles and bombers, the number would come to more like 4,000 nuclear warheads each. It thus emerges that the two powers each have a total nuclear arsenal that is 4-5 times more than the sum total of third country holdings and at least ten times more than each third country has individually.

In global terms, third country nuclear forces grew from 2-3% of the overall total at the height of the Cold War to what is now 10-20%. (China keeps a tight lid on official figures, but what with their tremendous economic, scientific, and technical potential, estimates of their nuclear holdings range anywhere from 260 to 900 units.[51]) Whatever the case, the nuclear arms stockpiles of the other seven states have no significant impact as yet on the nuclear balance between Russia and the US.

Indirectly, though, rather than in any outright way, third nuclear states and terrorist organizations are already noticeably destabilizing strategic relations between Russia and the US. The American missile defense system, aimed at countering North Korean or Iranian missiles, is perceived as a major strategic threat by Russia, as a result of which Russia has called a halt to START talks and is pursuing a broad program to arm against the US, who in turn will only respond in kind. US development of long-range, high-precision conventional weapons (including hypersonic ones) for use against hostile regimes, terrorists, and – by implication – China, is seen by Russia as the threat of an aerospace attack. And the Russian response is taking the form of defense programs (ASD) as well as offensive systems: i.e. cruise missiles and hypersonic vehicles, both conventionally and nuclear-armed. The 2018 US nuclear doctrine then takes this to be a new threat for which military programs are to be accelerated. Moscow's concerns over third country intermediate-range nuclear missile systems have also provided grounds for officially questioning the merits of the INF Treaty.[52] With all that as a backdrop, the

51 See Esin V. China's nuclear might. In *The prospects of Chinese involvement in nuclear arms limitation*, ed. by A. Arbatov, V. Dvorkin, S. Oznobischiev. Moscow: IMEMO RAN, 2012. Pp. 27-35.

52 Speech and discussion at the Munich Security Conference. Official website of the President the Russian Federation. February 10, 2007. Available at: http://www.kremlin.ru/appears/2007/02/10/1737_type63374type63376type63377type63381type82634_118097.shtml; The INF Treaty cannot last forever, said Ivanov // RIA Novosti. 2013. 21 June. Available at: http://ria.ru/defense_safety/20130621/945019919.html.

mutual recriminations that had begun between Russia and the US about treaty violations spilled over into a political crisis in their [bilateral] relations, jeopardizing the entire nuclear arms control system.

All of these trends also disrupt strategic stability, even if they do not directly affect the formalized 1990 principles. For stability to be maintained, there need to be new principles to govern strategic relations between the major powers and mechanisms ensuring they mutually refrain from dangerous strategic innovations. However, that is scarcely feasible at a time of disintegrating nuclear arms control and a no-holds-barred arms race.

“Restoring” stability

For the first time ever in over half a century of nuclear arms talks and agreements, the world faces the imminent prospect of losing all treaty-based control over the most destructive weapons in human history. The weakest link is the 1987 INF Treaty between the USSR and the US, which could very soon be denounced. That Russia and the US have gone seven years without meeting to discuss a follow-up START treaty is a further sign of the crisis in nuclear arms control. That is the most protracted hiatus to occur in a half-century of such negotiations. New START expires in 2021, after which a vacuum will set in for strategic arms control. For two decades now the Americans have prevented the Comprehensive Nuclear Test Ban Treaty (CTBT) from entering into legal force. The 2015 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) proved a fiasco, while the next such event, slated for 2020, stands scant chance of faring better. That would spell out the demise of the NPT, *de facto* if not *de jure*.

Although today’s world is a multi-polar one, the key players in this domain are still Russia and the US. In principle, both powers are keeping the door open for disarmament. Sadly, no one has come up with any specific proposals yet, while strategic stability has continued to deteriorate in objective terms. It seems imperative, therefore, that the two powers relegate to a back burner all other foreign and domestic policy differences in order to undertake urgent remedial measures.

The top priority is to save the INF Treaty. Instead of trading accusations, the two parties should be hammering out additional verification measures together to dispel mutual suspicions. Then, they should conclude a follow-on START treaty to take over from 2021. In conjunction with that treaty, measures must be taken to enhance transparency and predictability in mutual dealings on missile defense systems, even as criteria are to be agreed upon to prohibit systems that threaten strategic stability. Furthermore, besides counting rules for air-launched cruise missiles that are actually carried by bombers (as in START I), the next START treaty should cover conventionally delivered strategic weapons as well, covering hypersonic systems, intercontinental cruise missiles, and submersible craft. There should then follow a step-by-step, selective process providing a multilateral format for nuclear arms limitation and reduction.

Crucially, the conceptual foundation for such agreements (such as the 1990 Joint Statement was for START I) would have to rework the earlier principles of strategic stability as a function of developments over the last quarter century or more. First and foremost, the very definition of stability would need to be extended beyond Russian-American strategic relations that *"remove incentives for a nuclear first strike"* to those that remove "incentives for any use of nuclear arms" at all. Prevention of conventional arms offensives should rely on the provision of sufficient numbers of general purpose forces and equipment, or, better yet, on an agreement like the 1990-1999 Treaty on Conventional Forces in Europe (CFE). Ideally, other changes could be introduced as well:

- The provision on *"reducing the concentration of warheads on strategic delivery vehicles"* and on *"giving priority to highly survivable systems,"* would gain from a mutual recognition that systems compromising the survivability of strategic arms and their information and control systems are destabilizing and should be limited as a matter of priority.
- To ensure compliance with the above condition, missile launch systems and plans using an early warning system (to effect a retaliatory strike or a launch-on-warning) should be eliminated on a

reciprocal basis to avoid the risk of a nuclear war being triggered by a false alarm, technical error, or cyber-sabotage.

- Weapons systems that blur the distinction between nuclear and conventional arms – (e.g. dual use or capability) – are destabilizing and should be subject to reciprocal limitations and confidence-building measures.
- Missile defense systems against third countries and non-state actors should be subject to a mutually agreed *"relationship between strategic offensive and defensive arms."*
- Space weapons, primarily special anti-satellite systems, are destabilizing and should be banned by verifiable means.
- Cyber-warfare systems targeting one another's strategic information and control systems are destabilizing and should be banned, with confidence-building measures put in place.
- Both parties should acknowledge that their military programs have an impact on one another and can fuel an arms race, suggesting there should be regular exchanges of view between the relevant stakeholder agencies.
- Third state involvement in the nuclear arms limitation process should be based on an objective assessment of their forces and programs, as well as on agreement as to sequence, membership, and the principles and methods of verifying their involvement in the process.

Suggestions like these may seem utopian in the current context. However, we know from experience how swiftly things can turn around, both for better or for worse. To avoid the latter eventuality, we need to do our utmost to secure the former. We need to rescue strategic stability as the very foundation upon which we can end the arms race and prevent a nuclear war.

2.2. US–RUSSIA STRATEGIC DYNAMICS

***Steven Pifer*[1]**

Introduction

The US–Russia relationship has fallen to its lowest point since the end of the Cold War. Burdened by sharp differences over Ukraine, Syria, interference in the US presidential election, economic and other sanctions, and competing charges of arms control violations, it is difficult to see how – or when – Washington and Moscow will find their way back to a more normal relationship.

This comes at a time when developments in several areas are undermining US–Russian strategic stability, with stability defined as a situation in which neither side has an incentive, even in an intense crisis, to resort to use of nuclear weapons. Trends raise a large prospect in the future of an even less stable, less predictable and less secure strategic relationship between the two nuclear superpowers.

Russia and the United States are engaged in major modernizations of their nuclear arms. The modernization of strategic forces seems largely a matter of replacing old systems with new systems, and both sides appear to be sizing their forces to fit within the limits of the 2010 New Strategic Arms Reduction Treaty (New START). More worrisome are developments regarding other kinds of nuclear arms, nuclear doctrine and a possible lowering of the nuclear threshold on one or both sides.

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Washington and Moscow remain far apart on the issue of missile defense. In March, Russian President Putin described a number of nuclear delivery systems intended to defeat US missile defenses. Most (perhaps all) of these would not be constrained by existing nuclear arms control arrangements.

During the Cold War decades, strategic stability was measured largely in terms of US and Soviet strategic nuclear weapons, with some consideration to missile defense (which was tightly constrained by the 1972 Anti-Ballistic Missile Treaty). Additional factors that did not figure in the bipolar Cold War stability model are now becoming more relevant. They include new missile defense developments, precision-guided conventional strike systems, third-country nuclear forces, and new domains such as cyber and space. It is increasingly appropriate to think in terms of a multilateral, multi-domain stability model, but the particulars have yet to be detailed.

Another complication is the fraying of the bilateral nuclear arms control regime. The 1987 Intermediate-range Nuclear Forces (INF) Treaty is in trouble. New START expires by its terms in 2021. While New START can be extended by up to five years, agreement to do so is not a foregone conclusion. Matters are further complicated by the fact that US and Russian officials currently have no ongoing channel to address new arms or doctrinal developments or how the arms control regime might be maintained, let alone strengthened.

At times of US–Russia tension, arms control becomes more important. The sides should share an interest in regulating their strategic competition, in order to minimize the risk of a conflict whose consequences would be devastating. As a first priority, US and Russian officials should act to preserve the existing nuclear arms control regime and discuss measures to reduce the risk of conflict arising from accident or miscalculation.

For the longer term, Washington and Moscow should explore whether additional arms control or other cooperative measures could enhance their security. It may take time to identify areas for specific negotiation, but the sides would benefit from regularized dialogue on strategic issues, a dialogue that since 2010 has been episodic at best.

Nuclear modernization and doctrine

Russia and the United State have each embarked on major nuclear force modernization programs. Russia is currently building Borey-class ballistic missile submarines, Bulava submarine-launched ballistic missiles (SLBMs) and SS-27 intercontinental ballistic missiles (ICBMs) to upgrade its strategic nuclear forces. It is also modernizing the Blackjack strategic bomber and developing the Sarmat, a new heavy ICBM. In the 2020s, the US military plans to build Columbia-class ballistic missile submarines, a new ICBM (the Ground-Based Strategic Deterrent or GBSD), the B-21 strategic bomber and Long-Range Stand-Off (LRSO) air-launched cruise missile.

One can question the necessity of the numbers on both sides, but these programs largely appear intended to replace aging systems with new, and announced plans seem sized to fit within the limits of New START. On the whole, these replacement programs do not appear likely to have a significant negative effect on strategic stability, with one exception. The Sarmat – a large, silo-based, multiple-warhead ICBM – raises questions for stability, just as did its predecessor, the SS-18. It could prove a tempting target in a crisis, though how tempting would depend on factors such as what portion of Russian strategic ballistic missile warheads are deployed on Sarmat ICBMs.

More worrisome are developments regarding other kinds of nuclear arms and nuclear doctrine. If the United States and Russia engage in a nuclear exchange, it likely would begin with the use of nuclear weapons – most probably non-strategic nuclear weapons – escalating out of a conventional conflict.

Russia continues to maintain and modernize a panoply of non-strategic nuclear warheads to arm dual-capable land-, air- and sea-based delivery systems. The number and variety of these weapons raise concern that Russia may see them for purposes beyond deterrence. The official doctrine states that Russia reserves the right to resort to nuclear weapons in two circumstances: in response to an attack on Russia or a Russian ally with nuclear or other weapons of mass destruction, and in response to an attack on Russia with conventional forces that threatens the existence of the state. On its face, this raises little reason for concern. However, how would the Kremlin define a threat to the existence of the state? Moreover, does this reflect the totality of Russian doctrine, i.e., is Russian action doctrine the same as its declaratory doctrine?

The 2018 US Nuclear Posture Review reflects considerable continuity with its 2010 predecessor and the goal of maintaining a safe, secure and effective deterrent, but it has some significant differences. For example, the new review expresses concern that Russia has “added new types of nuclear capabilities to [its] arsenal, increased the salience of nuclear forces in [its] strategies and plans, and engaged in increasingly aggressive behavior,” and may be lowering the nuclear threshold. Much of the Nuclear Posture Review is driven by concern over what is sometimes referred to as the “escalate to de-escalate” doctrine, which postulates Russian use of one or a few low-yield nuclear weapons to terminate a conventional conflict on Moscow’s terms – even if Russia began the conflict and the existence of the Russian state were not at stake. Most Russian analysts and some experts in the West deny that this is part of formal doctrine. Pentagon and NATO analysts, however, worry that, were Russia to begin losing a conflict at the conventional level, it would resort to nuclear weapons.

The 2018 Nuclear Posture Review states that the Pentagon will return nuclear-armed sea-launched cruise missiles (SLCMs) to US Navy warships (nuclear-armed SLCMs were removed to storage in the early 1990s) and convert some Trident D5 SLBM warheads to low-yield variants. The review describes the nuclear-armed SLCM and low-yield Trident warhead as creating options for regional non-strategic nuclear response. That presumably is for scenarios in which the United States might otherwise be self-deterred from employing larger nuclear warheads because of their size.

The 2018 Nuclear Posture Review differs from its predecessor in other ways. The 2010 review sought to reduce reliance on nuclear arms (as well as the number of those weapons). It stated that the United States would resort to nuclear weapons only in "extreme circumstances" but did not attempt to define those circumstances. The 2018 review put forward a definition of "extreme circumstances" that includes "non-nuclear strategic attacks" against civilian populations, infrastructure, US nuclear forces or command and control systems, raising at least the perception that the United States has significantly broadened the circumstances in which it might resort to nuclear weapons.

These doctrinal developments provide an unhealthy dynamic for US–Russian strategic stability. Russia maintains a large array of non-strategic nuclear weapons, at a time when there are instances of loose talk regarding nuclear use coming from the Kremlin and questions about Russian readiness to employ nuclear arms. The United States, believing that Russia has lowered the threshold for use of nuclear weapons, is taking measures that in effect lower the threshold for US nuclear use – or at a minimum are intended to create in Russia the perception that the United States is more ready to resort to nuclear weapons. While the 2018 Nuclear Posture Review seems to imply that US low-yield nuclear weapons would be used only in response to Russian first use of nuclear weapons, it is unclear how that policy will be understood in Moscow, especially given the definition of "extreme circumstances."

It would be dangerous for stability if one or both sides fell into the trap of believing that use of one or a small number of low-yield nuclear weapons was somehow "acceptable" and could be controlled. In fact, *any* use of a nuclear weapon by Russia or the United States, no matter how low the yield or discriminate, would breach a threshold that has not been crossed for more than 70 years and open a Pandora's box of unpredictable and potentially catastrophic consequences. This is an issue that could benefit from a detailed political-military exchange between the two countries.

On March 1, President Putin described new nuclear weapons systems under development, which he asserted would be capable of overcoming American missile defenses. Three of those systems – the Poseidon nuclear-armed and nuclear-powered drone torpedo, Burevestnik nuclear-armed and nuclear-powered cruise missile (presumably ground-launched) and the Kinzhal hypersonic air-launched cruise missile – would not be captured by New START's limits (though a nuclear-capable bomber carrying the Kinzhal would be limited). Russian analysts say that a fourth weapon, the Avangard intercontinental hypersonic glide vehicle, would fall under New START, as an ICBM would launch it. However, Pentagon officials in 2010 said that such a weapon would not be treaty-limited if it did not fly a ballistic trajectory to its target. The question could be affected by whether Avangard is deployed on an existing New START-accountable ICBM such as the SS-19 or on a new booster.

US officials reacted with relatively little concern to the systems announced by President Putin. That likely reflects the fact that US missile defenses to date have not been designed to defeat Russian strategic forces. Recognizing the limitations of current missile defenses, US officials understand that existing Russian ICBMs, SLBMs and cruise missiles can hold at risk a large and broad range of targets in the United States. The new systems announced by President Putin appear redundant.

Article V of New START provides that the Bilateral Consultative Commission may be used to discuss new kinds of strategic arms. US officials could raise the new weapons in that forum, but Russian officials likely would condition their readiness to address constraints on these systems on US readiness to engage on missile defense.

The deployment of these new Russian weapons thus might have a limited impact on the bilateral strategic dynamic, simply amounting to overkill – and some may seem them as contributing to stability by ensuring a Russian second-strike retaliatory capability. Still, the deployment of new kinds of nuclear arms that replicate strategic capabilities and are unconstrained by the New START would not be a positive development.

Other factors

Missile defense has long been a problematic issue for the bilateral strategic relationship. Russia disagreed with the decision by the George W. Bush administration to withdraw in 2002 from the Anti-Ballistic Missile (ABM) Treaty, which Russian officials have described as a cornerstone of strategic stability.

Moscow has expressed concern about American plans for a limited national missile defense designed to protect against a small number of ballistic missile warheads that might be launched by a rogue state such as North Korea. Russian officials express concern not just about the Ground-based Mid-course Defense (GMD) interceptors based in Alaska and California, which are designed to intercept ICBM warheads. Interestingly, they express greater concern about US Standard Missile-3 (SM-3) and Terminal High Altitude Area Defense (THAAD) missile interceptors deployed in Europe and South Korea, despite the fact that such interceptors lack the velocity and are badly placed to engage Russian ICBM or SLBM warheads.

Recent US policy changes could well increase concern in Moscow. The 2018 Defense Authorization Act authorizes "an effective, robust layered defense system capable of defending the territory of the United States and its allies against the developing and increasingly complex ballistic missile threat." The Trump administration has significantly boosted spending for missile defense. One question for the yet-to-be-completed US missile defense review is how it will treat the issue of defense against Russian and Chinese strategic missiles. A policy suggesting greater missile defense attention to those two countries would likely solidify Russian unreadiness to consider further strategic arms control steps.

At the same time, Russia continues missile defense programs of its own. These include upgrading the anti-ballistic missile system around Moscow and developing the S-400 and S-500 air defense systems, which Russian officials assert have capabilities comparable to those of the SM-3 and THAAD. US defense officials, however, have not expressed the same degree of anxiety about Russia's ability to defend against US ICBMs and SLBMs as have the Russians about American missile defenses.

Russian officials have sought to constrain US missile defenses, calling in 2011 for limits based on "objective criteria," by which they meant limits on numbers, velocities and locations of missile defenses. There is no interest in Washington in such limits. Given current views in the Senate, no treaty limiting missile defense would have a prospect of obtaining the two-thirds vote needed for consent to ratification. Thus far, no indications out of Moscow suggest that Russia would be prepared to accept less formal arrangements regarding missile defense, such as an executive agreement to exchange data on existing and planned missile defense systems that would not require Senate consent.

Current and near-term missile defenses of the United States and Russia pose no serious threat to the retaliatory forces of the other nuclear superpower. While a breakthrough, perhaps in directed energy weapons, that provided a capability to engage a significant percentage of the other's strategic ballistic missile warheads would dramatically undermine stability, that is a concern for the longer term. Still, the current course of missile defense developments is unhealthy for the US–Russia strategic dynamic. If Moscow holds to the line it has taken since 2011, no new nuclear arms reduction or control agreements will be possible if missile defenses remain unlimited by treaty.

Other factors influence the US–Russia strategic dynamic. Development of greater precision means that conventionally-armed weapons – ballistic missiles, cruise missiles and other air-delivered munitions, such as gravity bombs – can hold at risk targets that previously had to be targeted by nuclear arms.

The US military has long deployed highly accurate conventionally-armed sea- and air-launched cruise missiles on a wide variety of platforms. They comprise a key element of US power projection. In recent years, the Russian military has demonstrated that it is starting to acquire comparable capabilities. Both sides are developing other conventional capabilities, including hypersonic cruise missiles and hypersonic glide vehicles.

Russian officials and non-governmental experts in the past have expressed concern about the numbers and wide dispersion of US long-range, conventionally-armed precision-guided weapons, particularly sea-launched cruise missiles. Some expressed worry that the United States might be tempted to use such systems to attack strategic nuclear targets in Russia in the belief that Moscow would not respond to conventional strikes with nuclear weapons. That belief appears extremely dubious, and there is no evidence to suggest that American officials hold it.

In any case, both the United States and Russia will continue to develop and deploy precision-guided conventional strike weapons. They increasingly will have to be factored into calculations about strategic stability. A bilateral dialogue on the impact of existing and planned conventionally-armed systems on the broader strategic dynamic could be useful, but is not underway at present.

New domains such as space and cyber also can affect the US–Russia strategic dynamic. Russian officials in the past have expressed concern about the "militarization" of space. The two countries already use satellites for purposes of reconnaissance and intelligence activities, GPS precision location, and command, control and communications for both nuclear and conventional force operations. US missile defenses provide some capability against satellites, while Russia is exploring various means, kinetic and other, to attack or disable adversary satellites.

Given the dependence, particularly of the US military, on space-based assets, greater anti-satellite capabilities could undermine strategic stability. The 2018 Nuclear Posture Review raised the possibility of nuclear use in response to a non-nuclear strategic attack against US nuclear command and control systems. Even in a conflict limited to conventional means, one side might be tempted to attack the other's space-based assets to disrupt its conventional ground, sea or air operations and end up attacking systems that the other considered critical for command and control of its strategic nuclear forces.

The potential for cyber attacks on adversary command and control systems raises new questions, though the US and Russian militaries presumably are taking precautions to prevent intrusion into their respective systems. The problem is that, if there is a vulnerability, a side may not know until the other has exploited it. More generally, cyber attacks on infrastructure could have major economic and health consequences, and could provoke the other to respond with nuclear weapons.

Yet another factor is third-country nuclear forces. Russia has long expressed concern about third-country nuclear forces and sought to limit them – or secure compensation – in bilateral arms control negotiations with the United States. Moscow asserts that the next round of nuclear arms reduction negotiations should be multilateral. The United States has resisted the inclusion of third-country forces in arms reduction negotiations, but third-country nuclear forces appear to be a growing factor in US calculations, particularly as China expands its political, economic and military power.

The stability model during the Cold War and immediately thereafter was primarily a US–Soviet/Russian construct focused on strategic nuclear forces, with some attention to ballistic missile defenses (which were regulated by the ABM Treaty in 1972-2002). That model appears increasingly outdated. A new model should be developed that is both multilateral, to include third-country nuclear forces, and multi-domain, to factor in the impact of developments in missile defense, precision-guided conventional strike, and the space and cyber domains on strategic stability. It will be a much more complex model than the Cold War version, and it will likely be harder to chart the impact of specific developments on multiple players and multiple domains. Trends in these areas appear likely to complicate the US–Russia strategic dynamic and make it less stable and less predictable in the coming years.

Fraying nuclear arms control and non-proliferation regimes

Washington and Moscow in the late 1960s launched a process to regulate their nuclear arms relationship. It produced a string of treaties and agreements. Today, two remain in force, and the overall regime appears to be fraying.

The INF Treaty banned all US and Soviet (later Russian) ground-launched ballistic and cruise missiles with ranges between 500 and 5,500 kilometers, resulting in the elimination of nearly 2,700 missiles. The treaty contained a robust verification regime, including on-site inspections (though they expired 15 years after the treaty's entry into force). It accelerated a major shift in Cold War attitudes and provided the prelude to other important arms control agreements, such as START I.

Unfortunately, the INF Treaty is in trouble. The United States charged in 2014 that Russia had violated the treaty by testing a ground-launched cruise missile of intermediate range. US officials in 2017 stated that Russia had begun to deploy the missile, which they identified by the Russian designator 9M729 and US/NATO designator SSC-8.

Russia has denied the charge and asserts that the United States has violated the treaty by (1) using prohibited intermediate-range ground-launched ballistic missiles as targets in missile defense tests; (2) arming unmanned aerial vehicles intermediate range, making them the equivalent of ground-launched cruise missiles; and (3) using Mk-41 launchers for SM-3 interceptor missiles at the Aegis Ashore sites in Romania and under construction in Poland.

The first two Russian charges seem to have little merit, and Russia may be engaging in similar activities. The INF Treaty has a provision that allows the use for other purposes of what otherwise might be intermediate-range ballistic missiles. Unmanned aerial vehicles differ significantly from cruise missiles and did not exist when the INF Treaty was negotiated. The third Russian charge may have some substance, as Mk-41 launchers on US warships can launch a variety of weapons, including cruise missiles as well as SM-3 interceptors.

In December 2017, the Trump administration announced that it would continue to seek to bring Russia back into compliance and would complement its political approach with economic measures against Russian entities involved with the 9M729 and a research and development program for a US ground-launched intermediate-range missile. At this point, Moscow has not visibly altered its course in response to the

US strategy, and there appears little prospect of preserving the treaty.

Moscow in the past has suggested that the INF Treaty be made a multilateral agreement, noting the increasing number of third countries that now possess ground-launched intermediate-range ballistic and/or cruise missiles. Those countries are closer to Russia than to the United States. Third countries, however, have shown no interest in this.

The second bilateral treaty is New START. New START's limits took full effect on February 5, 2018. Those limits require that the United States and Russia each have no more than 700 deployed ICBMs, SLBMs and nuclear-capable bombers and no more than 1,550 deployed strategic warheads.

The treaty's terms provide for semi-annual data exchanges, notifications (which are exchanged at the rate of about 2,000 per year) and up to 18 inspections per year of the strategic forces of the other side. The sides generally appear to be in compliance with New START, though Russian officials have questioned the techniques the US military has used to convert some strategic delivery systems so that they would no longer be counted under New START's limits.

New START will remain in force until February 2021. By its terms, the treaty can be extended by up to five years with agreement by the sides (without requiring new ratification action by legislative bodies). Indications are that the Russian government would be prepared to consider extension. Extension would likely have the support of the US military, which particularly values the information provided by New START's data exchanges, notifications and inspections. It could be difficult politically, however, for Washington to decide to extend New START if the INF Treaty has collapsed or if the treaty remains in force but questions remain about Russian compliance. New START extension may grow more difficult with time if/as INF Treaty compliance issues persist.

Unfortunately, there is little in the way of government-to-government dialogue underway between Washington and Moscow on nuclear arms control or other issues related to strategic stability, even though the importance of such dialogue has increased with the downturn in overall relations. New START's Bilateral Consultative Commission meets periodically to discuss New START implementation issues, but Russia did not take up US readiness in 2011 to negotiate a follow-on agreement to New START. Otherwise, the Special Verification Commission established by the INF Treaty has met just twice in the past two years to address the charges of treaty violations, with no apparent progress. US and Russian officials held a round of strategic stability talks in September 2017, but an early 2018 round was cancelled. Overall political-military contacts have decreased since the Russian annexation of Crimea in 2014.

More broadly, Russia has offered no proactive steps on nuclear arm control. On the American side, the 2018 nuclear posture review appears to downplay the contribution that arms control could make to US national security.

Under current trends, it appears likely that the INF Treaty will break down in the near future and that New START will expire in 2021. That raises the very real prospect that, for the first time since the early 1970s, US and Russian nuclear forces will not be regulated by a bilateral treaty.

If New START expires with no follow-on agreement, the sides would lose the transparency and predictability provided by its verification provisions. That would have expensive implications for both the US and Russian militaries, which would have to make worst-case assumptions, invariably leading to more costly decisions about how they equipped and operated their own nuclear forces.

While factors such as limited budgets might prevent a major strategic arms race absent New START, nuclear weapons levels on one or both sides could creep upwards. In order to comply with the treaty's limit of 1,550 deployed strategic warheads, the US military deploys the bulk of its ICBMs and SLBMs with fewer warheads than they could carry. For example, the Trident D5 SLBM can carry eight warheads, but Trident SLBMs are deployed with an average of four to five warheads each. New START will likely require that Russia deploy its Sarmat ICBM with fewer warheads than its capacity. Absent New START, the two countries might be tempted to upload additional warheads on SLBMs and ICBMs, resulting in an upward creep in deployed strategic warhead numbers.

It is difficult to see how the bilateral strategic dynamic, or the security interests of either country, would benefit from such a situation. The collapse of the US-Russian arms control regime would also raise questions for China. While limited fissile material has been a factor constraining the size of China's nuclear arsenal, Beijing has only modestly expanded its strategic nuclear forces over the past 30 years – in the context of agreed US–Russian strategic force reductions. Would China maintain its restraint in a situation in which US and Russian strategic forces were not being reduced or even limited?

The broader nuclear non-proliferation regime already faces significant challenges. North Korea, which has assembled a small nuclear arsenal, committed in the Singapore summit "to work toward" complete denuclearization of the Korean Peninsula. It is unclear, however, how – or whether – North Korea is prepared to implement that commitment or even what Pyongyang understands by the term denuclearization. President Trump's decision to withdraw from the 2015 Joint Comprehensive Plan of Action, which applies significant limits on Iran's ability to enrich uranium, raises questions about whether Tehran will continue to abide by those limits.

More generally, the collapse of the US–Russia nuclear arms control regime would fuel frustrations among non-nuclear weapons states party to the 1970 Non-Proliferation Treaty (NPT) that the nuclear weapons states are not doing enough to meet their obligations under NPT Article VI, which requires that they work toward nuclear disarmament and separately toward general and complete disarmament. That in turn could undercut the ability of Washington and Moscow to mobilize diplomatic pressure against countries seeking to acquire nuclear arms. It could also generate additional support for the 2017 Treaty on the Prohibition of Nuclear Weapons, which neither the United States nor Russia supports.

The need for strategic dialogue

Current trends suggest that the United States and Russia are headed for a strategic relationship that in the coming years will be less stable, less predictable and less secure.

Washington and Moscow should begin a sustained and detailed political-military exchange on strategic stability issues. As a first priority, US and Russian officials should explore ways to maintain the existing nuclear arms control regime. That includes resolving INF Treaty compliance concerns and extending New START to 2026, which will give the sides more time to consider whether they might seek new arrangements and, if so, what kinds of arrangements. They should also discuss measures to reduce the risk of conflict arising from accident or miscalculation when their military forces operate in close proximity, such as in/over the Baltic and Black seas.

Looking to the longer term, the sides should explore whether additional agreed measures, including a follow-on treaty to New START, could enhance their security. The strategic stability talks, unfortunately postponed earlier this year, offer a venue for taking a broad look at stability questions. Those include nuclear force limits and reductions, nuclear doctrine, missile defense, precision-guided conventional strike, the space and cyber domains, and third-country nuclear forces. It may take time for Washington and Moscow to identify areas for specific negotiation, but they would benefit from a regularized dialogue on key strategic issues that since 2010 has been episodic at best. Even if it takes time to identify issues for specific negotiation, ongoing strategic stability talks would offer a venue that would allow the sides to better understand the expressed concerns of the other and perhaps defuse potential misunderstandings.

Addressing these strategic stability issues would benefit from a positive change in the overall US–Russian political atmospherics. It is unclear, however, how soon such a change might come, and the sides should not wait before tackling these questions.

III. US–RUSSIA: NUCLEAR AND NON-NUCLEAR INTERACTIONS

3.1. THE STATE OF US–RUSSIA STRATEGIC RELATIONS

***Vladimir Dvorkin*[1]**

The dynamic of strategic relations between Russia and the United States continues to show a negative trend. Antagonism between Russia and the West as well as significant changes in the global nuclear landscape since the end of the Cold War have brought negotiations on the reduction and limitation of both strategic and non-strategic nuclear weapons to a grinding halt.

Despite occasional signs of agreement between Moscow and Washington to extend New START for another five-year period until 2026, no real steps have yet been taken to actually do so, nor is the possibility of negotiating a new treaty with further strategic weapons reductions being considered.

The open-ended Intermediate-range Nuclear Forces Treaty (INF), signed by the leaders of the United States and the USSR in 1987, is at risk of being ripped to pieces due to unresolved mutual grievances.

The United States, Russia, and China are actively developing and testing new types of non-nuclear strategic and tactical weapons, including hypersonic ones, and the planned development and deployment of BMD systems remains ongoing. These countries are also establishing space forces.

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All this is taking place against a backdrop of uncertainty surrounding the North Korean nuclear and missile crisis, the resolution of which remains in the balance despite Pyongyang's decision to shut down its Punggye-ri nuclear test site and recent meetings of high-level officials from the United States, the Republic of Korea, China, Russia, and DPRK, and is further compounded by an imperiled Joint Comprehensive Plan of Action (JCPOA) on Iran's nuclear program, an agreement from which the US has withdrawn following a decision by President Donald Trump.

Ongoing armed confrontation in the Middle East, happening in the context of the civil war in Syria and involving the US-led coalition, the Russian and Israeli armed forces as well as forces from Iran, is also making matters worse.

It is against this background that senior Russian and US officials, as well as representatives of other countries, are increasingly referring to nuclear issues in their public statements, and this is having a very adverse effect on the sustainability of the Treaty on the Non-Proliferation of Nuclear Weapons.

Moreover, both strategic and regional stability are mainly achieved through treaty relations between Russia and the United States in the field of strategic nuclear weapons, but these relations are currently at a standstill. The last attempts to break the deadlock stemmed from Barack Obama's proposals in January 2016 for Russia and the USA to reduce their strategic offensive weapons' arsenals by one third, but these proposals met with a flat refusal from Moscow and therefore failed.

The reasons given as to why further negotiations are impossible were, firstly, that there is a need to transition to a multilateral agreement with other nuclear states; secondly, the ongoing deployment of the US global and European missile defense systems; thirdly, the potential threat of a disarming strike using non-nuclear high-precision weapons against Russian nuclear forces; fourthly, the fact that the danger of outer space militarization still remains. Finally, according to Moscow, the West marshalled by the USA is waging a hostile policy of sanctions against Russia due to the situation in Ukraine.

It is true that, since then, the threat posed by the US BMD system to Russia has been reinterpreted. If previously it was alleged that the US ballistic missile defense system would impact Russia's nuclear deterrence capability, despite objective appraisals refuting the existence of any such effect, more recently the claim has been that the deployment first in Romania and then in Poland of a missile defense system with Mk-41 launchers identical to those found on US Navy ships, would not only enable the launch of Standard Missile-3 interceptors, but also the launch of Tomahawk cruise missiles with a 2,500 km range.

The fact that Russia, China and the USA are establishing structures known as space forces could further compound the problem of the militarization of outer space. The question of prohibiting a genuine militarization of outer space, which is often considered only in terms of placing weapons in space, has been under discussion for many years already. However, reaching a verifiable agreement in this field with dozens of countries is extremely difficult. One such draft agreement proposed by Russia and China did not fly at the UN. Attempts to agree on a draft Code of Conduct for states' activities in outer space also met with failure. Firstly, this issue was maybe not considered an urgent one until quite recently, as previously the world's leading powers had no plans to place weapons in space. And secondly, prohibiting merely the placement of weapons in space would be insufficient. A ban on the testing and deployment, both on land, in the atmosphere and in the sea, of weapons that could strike space-based targets, and of space weapons that could strike a land, air or sea target on Earth, is also necessary. But for now, we must wait for new programs to appear that will make it possible to gauge how realistic it would be to create and deploy space weapons.

Meanwhile, there already are missile defense systems either in place or currently under development that are capable of striking low-orbit space vehicles. It is therefore essential to agree on special protocols that would prohibit strikes against satellites whilst allowing for space objects that pose a real danger of falling to or colliding with Earth to be destroyed. Preparing and reaching such agreements is a challenging task, but one that must not be shied away from.

All in all, what are touted as the main obstacles to new negotiations between Russia and the United States on further strategic nuclear weapons reductions cannot be considered well-founded, since they can by no means affect the sustainability of the nuclear balance, i.e. the strategic stability, between the two countries.

Moreover, further reducing the two countries' strategic offensive weapons arsenals to 1,000-1,200 warheads and 500-550 deployed delivery vehicles would be in the interest of both Russia and the US, since it would preserve a stable strategic balance whilst allowing for significant cost-savings compared to the expense of maintaining the levels of armaments set out in New START.

In the current circumstances, maintaining the INF Treaty is absolutely critical. The US accuses Russia of developing, testing and deploying a Kalibr land-based cruise missile with a range of more than 500 km. According to various sources, Russia test-launched this Kalibr missile from a specially modified Iskander missile launch system, which together with the rocket has been made longer and taller, and these distinguishing features were deemed sufficient. The Americans reject this explanation.

It would be desirable for Russia to present, in the framework of the Special Verification Commission, the real conditions in which the Kalibr missile tests took place, along with Moscow's conception of the missile launcher's distinguishing features and, if necessary, to agree to additional structural alterations to these features in accordance with paragraph 11 of article VII of the INF Treaty.

As has already been mentioned, Russia accuses the US of having developed a ground-based version of their Mk-41 missile defense systems that is capable of launching Tomahawk cruise missiles. Moscow is also irked by the fact that the BMD system was tested using Hera target missiles, which are analogous to intermediate range ballistic missiles, as well as by the creation of the Predator and Reaper combat drones which have a range of more than 500 km.

However, though it is technically possible to launch Tomahawk missiles from the ground-based Mk-41 launchers, doing so would make no sense, since the US currently has more than 6,000 Tomahawk missiles deployed on surface ships and submarines alone. Substituting the interceptor missiles in Romania and Poland with Tomahawk missiles, that is to say adding 20 to 40 of these missiles to the US existing capabilities, would have a negligible effect. There is no rational case to be made for launching Tomahawk cruise missiles from the missile defense systems' launchers in combat. The possibility of using Hera missiles, assembled from the second and third stages of the decommissioned Minuteman-II, as booster systems for launching payloads into the upper layers of the atmosphere for various purposes, is foreseen by paragraph 12 of Article VII of the INF Treaty. This is an issue that must be settled in the Special Verification Commission.

The INF Treaty does not formally prohibit the creation of UAVs with flight ranges above 500 km – this issue did not exist when the Treaty was drawn up – though its definition of the term "cruise missile" could apply to UAVs also. A separate agreement that would take account of all the rapid developments occurring in this field in the US, Russia and many other countries is needed.

In sum, all of the mutual grievances examined so far are of a formal, technical nature; they do not in fact alter either side's offensive combat capabilities and could be ironed out in the Special Verification Commission.

That said, should the INF Treaty be terminated, relations between Russia and the West would be cast back to Cold War era levels of confrontation, with tensions running even higher than in the mid-1980s.

Even more effective ballistic and cruise missiles would appear in Europe and would be deployed much closer to Russian borders. Russia would have to develop and deploy costly missiles/weapons capable of posing the threat of a nuclear strike against large administrative and industrial metropolises as well as against NATO's entire military infrastructure. Therefore, any withdrawal from the INF Treaty is utterly undesirable, and would spell disaster for both Europe and Russia and for the United States.

Given the hostility of the current climate, it is imperative that trust between Moscow and Washington be rebuilt step-by-step for the sake of strategic stability and strengthening the nuclear non-proliferation regime. A good example of one area in which trust still endures is the compliance process under New START, which permits both countries to conduct up to 18 inspections per year at ICBM and SLBM launching facilities and heavy bomber bases, and through which the two sides exchange dozens of notifications relating to their strategic offensive arms.

Such potential should not be wasted; Russia and the US should without further ado engage in talks aimed at preserving their treaty relations in the field of strategic offensive arms and ensure the sustainability of the open-ended INF Treaty. They should also resume collaboration between their nuclear scientists and come to an agreement about eliminating excess weapons-grade materials.

3.2. THE CHANGING FEATURES OF STRATEGIC MILITARY COMPETITION BETWEEN RUSSIA AND THE UNITED STATES AND THEIR IMPLICATION FOR STRATEGIC STABILITY

Brad Roberts[1]

In the period since the end of the Cold War, the views of Moscow and Washington about the requirements of strategic stability have diverged sharply. Washington has put the focus on the threat to stability posed by regional nuclear-arming challengers and has adapted the US strategic posture, with the introduction of new defensive and offensive systems, so as to escape a relationship of mutual nuclear vulnerability with them. Moscow has put the focus on those US adaptations and the potential future threat they might pose to the credibility of Russia's strategic deterrent. While our two governments have been disagreeing about the requirements of strategic stability and about how best to protect it, the problem has been evolving. Russia and the United States are competing in new domains and in new ways. Moreover, the rate of change appears to be accelerating. This problem appears likely get worse before it gets better. Political paralysis increases the likelihood that the strategic military relationship will be further poisoned in ways that will be difficult to reverse.

What are we prepared to do, together and separately, to prevent such developments? To help shed light on this matter, this short paper

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proceeds as follows. It begins with a set of observations about the key new features of the competition between our two countries in the strategic military realm. It then sets out some arguments about possible pathways forward. The focus here is on competition in areas beyond the balance of nuclear forces and nuclear modernization, as these topics have been examined elsewhere in this volume, along with the prospect for a renewal of arms control.

The missile defense problem in the bilateral relationship has become a 3-party problem

Until recently, missile defense has been seen as a problem by one party (Russia – with its focus on potential developments in the US posture following its withdrawal in 2001 from the ABM Treaty). It has become more complicated.

The first new part is contributed by Russia. Its formation of an Aerospace Force, with its combined forces for offense and defense, has introduced a significant new missile defense factor at the regional level of war. American experts are coming to appreciate the very high importance attached to this force by Russian leadership ("the second most important military priority after Russia's nuclear deterrent"). Russia's modernization of the perimeter defense of the national capital region adds new questions about whether Russia seeks to negate the deterrents of France and the UK (and China). Indeed, there are broader questions about the intended future role of missile defense in Russian military strategy. Is it to enable A2/AD strategies of a defensive character? Is it to enable power projection? Is it to protect strategic military assets? It may be all of these things. Different answers have different implications for the United States and NATO.

The second new part of the problem comes from NATO. In 2010, NATO embraced territorial missile defense against threats from outside the Euro-Atlantic security environment and promised that its defenses would not undermine Russia's strategic nuclear deterrent. In 2012, NATO concluded that its then existing mix of deterrence capabilities was appropriate for the security environment (in which the existence of a threat from Russia was explicitly ruled out). In 2014, Russia's annexation of Crimea changed that security environment and NATO began to adapt the mix (with, for example, an increased emphasis on conventional deterrence). A key question now for NATO is whether some limited territorial defenses that would provide A2/AD capability against Russian missile attacks would reduce the alliance's vulnerability to coercion and thus contribute to regional stability.

The third piece is of course the evolving US posture. Although the Trump administration's Missile Defense Review has not been released at this writing, key elements of its approach have been set out. US homeland defenses will continue to improve in the near term and over the longer term to stay ahead of the threats posed by regional challengers (now again called "rogue states") but are not intended to negate the strategic deterrents of Russia and China. But there is an important caveat: the Trump administration plans to protect the US national capital region from cruise missile strikes from sea – which might be plausibly delivered by only one country at this time. Regional defenses will continue to improve so as to reduce the coercive and blackmail strategies of any adversary, whether rogue state or major power, posing threats to US forces and US allies. This will include additional Aegis Ashore units as well as deployment of the SM-3 Block IIA advanced interceptor, both of which will trouble Russia. As a hedge against future improvements of adversary capabilities, the United States will increase its investments in future technologies such as directed energy. The United States will continue to adapt its defenses in these ways understanding that there will be compensatory developments in the Russian (and Chinese) military posture to maintain the credibility of deterrence in their eyes. And of course Russia's political and military leaders reject these assessments. To cite a recent (April 24, 2018) report of the Russian Foreign Ministry: "The so-called missile shield gives the United States a wrong feeling of impunity and pushes it to dangerous steps… a vile feeling of invincibility and impunity… part of a dangerous global project to ensure total US military advantage to the detriment of security interests of other nations." Every American interested in missile defense also knows that Russia has for 15 years rejected every US proposal for BMD confidence and security building measures in Europe on the argument that only a legally binding guarantee will suffice to meet its concerns.

This points to the conclusion that we cannot possibly return to a world of offense dominance (and nuclear dominance). So we must adjust our strategies for stability accordingly.

Military competition in cyber space and outer space is apparently irresistible and brings with it significant new forms of instability

The Obama administration coined the phrase "congested, contested, and competitive" to characterize the space domain – a phrase that fits the cyber domain as well. Quite obviously competition has accelerated over the last decade.

Competition in these domains raises new concerns about crisis stability. Because space-based systems are vulnerable to both kinetic and non-kinetic attack, they are likely targets early in a conflict. And because their loss could decisively shift the balance of advantage in war to the attacker, there is pressure to strike them early and hard, with the aim of blinding the enemy and denying it the communications necessary to sustain military operations with weapon systems that depend critically on information technologies. A related strategic stability concern is the inherently unpredictable effects of actions in these domains, which accentuates the risks of inadvertent escalation.

As in the missile defense realm, fundamental questions have emerged about what the competitors seek in these new domains. In its strategy for space, Russia seeks to "gain and maintain supremacy." The United States, in the Trump formulation, seeks "to put America first in space" and preeminence and pursues a deterrence and defense strategy there aimed at peace through strength. This juxtaposition of objectives raises a basic question about the future in space of what might be called arms race stability.

Russians often claim that the United States plans to deploy space strike weapons designed to attack targets on the surface of the earth. Yet neither side appears to be planning such weapons. Perhaps this is something we could foreswear jointly in a legally binding way.

My conclusion is that military competition in the new domains is not guided, so far, by the principles that came to guide military competition in the nuclear domain – that is, the recognition of mutual vulnerability as an essential requirement of strategic stability. This puts us onto uncomfortable new terrain.

A new form of competition is unfolding in advanced conventional weapons – which become even more significant with the future use of artificial intelligence technologies

Until recently, there has not been much competition. The United States has talked about the fielding of prompt non-nuclear strategic strike systems for decades. The 1988 Ikle-Wohlstetter Commission on Long-term Integrated Strategy set down one of the first important arguments about the value of such systems. The George W. Bush administration proposed to modify a few Trident ballistic missiles for non-nuclear strike but was denied funding by the Congress (the Conventional Prompt Global Strike or CPGS system). The Obama administration left room for a “niche capability” for non-nuclear strike in its approach to New START but the Budget Control Act prevented the creation of a procurement program. The Trump administration is exploring various technology options but has not proposed to procure or deploy specific capabilities.

In contrast, Russia has introduced a diverse set of new strike systems, both ballistic and cruise, capable of delivering both conventional and nuclear warheads. It has also made significant progress in developing hypersonic capabilities (for the purpose of penetrating a defense that will in any case have no protection against advanced Russian penetration aids). So far, it has apparently refrained from deploying non-nuclear warheads atop intercontinental range missiles.

These developments have generated new concerns. Western experts interested in strategic stability in Europe have begun to debate the impact of these Russian capabilities on the prospects for conflict with Russia and on the dynamics of escalation and war termination in such a conflict. Russian experts have shifted their focus of concern from CPGS to stealthy sea-launched cruise missiles. But Russian concerns about a potential disarming first strike by this means are unconvincing to most Americans. A first strike would require the entire US submarine fleet and a quantity of missiles that does not exist. And it would require that those submarines all approach the Russian coast unnoticed and then launch their full loads, again without Russian notice, in a manner timed to enable simultaneous arrival on target, including on mobile targets. This is not a plausible scenario.

The impact of artificial intelligence (AI) capabilities (and Big Data) on this calculus is unknown and unpredictable. But it is potentially troubling. AI holds out the potential of greatly improving the effectiveness of strike systems by eroding the benefits of concealment, deception, and mobility and accelerating decision time and action.

This reinforces the conclusion that, from a strategic stability perspective, we have moved onto new terrain with new problems and challenges. It is aggravated by a significant gap in perceptions: each side perceives itself as the victim of a significant imbalance of capability favoring the other.

These new forms of strategic military competition are framed in our political relationship as a bilateral problem, when in fact this competition has a significant multipolar dimension

China is a major player in the new domains and also seeks dominance in cyber space and outer space. It is also mastering missile defense technologies. But China is not the only player of consequences. Many countries are gaining access to space and its potential military applications. Most countries have some cyber capabilities. Eventually, all countries will gain access to applications of artificial intelligence.

Competition over the new technologies can be expected to have a number of impacts on the security environment generally. This competition is likely to:

- increase the expectation of uncertainty and unpredictability in the security environment;
- introduce new sources of competition among technologically advanced states, especially those seeking disruptive benefits from such technologies;
- enable smaller states and non-state actors to acquire high-leverage military means;
- increase the anxiety of US allies about being caught in the middle as the major powers compete for new forms of advantage;
- generate friction and anxiety over potential developmental programs that might be hidden under the cloak of secrecy;
- incentivize new forms of hedging behavior by those states fearful of being left behind technologically;
- increase political pressures from those fearful of these technologies or their consequences to constrain them with arms control or new forms of unilateral restraint;
- increase the role of private sectors actors in creating militarily-consequential technologies.

This points to the conclusion that Russia and the United States have good reason to cooperate to minimize the negative security consequences of these factors. But so far they have not found the political will to do so.

The trajectory of the US–Russian bilateral strategic military competition brings new instabilities and new dangers

Let us look ahead a dozen years to 2030. Unless some departure becomes possible from the trajectory as it has taken shape over the last dozen years or so, the continuation of these developments points to the following new factors in the strategic military relationship:

Advanced missile defenses. This would follow from a robust integration of regional defenses in the military postures of both countries (and among US allies) and major improvements to US homeland defense and Russian strategic defense, including (for the US at least) initial fielding of new systems based on advanced technologies. One or both sides may then also have to worry about preferential defense of nuclear strike systems.

Advanced offenses. This would follow from Russian deployment of advanced strategic strike systems along with a capability for the large-scale production of additional, modern nuclear weapons; US completion of the current cycle of nuclear modernization and potential deployment of advanced non-nuclear strike; and the highly competitive pursuit of advantage and even dominance in cyber space and outer space.

The arrival of artificial intelligence as an enabler of both offense and defense. The prospect of intensifying competition to exploit AI would likely be highly motivating to both sides. The United States would likely calculate that this is an area of US advantage over time and would move to seize that advantage.

Significant "arms race" instabilities. Separate national efforts to secure early benefits of new, disruptive technologies will intensify competition by the other in the context of rising fear that technical breakthroughs may produce significant strategic advantages.

Significant crisis instabilities. The incentives to strike first with the aim of gaining a decisive advantage seem likely to rise, but so too are the risks that strikes in the new domains will generate unexpected and uncontrollable consequences. The particular vulnerabilities or nuclear command and control systems to space and cyber attack add a potentially significant dimension of crisis instability. If nuclear thresholds are crossed only after a devastating opening conventional phase, nuclear command and control systems may already have been degraded even before they come into play, thus increasing risk.

Corrosive political implications. Leaders in both capitals would lack confidence in the future of the bilateral relationship and would be fearful, fueling worst-case military planning. US allies in Europe would likely be participating eagerly in efforts to improve the deterrence and defense posture of the alliance, including especially in its ability to manage escalation risks, and would likely draw closer to American projects to counter Russian power and influence.

This points to the conclusion that strategic stability is certain to erode over the next two decades unless some means can be found to moderate competition and increase cooperation.

The usual tools for managing and mitigating risks have been poisoned and their repair and recovery are highly questionable

In the past, when faced with new forms of strategic military competition and rising risks of arms race and crisis instability, our two countries have turned to arms control and confidence building measures. But, from a US perspective, the arms control tool has been poisoned by the clear pattern of Russian non-compliance. Moscow's refusal to correct or even address violations of the INF and other treaties is widely interpreted in the United States as further proof that Russia is no longer an arms control partner. Russian experts seem not to appreciate how much Russian actions have made future treaty ratification – of any treaty with Russia – extremely unlikely. And from a Russian perspective, Washington's refusal to address concerns about US compliance only aggravate the problem. In addition, it appears that confidence building measures make no sense for a Russian leadership that (1) sees the United States as already having too much confidence and (2) rejects the existing European security order and the agreements on which it was built.

This leaves some in the United States arguing for unilateral action by the United States and its allies to reduce nuclear dangers, on the argument that nuclear risk reduction would help to lay the foundation for a political improvement in the relationship. Others in the United States argue that such unilateral action would be read in Russia as a sign of appeasement.

This points to the conclusion that we are ill equipped to cope with the emerging challenges to strategic stability in the bilateral relationship.

Alternative pathways forward

From a US perspective, there are at least three alternative pathways forward. One is to embrace competition (as Russia seems already to have done). For the United States, this means embracing the idea set out in the Trump administration's National Security Strategy – the pursuit of over-matching capabilities that put the United States in a position of strategic advantage over Russia (and China). Whether this is technically and financially a feasible option for any country is debatable. Whether it is politically feasible is equally debatable – in the sense that neither Russia nor China is prepared to accept a position of strategic inferiority *vis-à-vis* the United States. As Mao put it, China acquired nuclear weapons "to smash nuclear bullying" and leaders in both Moscow and Beijing expect such bullying of the United States if it were somehow to escape a relationship of mutual strategic vulnerability with them.

The second is for the United States to opt out of competition. This would involve a decision to retreat from its alliance commitments in Europe (and Asia), to reduce the role of extended deterrence in its military strategy, and to put the emphasis on homeland defense and a nuclear posture of minimum deterrence. This would generate new instabilities in Europe (and East Asia), which could further aggravate the security of Russia (and China).

The third alternative pathway forward is to renew cooperation on strategic stability and expand it to the new domains. This has been impossible for the last decade or more but could be feasible if there were political will at the top to do so. What would this require? There are at least five such requirements.

Progress on this pathway would require that the United States and Russia have a shared view of the troubled trajectory of the bilateral strategic military relationship as described above. This is taking shape. A key factor has been American acceptance of the long-standing

Russian view that the relationship is fundamentally adversarial and competitive.

Progress on this pathway would also require Russian confidence that it has restored a sufficient degree of balance to a strategic military relationship that it assessed to be badly unbalanced a decade ago. Russia has worked had to shift that balance and can take some satisfaction in the results. For the moment at least, it appears well positioned to deal with potential future evolutionary developments in the US posture. It appears confident that the United States cannot possibly believe that it could escape mutual vulnerability in the strategic relationship. Washington too sees no prospect that Russia could reasonably hold such a belief.

Progress on this pathway would require a willingness in both capitals to explore all of the areas of strategic military competition and their stability implications, not just the nuclear balance. This willingness appears to be taking shape.

Progress on this pathway would also require a solution to the poisoning of arms control and confidence building measures. This appears more problematic.

Finally, progress would also require a willingness of one side to take the initiative by framing a practical agenda of cooperation. Whether the larger political relationship will permit and/or encourage the work necessary to make progress is an open question.

As noted, these requirements are not all met at this time. But there are some encouraging signs.

IV. CRUCIAL ISSUES OF NUCLEAR SAFETY AND SECURITY

4.1. NUCLEAR RISKS AND COOPERATION BETWEEN RUSSIA AND THE UNITED STATES

Anatoly Diakov[1]

Introduction

Not so long ago, cooperation between the United States and Russia on nuclear issues was fairly broad and, through the Cooperative Threat Reduction (CTR) program, encompassed many projects.[2] Projects carried out under the CTR program included the modernization of security systems for nuclear sites belonging to the Ministry of Defense and Rosatom, the exchange of technical information in the field of nuclear warheads, the decommissioning of Russian industrial reactors in Seversk and Zheleznogorsk, and the improvement of the system for nuclear material physical protection, control and accountability. In the framework of the lab-to-lab cooperation, scientists from Russian and American nuclear laboratories looked at possibilities for the transparent dismantling of nuclear warheads and control over nuclear weapons materials. There were also a number of projects relating to nuclear power and fundamental research. This joint work by Russian and American

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2 The purpose of the Cooperative Threat Reduction program was to tackle nuclear risks arising from the collapse of the Soviet Union. Under this program, which ran from December 12, 1991 through to 2012, the United States provided funding and technical assistance to Russia and other former Soviet states for the elimination of strategic offensive weapons, the transportation and storage of fissile materials, and the destruction of chemical weapons.

experts under the CTR program greatly strengthened nuclear security.

In addition to addressing many specific challenges linked to nuclear threat reduction and laying the groundwork for the future, these projects also enabled both countries' legislative bodies, nuclear laboratories and other nuclear facilities, as well as their experts, to acquire a unique and immensely valuable experience in cooperation. The book *Doomed to Cooperate*, which describes Russian-American collaboration on a range of nuclear projects, concludes that the most important outcome from this collaboration was most likely the establishment of personal contacts and mutual trust between Russian and American scientists.[3]

Unfortunately, today cooperation on nuclear issues between Russia and the US is minimal. In March 2014, the US ceased collaboration in the Nuclear Energy and Nuclear Security Working Group (the Poneman-Kirienko group) of the US–Russia Bilateral Presidential Commission. One month later, joint work under the US–Russia Agreement on Cooperation in Nuclear-and-Energy-Related Scientific Research and Development of September 16, 2013, was also suspended, again at the initiative of the US. In response, Russia ceased all bilateral cooperation in the framework of the Intergovernmental Protocol to the Multilateral Nuclear Environmental Program in the Russian Federation Agreement of June 14, 2013. It was this particular Protocol that set forth areas for collaboration in the field of security, including physical protection, control and accounting of nuclear materials.[4]

3 Hecker S. *Doomed to Cooperate*. Bathtub Row Press, 2016.

4 Under this Protocol, the parties agreed to collaborate in the following areas:
– nuclear material physical protection, control, and accounting;
– security management relating to nuclear material physical protection, control, and accounting;
– customs control of nuclear and other radioactive material;
– identification, recovery, storage, securing, and disposal of high-risk radioactive sources;
– consolidation of nuclear material, including irradiated and non-irradiated uranium enriched to 20% or more of the U-235 isotope (HEU), and conversion of excess HEU to low enriched uranium (LEU);
– conversion of Russian Federation HEU-fuelled research reactors to operate with LEU fuel, and development of new LEU fuel technologies to enable future HEU to LEU research reactor conversions;
– dismantlement, transportation, fuel removal and safe storage of nuclear submarines, including transportation and safe storage of reactor compartments and associated materials, aimed at ensuring the security of highly enriched spent nuclear fuel.
Protocol between the Government of the United States of America and the Government of the Russian Federation to the Framework Agreement on a Multilateral Nuclear Environmental Program in the

Ultimately, in early October 2016, Russia, via a presidential decree, suspended its bilateral agreement with the USA on the disposal of weapons-grade plutonium no longer required for defense purposes, as well as the protocols to this agreement.[5]

The lack of cooperation between Russia and the US on nuclear issues basically reflects the fact that these two nuclear juggernauts are no longer fulfilling their obligation to agree on and coordinate measures aimed at maintaining global nuclear security. And yet it is clear that nuclear risks have by no means disappeared, on the contrary, new threats relating to nuclear security are emerging and the risks run higher now than ever before.[6] They include the proliferation of nuclear materials and technologies, devastating terror attacks and a dangerously high level of fast evolving cyber-threats.

Reducing the threats posed by cyber weapons to a minimum and placing the denuclearization of North Korea on the global agenda will necessarily require reviving nuclear-related cooperation between Russian and the US.

Cyber threats and cyber attacks

20 to 25 years ago, few people were giving much thought to the accessibility and integrity of information systems, two features which are of paramount importance for nuclear sites or any other infrastructure featuring an industrial process control system (ICS). Today however, terms such as *cyber threats*, *cyber weapons*, *cyber attacks*, *military activities in cyberspace* can be heard everywhere.

The development of information technologies, with their openness and accessibility, has led to the appearance of extremely destructive tools, generally known as cyber weapons. Nowadays, the term *cyber*

Russian Federation of May 21, 2003, signed June 14, 2013.

5 Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes, signed August 29, 2000, an amended version of which entered into force in July 2011.

6 Moniz E. We have forgotten the main thing // Kommersant. 2018. 30 May. Available at: https://www.kommersant.ru/doc/3643516.

weapon refers to all sorts of computer technologies, hardware and software (viruses) that are used for political and military purposes and are usually designed to exploit the vulnerabilities in data-transmission and data-processing systems or hardware-and-software systems. Cyber weapons are available not only to states but also to non-state actors, and in fact the latter – transnational corporations, international organizations, grassroots associations, networked structures – often have far more powerful information systems than states themselves.

Cyberspace is the space in which cyber-entities function and interact. Cyberspace today is recognized as a new theatre of military operations.

A cyber attack should be understood as a premeditated, organized series of actions, involving hardware and software and which is aimed at inflicting economic, technical or informational harm.[7] As a rule, cyber attacks generally compromise the workstation and network server in an ICS, which hosts standard software and on which data intended to be transmitted, processed or used for the control of technological processes, is stored. An attack will usually strike the data storage medium.

The technological basis for cyber attacks against industrial control systems resides in the fact that, despite the large number of competing suppliers of hardware and software, most software runs on just two or three operating systems. The widespread use of common communication standards has resulted in a single information space that transcends national borders. However, this has made modern-day infrastructure vulnerable to deliberate and targeted actions involving malicious software and hardware, i.e. malicious code that is spread through cyberspace.

For cyber attacks, there are no borders or off-limit areas. They can have a local and/or global reach, they are known for their high degree of anonymity and stealthiness and for how difficult it is to detect who and what means are behind them. A cyber attack can be initiated either by a state or by non-state actors, like illegal armed group or cyber

7 Alpeev A.S. Security terminology: Information security // Cybersecurity Issues. 2014. No. 5(8).

combatants. Moreover, it is often impossible to actually determine what entity, state or non-state, is responsible for the attack or from which country it is being carried out. Depending on where and who they are coming from, cyber attacks can be classified into two categories: outsider and insider attacks.

Cyber attacks may be aimed at causing technical and/or economic harm by destructively targeting management information systems. An example of a cyber weapon being used to inflict technical damage is the case of the *Stuxnet* virus.[8] In 2010, this malware infiltrated the control systems of the gas centrifuges on Iran's uranium enrichment plant in Natanz, and was purposefully used to cripple the centrifuges. It has been alleged that this cyber weapon was put to use a year earlier on the Sayano-Shushenskaya hydropower plant, whose turbine 2 was destroyed in 2009 when its vibration frequency was increased through the microprocessor of the plant's joint active and reactive power control system, which had a direct internet access.[9] The Saudi Aramco oil and gas company in Saudi Arabia and the RasGas company in Qatar were attacked by the *Shamoon* virus.[10]

The viruses *Flame*, *Duqu*, *Gauss* and *Wiper* were designed to inflict data-related harm by leaking or deleting confidential information about critical infrastructure or specific organizations and individuals from computer hard drives, or by removing sensitive data from government databases.[11]

Many Russian and American international security pundits believe that the development of cyber weapon technologies could disrupt the world's strategic security balance. A peculiarity of cyberspace is that

8 Stuxnet in detail: Kaspersky Lab publishes details of an attack on Iran's nuclear project. Kaspersky Lab. November 11, 2014. Available at: https://www.kaspersky.ru/about/press-releases/2014_stuxnet-v-detaliakh.

9 Varsegov N. The tragedy at the Sayano-Shushenskaya Dam was the work of a commando of hackers // Komsomol'skaya pravda. 2013. 5 December. Available at: https://www.kp.ru/daily/26168.4/3055322/.

10 Hackers attack Saudi Aramco again. SecurityLab.ru. Available at: https://www.securitylab.ru/news/433411; Cybersecurity of oil and gas companies. Neftegaz.ru. April 22, 2015. Available at: https://neftegaz.ru/science/view/1067-Kiberbezopasnost-neftegazovyh-kompaniy.

11 Vesti.net: Destroy and Self-Destruct // Vesti.ru. 2012. 29 August. Available at: https://www.vesti.ru/doc.html?id=893107.

one side may not realize it is vulnerable until this vulnerability is exploited by another party. With cyber weapons, it is potentially possible to strike a broad spectrum of military and economic targets that are critical to national security, including by disrupting military command and control, interfering with strategic decision-making, or wrecking the systems of political and military administration. Cyber attacks carried out by one side against another's infrastructure could provoke a response with nuclear weapons.

Cyber attacks by countries that enjoy a dominant position in the global information space pose a major risk. In the position papers of many countries, cyberwarfare is increasingly presented as a strategic issue of national importance with far-reaching consequences. The political and technological measures taken by some states to prepare for and wage such wars have become a key thrust in their preventive national security strategies and one of their main ways of exerting pressure on other countries in order to gain a political and strategic advantage. In light of the threats and opportunities of cyber weapons for national security, many countries, including the United States, China and Russia are developing cyber weapons capable of both destroying enemy infrastructure and beefing up their cyber-defense capabilities.

State agencies, banks, large retail chains, airlines, social media and media outlets have all fallen prey to cyber attacks. For instance, in 2017 there were 240 attacks against Russian financial institutions, 11 of which were successful with more than one billion roubles being stolen.[12] The attacks also caused many of the targeted institutions to suffer glitches and breaches, though not catastrophic ones.

Cyber attacks on nuclear facilities

But it would be a very different story if nuclear infrastructure were to be successfully targeted. If the cybersecurity of a nuclear site is compromised, the consequences could be of catastrophic proportions. There

12 The loss incurred by Russian Federation financial institutions due to Cobalt Strike attacks amounts to 1.2 billion rubles // Interfax. 2018. 13 February. Available at: http://www.interfax.ru/business/599706.

are currently more than a thousand nuclear sites in 47 countries around the world, including power reactors, research reactors, spent fuel storage facilities, spent nuclear fuel processing facilities or weapons-grade nuclear material storage facilities. All of these are potentially vulnerable to a cyber attack. For example, if hackers manage to penetrate a nuclear power reactor's control system, they can take control of the reactor and at the very least blackmail a government, demanding that some conditions be met, or, at worst, disrupt the reactor's cooling system, leading to the destruction of the reactor core through overheating and the subsequent radioactive contamination of the surrounding area. A cyber attack against a nuclear materials storage site and the disruption of its security system could serve as way to steal materials.

Unfortunately, there are several examples where the vulnerabilities of nuclear infrastructure were exploited both by malware and by targeted destructive cyber attacks. The *Stuxnet* cyber attack against the Iranian enrichment plant in Natanz in 2009-2010, which destroyed the centrifuges and thus delayed the uranium enrichment program, has already been mentioned. The same virus, launched from within Israel and the US state of Texas, was also used against the Busherh nuclear power plant.[13] According to Iranian experts, the attack used the SCADA data collection and processing system that had been installed on the power plant by Siemens.

There are also a number of examples of malware infiltrating the control system of nuclear reactors. In January 2014, a cyber attack against Japan's Monju reactor was reported. It involved the introduction of malware into one of the eight computers of the reactor's central control room.[14] In this attack, the malware introduced was intended to change the software, and some data was stolen and sent to a server located in South Korea.

A nuclear power plant in South Korea was reportedly hacked in

13 Iran's Bushehr in Iran suffers a cyber attack // BBC. 2010. 26 September. Available at: https://www.bbc.com/russian/international/2010/09/100926_iran_virus.

14 Malware based attack hit Japanese Monju Nuclear Power Plant. Security Affairs. January 10, 2014. Available at: http://securityaffairs.co/wordpress/21109/malware/malware-based-attack-hit-japanese-monju-nuclear-power-plant.html.

December 2014, during which data being stolen.[15] The government was unable to establish the identity of the perpetrators, and the hackers, who are assumed to be antinuclear activists based in Hawaii, demanded that three reactors with long operational lifespans be brought offline as well as a ransom be paid in exchange for returning the stolen data.

In April 2016, Reuters reported that software at the Gundremmingen nuclear power plant near Munich had been infected with the computer viruses *W32.Ramnit* and *Conficker*.[16] The viruses were found in a computer system that contained software associated with equipment for moving nuclear fuel assemblies.

Cyber-defense of nuclear facilities

The above examples of cyber attacks on nuclear sites are proof of a rapidly evolving global threat with potentially devastating consequences. It is clear that the nuclear industry and national governments must respond to this global security threat.

It should be recognized that it is very difficult to ensure the cybersecurity of nuclear facilities because they often include more than a thousand digital devices, including some with no built-in security. The risk of targeted attacks in which the software on a piece of equipment is infected before it the equipment is installed on site cannot be excluded. It is equally obvious that a facility's vulnerability to cyber attacks increases with its complexity.

Against this backdrop, it is vital to have an answer to the following question: are the cyber threats faced by nuclear facilities in various countries properly understood? NTI's Nuclear Security Index "Outpacing Cyber Threats" presents the results of evaluations carried out in 47 countries with nuclear facilities.[17] The evaluation used a scale

15 South Korea nuclear plant operator says hacked, raising alarm // Reuters. 2014. 22 December. Available at: www.reuters.com/article/us-southkorea-nuclear-idUSKBN0K008E20141222.

16 German nuclear plant infected with computer viruses, operator says // Reuters. 2016. 27 April. Available at: https://www.reuters.com/article/us-nuclearpower-cyber-germany-idUSKCN0XN2OS.

17 Vin Dine A., Assante M., Stoutland P. Outpacing Cyber Threats: Priorities for Cybersecurity at Nuclear Facilities. Nuclear Threat Initiative. December 7, 2016. Available at: https://www.nti.org/media/documents/NTI_CyberThreats__FINAL.pdf.

of one to four. Out of the 47 countries, 25 received a grade of either 0 (20 countries) or 1 (five countries). This shows that most countries do not implement any cybersecurity measures at their nuclear facilities.

Obviously, the primary responsibility for responding to cyber threats rests first and foremost with the operators of nuclear plants and other nuclear facilities, as well as with national regulatory authorities. In Russia, information security falls within the remit of the Federal Service for Technical and Export Control (FSTEC).[18] FSTEC's standards are used by Rosatom for developing general regulations and standard operating procedures that set out cybersecurity principles, criteria and requirements for the industrial control systems of nuclear power plants. These instructions define the necessary measures and actions (plant administrative procedures and technical solutions) for ensuring the information security and cybersecurity requirements for ICS, as applicable to both the individual elements or monitoring-and-control systems, and to the ICS as a whole. In Russia, in order to systematize the detection of, defense against and neutralization of cyber attacks targeting the ICS of nuclear power plants, and also in order to form an industrial, scientific and technological policy in this field, a Center for Nuclear Plant Cybersecurity was established.[19] This center is responsible for coordinating all work relating to the cybersecurity of nuclear power plants, including for the creation of a central database of current and potential threats and challenges, as well as the operation of a common IT cybersecurity platform.

In the United States, the protection of nuclear sites against cyber attacks is regulated by the Nuclear Regulation Commission (NRC) and by the Department of Homeland Security (DHS).

Since 2001, the NRC has issued a series of recommendations and requirements for ensuring the cybersecurity of nuclear facilities. The most comprehensive among them is document RG 5.71 Cyber Security Programs for Nuclear Facilities, which is based on the National Institute

18 Lukatskiy A. The cybersecurity of nuclear sites // The Security Index. 2015. Vol. 21, No. 4(115).

19 Russia establishes a Center for Cybersecurity of Nuclear Power Plants. Digital Report. April 21, 2017. Available at: https://digital.report/v-rossii-sozdali-tsentr-kiberbezopasnosti-atomnyih-elektrostantsiy.

of Standards' (NIST) safeguards that are mandatory for federal information systems.[20]

At the international level, considerable efforts are made by the International Atomic Energy Agency (IAEA) and the World Institute for Nuclear Security (WINS). The IAEA has launched an Information and Computer Security Program, the purpose of which is to provide countries that are home to nuclear facilities with the necessary assistance for developing and implementing their own national programs on information and computer security at nuclear facilities. The IAEA regularly prepares and publishes recommendations on cybersecurity at nuclear sites.[21]

The system of international information security

As already noted above, cyberspace today is recognized as a new theatre of war, and cyber weapons offer the potential to strike a broad range of military and economic targets that are critical to national and global security.[22] Therefore, many countries are developing both cyber weapons, in preparation for cyberwarfare, and cyber-defense tools. For cyber attacks, there are no borders or off-limit areas. They can have a local and/or global reach, they are known for their high degree of anonymity and stealthiness, and for how difficult it is to detect who and what means lie behind them. It is important to note that cyber wars can be initiated not only by states and governments but also by non-state organizations. Because it is often impossible to determine which state is behind a cyber operation or what territory it is emanating from, identifying the enemy and establishing whether or not there is a war happening can be very difficult.

In 2010, the United States established the US Cyber Command.[23] The Command's functions include the protection of federal computer networks

20 Lukatskiy A. Op. cit.

21 Computer security at nuclear facilities. IAEA. 2011. Available at: https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1527_web.pdf; Computer security of instrumentation and control systems at nuclear facilities technical guidance. IAEA. 2018. Available at: https://www-pub.iaea.org/MTCD/Publications/PDF/P1787_web.pdf.

22 A recent article published in the *Kommersant* newspaper confirms that it is possible to strike a satellite information system: American satellites fall into the hands of Chinese hackers // Kommersant. 2018. 20 June. Available at: https://www.kommersant.ru/doc/3662913?from=four_mir.

23 US Cyber Command. TAdviser. Available at: http://www.tadviser.ru/index.php_ (US_Cybercom).

serving the Pentagon, the armed forces and strategic facilities. It is also tasked with conducting virtual military operations in cyberspace against analogous computer networks belonging to potential opponents and international terrorist organizations, which is tantamount to declaring that the US has cyber weapons.

Russia also is keen not to lag behind. In 2013, Russia's Defense Minister reportedly instructed that the matter of establishing a cyber command be finalized.[24] According to the information available, this future cyber command would largely emulate the functions and structure of the United States' Cyber Command USCYBERCOM. This cyber command would be managed by the Ministry of Defense's Main Office or take the shape of a new military branch that would answer to Strategic Command, along with missile defense, strategic nuclear and space forces. In February 2017, Russian Defense Minister Sergey Shoigu announced the creation of information operations forces within the armed forces of the Russian Federation.[25]

It should be noted that there is currently no proliferation control regime for cyber weapons. Because a cyber weapon essentially consists of computer programs, its spread is uncontrollable and limiting its proliferation is extremely difficult.

Nonetheless, the threats and risks of catastrophic consequences posed by cyber attacks on nuclear facilities are such that the international community must adopt measures in order to prevent countries from carrying out such actions in cyberspace. This could be done through a framework of an international information security system, the creation of which Russia has long been advocating.

Together, the participating countries of such a system could:

- develop, with the assistance of international organizations, international law rules applicable to cyberspace and prohibiting the conduct of destructive information operations against nuclear facilities and other critical infrastructure;

24 The Russian army will have a cyber command by 2014 // RT. 2013. 7 October. Available at: https://russian.rt.com/article/16464.

25 The Defense Ministry of the Russian Federation creates information operations troops // Interfax. 2017. 22 February. Available at: https://www.interfax.ru/russia/551054.

- jointly establish a technical verification and global monitoring regime for ensuring compliance with international cyberspace law and for recording all incidents of malicious use of ICTs;
- establish a joint response system for repelling destructive information operations emanating from states, terrorist and criminal organizations.

Reaching an agreement on the creation of such a system would require active cooperation between many countries around the world, first and foremost between Russian and US experts and politicians. Moscow is willing to engage in consultations on cybersecurity, and, according to official Russian statements, is prepared to do whatever it takes for them to be constructive. Unfortunately, the US shows no such readiness. A Russian-American meeting on cybersecurity was planned to take place in Geneva at the end of February 2018, but it fell through because the American delegation cancelled at the last minute. This is of course a consequence of the current, highly fraught state of Russia–US relations.

The "denuclearization" of North Korea

In January 2003, the Democratic People's Republic of Korea announced its definitive withdrawal from the Nuclear Non-Proliferation Treaty, before carrying out its first nuclear test at the Punggye-ri nuclear test site in October 2006 and thereby becoming the fourth *de-facto* nuclear weapon state, alongside India, Pakistan and Israel. Since its first nuclear test, the DPRK has conducted five more. The latest took place on September 3, 2017, with a yield of approximately 250 kilotons of TNT equivalent. According to most experts, this explosive yield suggests that the DPRK has made considerable progress in terms of developing the nuclear bomb and successfully detonated a thermo-nuclear device.

North Korea's nuclear tests, along with its ballistic missile development program, naturally caused great concern among countries in the region, like South Korea and Japan, but it also drew condemnation from the international community. The UN Security Council has adopted several resolutions imposing an embargo on the supply of certain types of weapons, materials and equipment to North Korea that could serve to advance nuclear weapons and ballistic missile related programs. The most stringent of the UN Security Council's sanctions were adopted on December 22, 2017. These new sanctions expanded the trade embargo against North Korea to include export to the DPRK of foodstuffs, machinery, electrical equipment, transportation vehicles and a number of commodities, including magnesite and wood, industrial equipment, and metals. The sanctions also tightened the restrictions on the supply of oil and petroleum products to the country.[26]

In November 2017, North Korea's leader Kim Jong Un announced that, with the development of ICBMs capable of reaching the territory of the USA, Pyongyang had achieved its objective and would cease any further nuclear and missile tests. The inter-Korean summit held towards the end of April earlier this year raised hopes for settlement of the nuclear crisis on the Korean peninsula. These hopes began to materialize with reports that the DPRK is ready for denuclearization. However, it is not clear yet what exactly the North Korean leadership means by "denuclearization." According to some press reports, the country would be prepared to grant international observers access to its nuclear weapons and to destroy its intercontinental missiles.[27]

The first-ever meeting between an acting US President and North Korea's leader took place in June in Singapore, where the main topic discussed was the nuclear disarmament of the DPRK. The US's aim at this meeting was to persuade the DPRK to renounce its nuclear weapons and to begin the process of transferring its nuclear warheads to a third party. As for the DPRK's plans, according to a report published by the Korean News Agency KCNA before the meeting, they included discussing "the establishment of new relations between the DPRK and the United States in order to meet the demands of a changed era, alongside

26 UN Security Council tightens sanctions against North Korea again // Lenta.ru. 2017. 22 December. Available at: https://lenta.ru/news/2017/12/22/sankt/.

27 Morozova V. The DPRK says it is prepared for denuclearization on US terms // TV Zvezda. 2018. 3 May. Available at: https://tvzvezda.ru/news/vstrane_i_mire/content/201805030753-3kum.htm.

peace with South Korea and nuclear disarmament."[28] But in terms of nuclear-related outcomes, the joint statement from the summit merely "reaffirms the April 27, 2018 Panmunjom Declaration", pursuant to which "the DPRK commits to work toward complete denuclearization of the Korean Peninsula."[29] There has so far been no information about a potential timeline for the destruction of the DPRK's nuclear weapons or about what security guarantees Pyongyang would receive in exchange.

Given all the previous, unsuccessful attempts to halt the development of the DPRK's nuclear program, Pyongyang's recent assurances of its willingness to denuclearize should be taken with a pinch of salt. There are good reasons to doubt Pyongyang's readiness to abandon its nuclear arsenal.

The complete, irreversible and verifiable denuclearization of North Korea will require not only the destruction of its nuclear weapons but also of most of the industrial facilities at its nuclear weapons complex, which in turn will require at least ten years or more.[30] And without detailed and complete information about the DPRK's nuclear weapons program, achieving this will prove impossible. Because the country has been so closed off to the world, the currently available information is very scarce and full of uncertainties. In light of this, efforts to conduct a verifiable and irreversible denuclearization process will face considerable challenges, primarily due to doubts over the completeness of the information to be provided by North Korea about its nuclear program to the inspecting party. This in turn could lead to the process of denuclearization becoming dragged out or even collapsing.

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28 Trump meets with Kim Jong Un. This is the first US-DPRK summit in history // BBC. 2018. 12 June. Available at: https://www.bbc.com/russian/news-44443479.

29 Text of the Joint Statement by President Trump and Kim Jong Un at the summit // TASS. 2018. 12 June. Available at: http://tass.ru/mezhdunarodnaya-panorama/5285294.

30 From the UN Security Council Resolution 2270 (2016): "Reaffirms its decisions that the DPRK shall abandon all nuclear weapons and existing nuclear programs in a complete, verifiable and irreversible manner, and immediately cease all related activities." United Nations. March 2, 2016. Available at: http://www.un.org/en/ga/search/view_doc.asp?symbol=S/RES/2270%282016%29.

The DPRK's industrial nuclear complex

As mentioned earlier, available information about North Korea's nuclear weapons industrial complex is fairly limited. We know that the country possesses significant reserves of uranium ore (~ 26 million tons), corresponding to about 300 thousand tons of uranium. Uranium ore is extracted on an industrial scale at the Wolbisan, Pyongsan, Unggi, Hungnam, Kusong and Suncheon mines.[31]

According to the information available, the country's main nuclear facilities are concentrated at the Yongbyon Nuclear Research Center, whose construction began in 1959. The Center started its work in 1965 when a light-water IRT-2000 nuclear reactor and radiochemical laboratory, both supplied by the Soviet Union, were brought into operation. The Yongbyon complex currently comprises, among others, a 20-30 MW thermal gas-graphite reactor, a fuel rod production plant, a radiochemical laboratory (which reprocesses spent fuel), a uranium enrichment plant, an isotope production unit and construction of a 50 MW(e) experimental light-water reactor is under completion. It is estimated that the Center's facilities can produce up to 6 kg of weapon-grade plutonium, 80 kg of weapon-grade uranium and up to 10 grams of the heavy hydrogen isotope tritium per year.

Moreover, it is fairly certain that, in addition to the Nuclear Center in Yongbyon, the DPRK has other, covert sites that are part of its nuclear weapons scheme. They include uranium enrichment plants, lithium and lithium deuteride production, production of components for nuclear munitions, and a nuclear weapons assembly plant.[32]

Estimating the quantities of North Korea's available nuclear materials and number of nuclear warheads.

At the Yongbyon center, North Korea has one source of plutonium production: a Magnox type gas-graphite reactor with a thermal capacity

31 Application of Safeguards in the DPRK. Report of the Director-General. IAEA. September 2, 2011. Available at: https://www.iaea.org/About/Policy/GC/GC55/GC55Documents/Russian/gc55-24_rus.pdf; The nuclear program of the DPRK. PIR-Center. Available at: http://www.pircenter.org/media/content/files/9/13509826440.pdf.

32 Verified Denuclearizing of North Korea: Mechanics and Prospects. Institute for Science and International Security. May 14, 2018. Available at: http://isis-online.org/isis-reports/detail/verified-denuclearization-of-north-korea-mechanics-and-prospects.

of 20-30 MW(t). Construction of this reactor began in 1979 and was completed towards the end of 1985; it was brought into operation at the start of 1986.

The amount of plutonium this type of reactor can produce depends on its fuel burnup rate, which is measured in MWd/t. Burnup of spent nuclear fuel in turn depends on the thermal capacity of the reactor, the duration for which the fuel remains in the reactor core, and the structural features of the reactor. There is no precise information available on the parameters or operating conditions of North Korea's gas graphite reactor. Therefore, given the reactor's low fuel burnup (~400 d/t), its plutonium production can be estimated on the basis of what is known about its electrical output.

We know that between early 1986, when it first started operating, and the beginning of March 1994, when its operation was halted, the reactor's energy yield was of 34,200 MWt/d.[33] Assuming a conversion factor (the ratio of plutonium mass produced relative to the mass uranium 235 consumed) of 0.75, that gives a plutonium yield of approximately 25-26 kg over that period.

Subsequently, the reactor operated again in four additional production cycles (campaigns): from January 2003 to March 2005, from June 2005 to January 2007, from August 2013 to October 2015, and from December 2015 to January 2018. Assuming a capacity utilization factor of 0.65, over the first two of these four campaigns the reactor would have generated some 21,700 Mw(t)/d and so produced approximately 16 kg of plutonium.

During the latter two campaigns, the reactor was most probably used for producing tritium. Its plutonium production levels certainly dropped considerably, three times approximately. On the basis of these assumptions, during its last two campaigns the reactor would have produced an additional 6.5 kg or so of plutonium. So, at the end of 2017 and since the start of the reactor's operating life, the DPRK could have produced some 47-50 kilograms of plutonium.

33 Yudin Yu. Technical Aspects of the DPRK Nuclear Program // Yaderny control. 2006. Vol. 12, No. 1(79). Available at: http://pircenter.org/media/content/files/9/13508329250.pdf.

Approximately 24-30 kg of this plutonium may have been used in nuclear tests. That would mean that at the start of 2018, the DPRK may have possessed approximately 20-25 kg of weapons-grade plutonium, an amount sufficient enough to produce 6 to 8 implosion-type nuclear warheads.

There is no reliable information about when the country began enriching uranium on an industrial scale, or how many enrichment plants it has, or what final level of enrichment it has achieved. A more or less accurate assessment of the amount of HEU the DPRK has produced is therefore impossible. Though some parameters of the enrichment processes at Yongbyon are known, there is a lack of clear data as to when the relevant facilities started operations, when they were brought up to full capacity or what the final product's level of enrichment actually is.

For our estimates, we used the information provided by Hecker.[34] The first production unit of the enrichment facility at Yongbyon had 2,000 P2 centrifuges each with an enrichment capacity of four separative work units per year (SWU/yr). The facility started operating at its full capacity of 8,000 kg SWU/year at the end of 2010. North Korean experts claim that the facility produced uranium enriched from 2.2% to 4% which was intended as fuel for the experimental light-water reactor; however, there is no verified information about the enrichment levels. We know that producing one kilogram of uranium enriched to 90% requires 200 SWU. This means that, with an annual capacity of 40 kg per year, the uranium enrichment facility's initial production unit could by the start of 2015 have produced 160 kg of weapons-grade uranium.

Construction of the second unit with the same capacity began in March 2013 and was completed at the end of 2014.[35] This means it could potentially have produced another 240 kg of weapons-grade uranium by

34 Hecker S. A Return Trip to North Korea's Yongbyon Nuclear Complex. Center for International Cooperation, Stanford University. November 20, 2010. Available at: https://fsi-live.s3.us-west-1.amazonaws.com/s3fs-public/HeckerYongbyon.pdf.

35 Application of Safeguards in the DPRK. Report of the Director-General. IAEA. August 28, 2013. Available at: https://www.iaea.org/sites/default/files/gc57-22_rus.pdf; DPRK starts a new uranium enrichment plant // Lenta.ru. 2014. 5 November. Available at: https://lenta.ru/news/2014/11/05/korea/.

early 2018. That being so, by tapping the full capacity of this uranium enrichment facility, the total amount of weapons-grade uranium produced in the DPRK could have reached 400 kg.

If, however, the facility's first unit was not used for HEU production – a possibility given the fact that in 2012 the DPRK intended to invite IAEA inspectors to monitor its uranium enrichment activities at the Yongbyon complex – then the HEU produced at Yongbyon would amount to 120 kg.

Nor can it be excluded that the enrichment facilities at Yongbyon were not at all used for HEU production, but that the DPRK has had another covert enrichment plant designed and operated exclusively for the production of weapons-grade uranium, in contrast to the Yongbyon facilities.[36] This is in fact the most likely scenario, given the country's rather uncharacteristic openness about the Yongbyon enrichment plant. If we suppose that this covert plant has the same capacity as the first unit of the Yongbyon site, and assuming that it started operations in 2005-2007, then by the start of 2018 it could have produced between 440 and 520 kg of weapons-grade uranium.

All in all, on the basis of all these assumptions, the amount of HEU produced in the DPRK at the end of 2017 could lie anywhere between 120 kg and 920 kg. Estimates by a group of experts from the Institute for Science and International Security put the figure[37] as ranging from 230 to 760 kg, whereas Siegfried Hecker from the University of California estimates that it lies somewhere between 250 and 500 kg.[38]

On the assumption that producing one implosion-type nuclear warhead requires 10 kg of HEU, it can be considered that the DPRK has at least 12 such warheads. Thus, country's overall arsenal could include 20 or more implosion-type warheads. As for thermonuclear warheads, their number is estimated at 1 or 2.

36 Verified Denuclearizing of North Korea: Mechanics and Prospects…
37 Ibid.
38 Hecker S.S., Carlin R.L., Serbin E.A. A comprehensive history of North Korea's nuclear program. Center for International Security and Cooperation, Stanford University. Available at: https://cisac.fsi.stanford.edu/content/cisac-north-korea.

The verifiable denuclearization of North Korea

The extreme secrecy surrounding North Korea's nuclear weapons program and the wide gap between high and low estimates of the DPRK's nuclear capacity will make it very difficult for inspectors to achieve their final stated objective of "complete, verified and irreversible denuclearization." Difficulties will arise mainly from the uncertainties surrounding the completeness and reliability of the information provided by North Korea on its nuclear weapons program.

The experience gained by Russia and the US through the CTR program could be useful for establishing an effective oversight mechanism for the dismantlement of North Korea's nuclear program. The denuclearization of North Korea will raise issues such as the conversion of nuclear facilities from military production to peaceful purposes, as well as the reorientation of the numerous scientific and technical personnel working for the nuclear weapons program towards more peaceful tasks. The conversion of Russia's nuclear and defense industries, as well as the establishment and work of the International Scientific and Technological Center, are experiences that could be beneficial for tackling these issues. If Russian, American and North Korean experts were to work hand in hand on the conversion of the DPRK's nuclear facilities, this would not only create a productive atmosphere, it would also help learn more about the nuclear program and the facilities involved in full.

Moreover, cooperation between Russia and the United States will be indispensable both for discussing and deciding on verification procedures. The IAEA does not have the mandate to conduct verification activities on any aspects associated with nuclear disarmament. A dedicated body for such verification efforts will therefore need to be created with experts from the five nuclear weapons states, bearing in mind that Russia and the United States will be key players here as their experts have the most experience in and knowledge about the implementation of verification procedures.

Conclusion

There are currently serious and bitter disagreements between Russia and the United States on multiple issues, relating to Ukraine, Syria, the expansion of NATO, missile defense systems and many other matters. However, both countries understand that they have a common and concurring interest in preventing a nuclear catastrophe, which is why for many years Moscow and Washington worked together to prevent the proliferation and use of nuclear weapons, to eradicate the threat of nuclear terrorism, and to promote the use of nuclear energy for addressing global challenges.

Unfortunately, though, nuclear risks have not disappeared, and in fact new and fast evolving threats are emerging, such as those of cyber attacks against nuclear facilities in various countries. North Korea's growing nuclear potential is a threat to peace. Preventing a nuclear catastrophe requires cooperation between Russia and the United States on reducing and eliminating these threats and places the resumption of dialogue between experts from both countries and the rekindling of bilateral work on nuclear energy and nuclear security back on the order of the day.

4.1. PERSPECTIVES ON NUCLEAR SAFETY AND NUCLEAR SECURITY

Tariq Rauf[1]

Introduction

In the broader United Nations system, the authority for matters pertaining to the nuclear fuel cycle is vested in the autonomous International Atomic Energy Agency (IAEA) that was established in 1956 following US President Dwight Eisenhower's historic *Atoms for Peace* speech on 8 December 1953 at the UN General Assembly. The Statute of the IAEA, which was approved on 23 October 1956 and came into force on 29 July 1957, gives the Agency authority *inter alia* for establishing nuclear safety standards and for safeguards. In order to give increased emphasis to nuclear safety and security matters, a separate Department of Nuclear Safety was created in 1996, an Office of Nuclear Security in 2002; the integrated Department of Safety and Security was established in 2004.

The Member States of the IAEA and States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) have agreed that the responsibility for nuclear safety and nuclear security in the civilian fuel cycle rests entirely with each individual state. In this regard, international binding and non-binding legal instruments provide states the common platform and strategic framework to work collaboratively to enhance nuclear safety and nuclear security worldwide. There now exist international frameworks principally under the aegis of the IAEA for nuclear safety and nuclear security based on the obligations and responsibilities outlined in the:

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- Convention on Nuclear Safety (CNS); the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention); the Convention on Early Notification of a Nuclear Accident (Early Notification Convention) and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention), the Vienna Declaration on Nuclear Safety on Principles for the Implementation of the Objective of the CNS to Prevent Accidents and Mitigate Radiological Consequences – all under Agency auspices;
- Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment; the non-binding Code of Conduct for the Safety and Security of Sources and its Supplementary Guidances (on the Import and Export of Radioactive Sources and on the Management of Disused Radioactive Sources); as well as the requirements for nuclear material accountancy, and for health, safety and physical protection as contained in project and supply agreements and safeguards agreements concluded by states with the IAEA; and the
- International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT); and the relevant Security Council resolutions (1373 and 1540).

IAEA Nuclear Safety Standards and the IAEA Nuclear Security Series provide international standards and best practices in their respective domains. The nuclear safety and nuclear security interface requires continued vigilance. Safety measures and security measures for nuclear facilities and activities must be designed and implemented in an integrated manner, such that security measures do not compromise safety and safety measures do not compromise security. Hence, IAEA international safety standards and security guidelines and recommendations provide practical advice to states on how to meet their international obligations.

IAEA nuclear safety standards cover: nuclear safety (NS), radiation safety (RS), transport safety (TS), waste safety (WS) and general safety (GS). These standards provide a system of Safety Fundamentals:

Fundamental Safety Principles establish the fundamental safety objective and principles of protection and safety, and convey the basis and rationale for the safety standards for government and regulatory bodies. *Safety Requirements* establish the requirements to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. *Safety Guides* provide recommendations and guidance on how to comply with the safety requirements, reflecting international consensus on the measures; and provide international best practices to achieve high levels of safety. The IAEA safety standards are applicable throughout the entire lifetime of civilian nuclear facilities and activities – existing and new – utilized for peaceful purposes, and to protective actions to reduce existing radiation risks.

The IAEA Nuclear Security Series provides guidance for the prevention and detection of, and response to, theft, sabotage, unauthorized access and illegal transfer or other malicious acts involving nuclear material and other radioactive substances and their associated facilities. The Series comprise four categories: *Nuclear Security Fundamentals*, containing objectives, concepts and principles of nuclear security and provide the basis for security recommendations; *Recommendations*, presenting best practices that should be adopted by member states in the application of the Nuclear Security Fundamentals; *Implementing Guides*, providing further elaboration of the Recommendations in broad areas and suggest measures for their implementation; and *Technical Guidance*, comprising Reference Manuals, with detailed measures and/or guidance on how to apply the Implementing Guides in specific fields or activities; Training Guides, covering the syllabus and/or manuals for Agency training courses in the area of nuclear security; and Service Guides, which provide guidance on the conduct and scope of Agency nuclear security advisory missions.

Nexus of nuclear safety and nuclear security

Nuclear safety and nuclear security both share the ultimate goal of protecting people and the environment from the harmful effects of radiation, but they are different in both cause and process. Nuclear accidents are caused by human and/or technical failures or extreme natural events, and the likelihood of their occurrence can be scientifically estimated within limits. In contrast, with regard to nuclear security, malicious events are intentional, much less predictable, and involve an adversary intent on evading prevention measures. That said, from the perspective of both operators and regulators, prevention measures must cover all safety and security requirements. Measures to combat illicit trafficking and nuclear proliferation are also closely interlinked but involve different constituencies. Taken together, these measures constitute a global nuclear order dedicated to ensuring that the benefits of nuclear technology will be available to all in a peaceful, safe and secure manner.

Nuclear safety and nuclear security are primarily the responsibility of the state, but recognition of the far reaching consequences of accidents, nuclear terrorist and/or cyber attacks has led to strengthened focus and efforts on global arrangements to address these risks – a process that is ongoing following three nuclear accidents (Three Mile Island 1979, Chernobyl 1986 and Fukushima Daiichi 2011); and five nuclear security summits (1996 Moscow, 2010 Washington, 2012 Seoul, 2014 The Hague, and 2016 Washington); and various inter-ministerial conferences held under the auspices of or in cooperation with the IAEA.

Nuclear safety

The IAEA's role in continuously advancing global nuclear safety standards is critical and is universally recognized. The Agency leads an international effort to establish a global nuclear safety network to ensure that critical safety knowledge, experience, and lessons learned are broadly exchanged and implemented. Though nuclear safety is fundamentally the responsibility of individual states, the IAEA has an important role to play as the only global body with relevant competence and expertise. States have recognized the essential role of the Agency in strengthening and ensuring nuclear safety. A new threat at the interface of nuclear safety and nuclear security emanates from cyber threats or vulnerabilities in the computerized control systems of nuclear installations.

Nuclear safety has improved significantly but the risk of accidents persists. A wide range of safety indicators make clear that nuclear safety in many countries has improved significantly since the Three Mile Island, Chernobyl and Fukushima Daiichi accidents. The third-generation nuclear reactors now being built are designed to reduce further the risk of nuclear accidents and any potential adverse impact on health and the environment. But the Davis-Besse incident in the United States in 2002, where less than a centimeter of steel remained in the steel pressure vessel to prevent a major loss of coolant, in a sequence of events that had never been included in probabilistic risk assessments; and the Fukushima Daiichi accident where although the four power reactors seemingly survived a seismic event beyond design parameters but suffered total loss of station power due to ocean inundation of the power supply resulting from a tsunami, that in turn led to core meltdowns and hydrogen gas explosions, and radioactive releases – were grim reminders that maintaining nuclear safety remains an ongoing process that requires the utmost care, not only at the design stage but also during operation and emergency preparedness. Some of the oldest-design reactors still in use in several countries pose particular concerns, and in newcomer states that are establishing their regulatory infrastructures, teams of qualified personnel, nuclear safety cultures – the safety of reactors will require special attention. Another serious nuclear accident anywhere whether due to safety or security would impair any prospect for large-scale global growth of nuclear energy and its vital contribution to the achievement of sustainable development goals.

According to the IAEA, a majority of civilian nuclear fuel cycle facilities worldwide were designed decades ago, according to the then IAEA Integrated Nuclear Fuel Cycle Information System, but their construction may no longer fully conform with the current IAEA Safety Standards (NS-R-5 (Rev. 1) Safety of Nuclear Fuel Cycle Facilities). Furthermore, in nuclear fuel cycle facilities there is a higher potential, compared to other nuclear installations, for an accidental criticality. Many nuclear fuel cycle facilities rely on a combination of static and dynamic containment for confinement that inherently provides potential pathways to the environment under abnormal operating or accident conditions. This is particularly so for extreme external events which also have the potential to damage these barriers directly. In some cases, the characteristics of the facility site and its vicinity may have changed since the construction of the facility, which may affect the potential for external events or accidents and their potential effects and/or public consequences.

A number of the lessons learned in the light of feedback from the accident at the Fukushima Daiichi nuclear power plant are applicable to nuclear fuel cycle facilities in general, as reported by the IAEA based on assessments carried out by the Agency's staff along with experts from various member states and the nuclear industry. Where these factors have not previously been considered, a revision of the safety analysis for nuclear fuel cycle facilities through carrying out a safety reassessment may be justified. The priority for carrying out safety reassessments would need to be decided in accordance with the potential hazard associated with each facility. The scope of the safety reassessment of nuclear fuel cycle facilities includes, but may not be limited to, the following: (a) safety requirements adopted for the facility; (b) changes to regulations and international good practice; (c) continued validity, in the light of current knowledge, of the safety criteria adopted for the design of the facility, including its seismic design; (d) design of the facility against flooding (resulting from a tsunami or another cause); (e) delayed or diminished capability of emergency response from external sources, owing to the widespread effects of some natural disasters; (f) physical damage (resulting from a major seismic event, tsunami, wind or another cause); (g) total loss of electrical power supply (including for an extended period); (h) loss of ultimate heat sink; (i) hydrogen (radiolysis) and exothermic chemical reactions; and (j) emergency arrangements, accident management and communication of information.

One major lesson from the Fukushima Daiichi accident was to identify conditions that are more severe than design basis accidents or involve additional system failures. Such evaluation would need to cover: (a) the possible inadequacy of the concept of defense in depth in the nuclear fuel cycle facility or site as a result of events leading to unacceptable radiological consequences; (b) failures of the main safety functions that could lead to unacceptable radiological consequences; and (c) potential human error (or a feasible combination of errors) that could result in the failure of one or more main safety functions and thus could lead to unacceptable radiological consequences. For conditions that meet these criteria, for which additional safety measures may be needed, include: (a) accidental criticality, leading to an early release of radioactive material; (b) melting of spent fuel or vitrified radioactive waste; (c) uncovering spent fuel or thorium/uranium breeder elements in a spent fuel storage pool; (d) extended blackout of the facility; (e) boiling of highly active liquid radioactive waste; (f) rupture of a pressurized UF6 storage or process vessel (> ~60 Celsius); and (g) major disruption of a plant handling of fuels containing plutonium or 233U.

Recommended mitigation measures are based on a graded approach to safety reassessment commensurate with the potential hazard of the nuclear fuel cycle facility. Factors affecting the application of a graded approach are related to the risk and the potential hazard, including, for example: (a) the scale of operations undertaken; (b) the inventory of radioactive material, the amount and enrichment of fissile material or the inventory of transuranic elements and the perceived criticality risk; (c) the amount, nature and physical and chemical forms of the radioactive materials that are used, processed or stored; (d) the facility design, the complexity of the site and the facility, the inherent safety features in the design and the maturity of the process; (e) the presence of high pressure piping or the use of high temperature or pressure processes; (f) the quality (robustness) of the means of confinement (containment and ventilation systems, etc.); (g) the facility utilization program; (h) the stage of the lifetime of the nuclear fuel cycle facility, including its ageing; (i) any other internal hazards (e.g. hydrogen, chemical and fire hazards); (j) siting (regional characteristics including location of reservoirs, dams and large water bodies, and geological or meteorological conditions); (k) structural concept (above or below ground) and the proximity of other nuclear or non-nuclear industrial sites; and (l) proximity to populated areas and the availability of off-site support to cope with accidents.

The accident at the Fukushima Daiichi nuclear power plant also demonstrated the need to explore scenarios in which external hazards exceed the design basis events of a nuclear installation. Knowledge of plant behavior during extreme event scenarios helps to improve plant safety, since potential vulnerabilities controlling the plant's capacity against such hazards can be identified and measures to limit the progression of potential accidents can be introduced. Many IAEA member states have already implemented actions targeted to identify quickly any weak links in the response to external hazards and to assess the plant's response if these links fail. Stress tests for European Union nuclear power plants; the review by the Near-Term Task Force established by the US Nuclear Regulatory Commission; the safety assessments during 2011 and 2012 by the member countries of the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO) having nuclear plants (Argentina, Brazil, Mexico and Spain); comprehensive safety examinations for operating plants and plants under construction in China, carried out in 2011; and stress tests and related activities in Canada and Pakistan derived from the regulatory integrated action plan on the lessons learned from the Fukushima Daiichi nuclear accident, were salient examples.

Despite these regulatory and industry activities to strengthen nuclear safety, the Convention on Nuclear Safety (CNS) remains an incentive convention lacking mandatory peer reviews, safety assessments and upgrades because of opposition from some of the principal users of nuclear power including France, Japan, the Russian Federation and the US. The IAEA Action Plan on Nuclear Safety of September 2011 called for the strengthening of nuclear safety through a number of measures including 12 main actions, each with corresponding sub-actions, focusing on: safety assessments in the light of the accident at Fukushima Daiichi Nuclear Power Station; IAEA peer reviews; emergency preparedness and response; national regulatory bodies; operating organizations; IAEA Safety Standards; international legal framework; member states planning to embark on a nuclear power program; capacity building; protection of people and the environment from ionizing radiation; communication and information dissemination; and research and development. In February 2015, the Contracting Parties to the CNS held a Diplomatic Conference at which they adopted the Vienna Declaration on Nuclear Safety, containing principles to guide countries in achieving the objectives of the Convention. Other Agency safety consultation mechanisms include the CANDU Operators Group (COG) and the Senior Regulators Meeting, but IAEA international peer reviews remain voluntary and outside the scope of the CNS. Nevertheless, over the years a great number of international peer reviews have been carried out by IAEA member states and the results reported publicly in many though not all cases. As such, IAEA nuclear safety and security reviews have become the international standard are regularly implemented in many states.

Nuclear security

The essential role of the IAEA in nuclear security of civilian facilities is globally recognized and enshrined in the declarations or communiqués of IAEA ministerial conferences, NPT review meetings and nuclear security summits. Since 1995, the IAEA has organized International Physical Protection Advisory Service (IPPAS) missions for the purpose of reviewing states' physical protection systems implemented at the national and facility levels, thereby helping states identify needs for improvement as well as good practices in implementation. IAEA INFCIRC/225/Rev.4 (Corr.) "The Physical Protection of Nuclear Material and Nuclear Facilities" underlined the importance of defining a Design

Basis Threat (DBT) as a basis in designing and establishing physical protection to prevent theft of nuclear materials and sabotage of nuclear material and nuclear facilities. The IAEA Secretariat, together with member states' experts has developed a methodology and a workshop curriculum for assisting states in developing their own DBT.

Historically, the term *physical protection* has been used to describe what is now known as the nuclear security of nuclear material and nuclear facilities. Revision 5 of INFCIRC/225 was approved by IAEA member states in September 2010. INFCIRC/225/Rev.5 applies to the physical protection of nuclear material against unauthorized removal with the intent to construct a nuclear explosive device, and to the physical protection of nuclear facilities and nuclear material, including during transport, against sabotage. However, these recommended requirements are provided for consideration by states and their competent authority but are not mandatory upon a state, unless they are included in safeguards agreements or project and supply agreements concluded by states with the IAEA, and do not infringe on the sovereign rights of states – the aversion of states to accept mandatory physical protection standards continues unabated.

As far back as May 2001, it was recognized that since the end of the Cold War many more nuclear facilities had come into operation and much more nuclear material was in use and storage. Furthermore, the dismantlement of nuclear weapons had contributed substantially to increased inventories of sensitive nuclear materials in both military and peaceful uses and storages. Incidents of illicit trafficking reported during the 1990s gave rise to a range of initiatives at national and international levels designed to prevent the loss of material and, where losses occurred, to ensure that measures to recover material were rapidly enacted and that any consequences were mitigated.

Until late 2001, the matter of nuclear security was addressed through the Agency's safeguards system under measures for the accounting for and control of nuclear material and for the physical protection of nuclear material and facilities. An effective state system of accounting for and control of nuclear material (SSAC) remains essential for combating illicit trafficking and an important element in support of physical protection systems.

IAEA member states have recognized that a comprehensive approach to security of material was required, taking into account both the risks for nuclear proliferation through the potential use of nuclear material in nuclear devices and the threat to radiation health and safety. And that states had the responsibility to ensure that their regulatory systems covered the measures required for prevention, detection and response to threats emanating from theft, sabotage or other illegal activities involving nuclear and other radioactive materials. It was also recognized that the Agency had a key role in supporting states' efforts to improve the security of material and combat illicit trafficking by providing guidance and normative documents, promoting technical development and, upon request, assisting states in their implementation.

The first IAEA Nuclear Security Plan outlined in March 2002 was the first to identify four threats of nuclear terrorism: (1) theft of an intact nuclear weapon; (2) theft of nuclear material to make an improvised nuclear explosive device (INED); (3) theft of other radioactive material for a radiological dispersal device (RDD); and (4) sabotage of a nuclear facility or nuclear transport containing nuclear and radioactive materials. As an international organization, the IAEA was not in any position to deal with nuclear weapons and thus the responsibility of security and protection of nuclear weapons was assigned to states possessing such weapons. For the other three scenarios, recognizing that states are solely responsible for the security and safety of their nuclear materials and facilities, the IAEA took on the burden of assisting states in enhancing nuclear security and to develop measures toward this end.

Consequently, in the IAEA's Nuclear Security Plan the strategy to counter nuclear terrorism was based on measures to prevent theft of nuclear and other radioactive material and to provide a defense against malicious acts on facilities, supplemented with a range of detection and response measures in the event that prevention was unsuccessful.

Because nuclear security measures were designed to address a malicious act; for example, an act of nuclear terrorism, a probabilistic approach to assessing the risk was not considered relevant. Rather, risk was assessed in terms of level of threats and the consequences of a successful attack. Preventive measures were formulated and implemented recognizing that they would face attempts to defeat or circumvent them. These measures took a graded approach dependent upon the level of threat and the severity of the consequences of a successful attack. Undoubtedly, the consequences of the detonation of any nuclear explosive device would be catastrophic. The consequences of an RDD or of a violent attack on a facility or transport containing nuclear or other radioactive material would, in most cases, be comparatively less destructive but with unpredictable social, economic, and political ramifications. The specific measures included effective management and control of materials through regulation and accountancy, physical protection of materials, facilities and transports to prevent theft and against attacks, and measures for detection and response. For its effective implementation, the Nuclear Security Plan required an integrated and multi-track approach. Where Agency activities contributed both to nuclear security and other Agency objectives (e.g. verification or safety), synergies were sought and exploited, with due recognition of established competences and with the goal of minimizing unnecessary duplication of efforts.

The methods by which the IAEA sought to assist member states to improve their nuclear security were divided into the following three broad activity areas: (1) encouraging and facilitating the development and implementation of binding and non-binding legal instruments; (2) developing international guidelines and recommendations acceptable to the international community and providing related advisory services, training, equipment and technical assistance; and (3) providing or facilitating the development of information exchange and services.

As part of its nuclear security activities, the IAEA supported efforts in 2006 and subsequently on the Minimization of Highly Enriched Uranium (HEU) in the Civilian Sector even though the bulk of global stocks of HEU remain in military use. It was recognized that fissile material – in particular HEU, as well as radioactive sources – posed a security risk as these could be used for the production of improvised nuclear explosive devices and RDDs.

This renewed focus on HEU minimization in civilian use further extended the scope and activities of the Reduced Enrichment Research and Test Reactor (RERTR) program established in 1978 at the Argonne National Laboratory (ANL) by the US Department of Energy (DOE). The primary objective of the RERTR program was to develop the technology needed to use Low-Enrichment Uranium (LEU) instead of HEU in research and test reactors, and to do so without significant penalties in experiment performance, economic, or safety aspects of the reactors.

One important aspect of the RERTR program and the HEU minimization in civilian use was to determine the feasibility of using LEU instead of HEU in fission targets for the production of Molybdenum (Mo99) for medical applications. Mo99 is by far the most important medical radioisotope which is produced in research reactors through the use of HEU targets.

More than 100 civilian nuclear facilities around the world utilized weapon-grade HEU (uranium enriched to 90% or greater); these facilities included research reactors and critical assemblies that were established in the 1950s and 1960s and played a central role in the development of peaceful uses of nuclear technology. Another 100 research reactors in military use also utilized HEU, as do more than 150 nuclear ship propulsion reactors for ice breakers, submarines, surface combatants and aircraft carriers. In all more than 7 MT (7,000 kilograms) of weapon-grade HEU was in research and naval reactors in the nuclear-weapon states and more than 5 MT (5,000 kilograms) in research reactors in non-nuclear-weapon states; and the global stock of HEU is estimated at about 1,400 MT (1,400,000 kilograms) – only 8 kg or less is sufficient for a nuclear bomb. Since the RERTR program started in 1978, some 65 HEU-fueled research reactors have been converted to LEU and nearly 150 have been retired. Of the approximately 100 remaining HEU-fueled research reactors, about half are in Russia.

As previously noted, despite five nuclear security summits and three IAEA ministerial conferences, 83% of global stocks of HEU and plutonium remain outside any international oversight – the summits only addressed 17% of these dangerous nuclear materials in civilian use which are under IAEA safeguards. The nuclear-weapon states and their allies oppose the inclusion of existing stocks in the negotiation of a fissile material cut-off treaty (FMCT) at the Conference on Disarmament. And, efforts in 2010 at the IAEA to start a voluntary HEU reporting scheme, patterned on the already existing reporting mechanism on plutonium (Pu) among Pu users and producers, foundered. Some 26 states and Taiwan (China) have phased out HEU in civilian uses and efforts are promoted to set up what is termed as *HEU-free zone*s in non-nuclear-weapon states leaving HEU untouched in nuclear-weapon possessor states.

The objective of the IAEA Nuclear Security Program 2018-2021 approved by member states is to: (1) contribute to global efforts to achieve effective nuclear security, by establishing comprehensive nuclear security guidance and, upon request, promoting its use through peer reviews and advisory services and capacity building, including education and training; (2) assist in adherence to, and implementation of, relevant international legal instruments, and in strengthening the international cooperation and coordination of assistance; and (3) play the central role and enhance international cooperation in nuclear security, in response to the priorities of member states expressed through the decisions and resolutions of the Agency's policy making organs. Activities include *inter alia*: information and computer security; nuclear security of materials and associated facilities; nuclear security approaches for the entire nuclear fuel cycle; enhancing nuclear materials security through improved accounting and control; upgrading security of radioactive material and associated facilities; security of transport of nuclear and other radioactive material; nuclear security of materials out of regulatory control; nuclear security detection and response architecture; radiological crime scene management and nuclear forensic science; nuclear security culture; and education and training programs for human resource development.

Despite states' assertions of the importance of nuclear security, the 2018-2019 IAEA budget for nuclear security projects amounts to more than €27 million, but only about €6 million is from the regular budget leaving about €21 million unfunded (to be funded through voluntary contributions by member states, mostly with strings attached).

Nuclear security culture. The IAEA describes the attributes of nuclear security culture as being ultimately dependent on individuals: policy makers, regulators, managers, individual employees and – to some extent – the public. Nuclear security culture is defined as: the assembly of characteristics, attitudes and behavior of individuals, organizations and institutions which serves as a means to support and enhance nuclear security. Nuclear security culture plays an important role in ensuring that individuals, organizations and institutions remain vigilant and that sustained measures are taken to prevent and combat the threat of sabotage or using radioactive material for malicious acts.

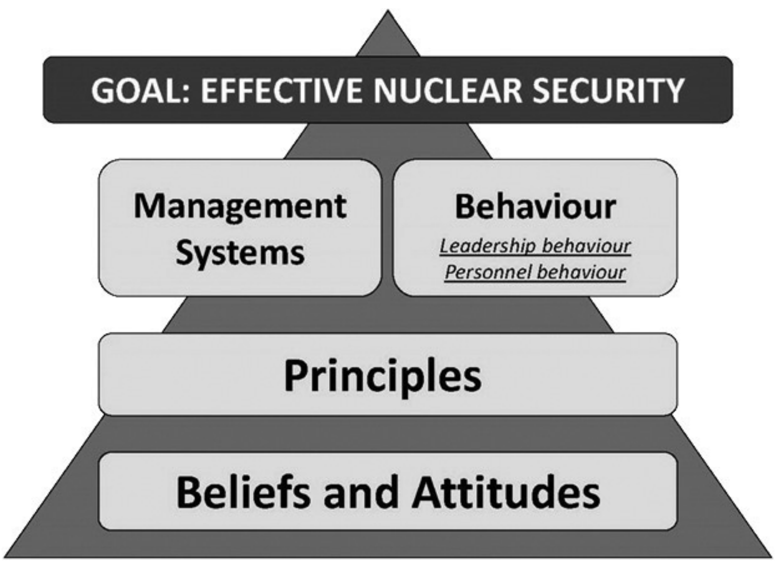

Figure 1. *IAEA nuclear security culture model.*

A nuclear security regime includes a range of elements and activities, including: legislation and regulation; intelligence gathering; assessment of the threat to radioactive material and associated locations and facilities; administrative systems; various technical hardware systems; response capabilities and mitigation activities. No single government or industry organization or subsection of such an organization can address these elements in isolation. An effective nuclear security culture is dependent on proper planning, training, awareness, operation and maintenance, as well as on people who plan, operate and maintain nuclear security systems. Even a well-designed system can be degraded if the procedures necessary to operate and maintain it are poor, or if the operators fail to follow procedures. Ultimately, therefore, the entire nuclear security regime stands or falls because of the people involved and their leaders, and it is the human factor, including management leadership, that must be addressed in any effort to enhance the existing nuclear security culture.

Nuclear security culture is one of the 12 Fundamental Principles codified in the 2005 Amendment to the Convention on the Physical Protection of Nuclear Material. The entry into force of the 2005 Amendment in 2016 made the Fundamental Principles of nuclear security, including security culture, binding on states parties to the Convention. The term security culture is also found in the 2004 Code of Conduct on the Safety and Security of Radioactive Sources. This Code is non-binding, but more than 120 countries have informed the IAEA Director General of their support for it.

Relationship between nuclear security culture and nuclear safety culture. While both nuclear safety and nuclear security consider the risk of inadvertent human error, nuclear security places additional emphasis on deliberate acts that are intended to cause harm. Because security deals with deliberate acts, security culture requires different attitudes and behavior, such as confidentiality of information and efforts to deter malicious acts, as compared with safety culture. Safety culture is defined as “that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance." In a similar manner, nuclear security culture refers to the personal dedication and accountability and understanding of all individuals engaged in any activity which has a bearing on the security of nuclear activities. Therefore, the principal shared objective of security culture and safety culture is to limit the risk resulting from radioactive material and associated facilities. This objective is largely based on common principles, e.g. a questioning attitude, rigorous and prudent approaches, and effective communication and open, two-way communications. Many diverse organizations are concerned with nuclear security. These include, in particular, individuals, organizations and institutions engaged in protecting radioactive material and their associated locations, facilities and transport; some of these bodies may have little technical knowledge about nuclear or other radioactive material. This lends greater weight to the need for effective structural, communication, information and exchange systems, and the integration of the functions of these diverse organizations into a unified nuclear security culture. Competent authorities for safety and security may be located in the same, or different, organizations and may have different forms of supervisory or regulatory power. In each case, many individuals are part of both the security and safety cultures. For safety culture, all individuals are prevailed upon to share information openly because of this area's overriding concern for transparency and dialogue. In the same way, security culture requires that individuals respond immediately to confirmed or perceived threats and incidents, and restrict communication to authorized persons with a need to know.

Nuclear safety and nuclear security cultures coexist and need to reinforce each other because they share the common objective of limiting risk. There will be occasions where there are differences between safety and security requirements. Therefore, an organization in charge of nuclear matters has to foster an approach that integrates safety and security in a mutually supporting manner.

Cyber/computer security

The protection of computer-based systems in civilian nuclear installations has become an important part of nuclear safety and nuclear security with the increasing use of computers, operational software and the Internet. The increasing application of computers and digital devices for the safety, security, monitoring and control functions of a nuclear facility necessitates their protection from the threat posed by cyber attacks. To guard against this threat, operators/organizations need to develop and implement a comprehensive cyber safety/security strategy, which should be based upon the assessments of the threats, plausible consequences, fault tolerance of the organization and its maturity *vis-à-vis* cyber security. It is understandable that the nuclear industry and regulators are not keen to engage in public discussion beyond a certain level, and that clear distinctions need to be made between state-sponsored cyber attacks, cyber attacks by organized criminals or terrorist entities, or hackers at various levels of expertise – though the consequences of successful cyber attacks might be similar.

It remains a matter of serious concern that states while promoting cyber security in general remain opposed to limiting their own options for cyber attacks on adversaries, or limiting cyber defense (active or passive) capabilities, etc. State sponsored cyber attacks against nuclear installations were pioneered by the US and Israel when they mounted cyber attacks against the Natanz uranium enrichment facility in combination with nuclear terrorism by assassination of four nuclear scientists.

With the expanded use of digital systems for nuclear power plant control systems, the likelihood of computer safety/security related incidents has increased in conjunction with an increase in the number of terrorist and criminal actors in developing cyber skills. In general, four global computer safety/security challenges in the civilian nuclear domain may be identified: (a) developing safe and resilient computer systems; (b) changing how we think about nuclear safety and nuclear security by integrating computer security in safety and security planning; (c) focusing on building effective computer security programs given the complexity and the many indirect interfaces with nuclear facilities; and (d) improving awareness and integration of cyber and physical security and determining the best way to share threat and computer security best practices internationally.

Cyber security in the civilian nuclear sector defined by the IAEA as the protection of confidentiality, integrity and availability attributes of electronic data, computer systems and processes, including the protection of those computer systems, networks and other digital systems that are critical for the safe and secure operation of the nuclear installation and for preventing theft, sabotage and other malicious acts involving computer systems.

Risk in the computer security context is the potential that a given threat will exploit vulnerabilities of an asset or group of assets and thereby cause harm to the nuclear installation. It is measured in terms of a combination of the likelihood of an event and the severity of its consequences. A threat and vulnerability assessment provides the basis for preparing the countermeasures required to prevent or mitigate the consequences of attacks against computer systems.

As in the case of nuclear security, an important tool commonly used to determine threat levels and as a basis for developing a security posture is the design basis threat (DBT). The DBT is a statement about the attributes and characteristics of potential adversaries (internal and/or external). A DBT is derived from credible intelligence information, but is not intended to be a statement about actual prevailing threats. Based on the current threat environment, the DBT represents the largest reasonable threat that a facility should expect to defend against. As for nuclear safety and nuclear security, human error is the main cause of computer security breaches. Recent estimates place the number of human error related breaches at 60%-80%; most of these errors could have been prevented with greater investment in awareness and greater diligence in operation and oversight. While sometimes the weakest link in the chain, the human operator or employee can be a stop-gate that prevents system failure or compromise. Technology can never be a complete solution. Employees are one of the layers of a defense in depth strategy for ensuring system security/survivability. Surveys regularly find that the foremost security issue is inadequate computer security awareness and training.

Reportedly cyber security incidents involving nuclear facilities have been occurring since 1990, these include:

- 1992: Ignalina Nuclear Power Plant (NPP) (Lithuania): a technician intentionally introduced a virus into the industrial control system, claimed this to highlight cyber security vulnerability;
- 1999: Bradwell NPP (UK): a security guard hacked into facility computers and deleted "sensitive data" that prompted a high-level security alert, shut down automatic access control system and locked all doors, however, no impact on the operational status of the NPP was reported;
- 2000: Kurchatov Institute, Moscow: US supplied software for tracking fissile material from dismantled nuclear weapons concealed or blocked data, and a US supplied update contained the same flaw (bug) but also allowed unauthorized access to the nuclear material;
- 2003: Davis-Besse NPP (US): infected by *Slammer* worm (*W32/SQLSlam-A* or *Sapphire*) that rapidly spread to computers exploiting vulnerability in Microsoft SQL 2000 database server software; this was introduced through a consultant's network which had an unreported back door connection to the NPP server, as a result the worm infected the corporate network of First Energy Nuclear (operator) and connected directly to the supervisory control and data acquisition (SCADA) system that could remotely monitor the plant without any type of firewall. As the NPP was in shut down status, there was no adverse impact;
- 2006: Browns Ferry NPP (US): malfunction of both reactor recirculation cooling pumps (that use variable-frequency drives to control motor speed) and condensate demineralizer controller (programmable logic controller); both devices used microprocessors to send and receive data over an Ethernet network; the network

produced excess traffic causing the reactor recirculation pumps and condensate demineralizer controller to fail. Since the NPP Unit 3 needed to be shut down manually, this incident was not characterized as a cyber attack *per se*, but revealed a vulnerability;

- 2008: Hatch NPP (US): an engineer, from the Southern Company contractor managing technology operations, installed an update to a computer on the plant's business network, this computer connected to the plant's ICS networks; the update was designed to synchronize data between the two computers; the updated computer restarted and as a result the synchronization reset the control system data to zero for a brief moment. The NPP safety system interpreted this temporary zero value of the water level to mean insufficient water to cool the reactor core, thereby NPP Unit 2 went into automatic shutdown (it took 48 hours for restart of the reactor);
- 2009/2010: Natanz Fuel Enrich Plant (FEP) and Bushehr NPP (Iran): the *Stuxnet* computer worm infected both facilities; the worm infected through USB flash drives, despite the system being "air gapped" (i.e., fully separated from the public internet); the result was to affect Siemens Step 7 SCADA (Supervisory control and data acquisition system) and the PLC (programmable logic controller) leading to the crash of an unidentified number of operating centrifuges;
- 2010: Unnamed Russian NPP: *Stuxnet* believed to have infected a Russian NPP during "the *Stuxnet* time" (2009-2010)?;
- 2014: Monju NPP (Japan): malware entered the ICS reactor control room computer which was accessed over 30 times in a few days by a cyber intruder; the intrusion was by an employee who updated a free video playback application running on one of the computers in the plant;
- 2014: Korea Hydro and Nuclear Power Co Ltd (KHNP): penetration by hackers to steal data;
- 2016: Gundremmingen NPP (Germany): *Conficker* and *W32.Ramnit* malware introduced into unit B computer network; *Conficker* rapidly spreads through networks and *W32.Ramnit* is a data stealer; this

malware was found on 18 removable data drives, mainly USB sticks, in office computers that were maintained separately from the plant's operating systems, but the malware infected system was utilized for the transportation of used reactor fuel to the warehouse; and

- 2017: Wolf Creek NPP (US): hacker penetration believed to be connected to ransom ware attacks; hackers sent emails with fake resumes attached to apply for engineering jobs; the documents carried cyber tools that would allow further penetration of the attacked computer networks; senior US intelligence and nuclear regulatory officials noted, however, that the overwhelming majority of US NPP reactors operate on analogue, not digital systems, making them less vulnerable to hacking attacks, "At most, the hackers might have been able to get the schedule for employee overtime," was stated by an official.

The IAEA has recommended that nuclear installations establish CERT (Cyber Emergency Response Teams) – these are integrated team(s) of nuclear plant personnel and cyber security personnel trained to isolate key control systems, install air gaps plus installed robust hardware-based isolation devices; and enhanced implementation of strict controls on use of portable media and equipment. In addition, the IAEA has called for Independent Engineering Review of Instrumentation & Control Systems (IERICS) that includes cyber security resilience and security by design.

Conclusion

The numbers of nuclear facilities and the quantities of nuclear material worldwide are a key component in assessing the global risk concerning nuclear safety and nuclear security. With regard to nuclear material, there are 454 operating power reactors in 30 countries producing 11% of the world's electricity (60 NPPs are under construction), and 225 research reactors remain in operation in 50 countries. In addition, under IAEA safeguards there are 18 conversion plants, 42 fuel fabrication plants, 10 reprocessing plants, 19 enrichment plants, 136 separate storage facilities and 74 other facilities under safeguards. Safeguarded facilities contain 208,889 Significant Quantities (SQ) of nuclear material. There are 641 Significant Quantities (SQs) of HEU and 11,233 SQs of separated plutonium (Pu) outside of reactor cores. Considerably more Pu is contained in irradiated fuel in reactor cores or in spent fuel. Global inventory of HEU is about 1,400 MT (1,400,000 kg) and 500 MT (500,000 kg) of plutonium, outside international accountancy, monitoring or control. In addition to the nuclear material stocks and nuclear facilities, there are transports carrying fresh and spent fuel, radioactive waste and other nuclear material. The total amount of spent fuel is estimated to be 400,000 tHM (tons heavy metal). To protect these facilities and this material from theft or sabotage present a formidable security challenge.

There also are a large number of radioactive sources in use or storage. The precise number is not known, but it is estimated that there are probably well in excess of 100,000 Category 1 and 2 sources and the number of Category 3 sources exceeds 1,000,000. In all, there may be over 3,000,000 sources worldwide. Many are not suitable for use in a simple radiological dispersal device (RDD) but estimates of how many might be used for malicious purposes are complicated by consideration of the disruptive and psychological effects of an RDD; immediate casualties and destruction are not the only considerations. There are, therefore, a large but unknown number of radioactive sources which could be used in an RDD. States participating in the IAEA Illicit Trafficking Data Base (ITDB) have reported 535 confirmed incidents involving radioactive sources since 1993. The large number of incidents indicates that measures to control sources are not adequate and that, for sources suitable for RDDs, security needs improvement.

While over the years the IAEA has put in place standards, recommendations and guidelines for nuclear safety and nuclear security, the global frameworks can be further improved and strengthened. Unlike the annual IAEA Safeguards Implementation Report (SIR) that provides information on safeguards implementation and challenges, there are no equivalent Nuclear Safety and Nuclear Security Implementation

Reports given resistance from states and nuclear industry. The reports on nuclear safety and on nuclear security provided by the IAEA to the General Conference (GC) in September every year review the actions and progress made in these areas based on the GC resolutions.

Thus, the IAEA Report on Measures to Strengthen International Cooperation in Nuclear, Radiation, Transport and Waste Safety provides information on implementation of the previous year's GC resolution and on other relevant developments in the intervening period but unlike the SIR it does not evaluate or assess states' implementation of the Agency's safety standards and related conventions.

Similarly, the IAEA's annual Nuclear Security Report provides information on activities undertaken by the Agency in the area of nuclear security, on the Incident and Trafficking Database (ITDB) and on past and planned activities of educational, training and collaborative networks, as well as highlighting significant accomplishments of the previous year within the framework of the Nuclear Security Plan and indicating programmatic goals and priorities for the year to come. Again, it does not evaluate or assess states' implementation of nuclear security guidance.

The human factor remains the weakest link in the chain of nuclear safety and nuclear security, as well as in computer/cyber security. The most dangerous and direct nuclear-weapon-use materials which are in the military fuel cycle remain outside international regulatory frameworks. It is regrettable that the so-called champions of nuclear security and nuclear safety remain adamantly opposed to placing these materials under any international regulatory framework but continue to increase the regulatory burden on nuclear materials in civilian use.

Though the IAEA promoted enhanced nuclear safety regulations following the Chernobyl accident, such as the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, and the Convention on Nuclear Safety and the so-called Joint Convention, no new international legal instruments were adopted after the Fukushima Daiichi accident.

First of all, the "accident state" failed to provide timely information on the accident to the Agency and continued to remain in an information deficit both to the IAEA as well as to its own public. Granted that the authorities were fully occupied in dealing with the accident as it evolved, nonetheless many IAEA member states, especially those in Japan's immediate neighborhood, vigorously complained about the lack of timely and accurate information. The report by the Diet, Japan's parliament, was highly critical of the authorities with regard to their conduct during and after the accident and of the regulator and the utility. In addition, many member states felt that the Agency failed to adequately deal with the Fukushima Daiichi accident in the first two weeks, including its failure to inform in a timely manner about the isotopic composition and quantities of nuclear fuel in the four reactor cores and the spent fuel in the ABWR reactor hall – information that the Agency already had in its possession; failure to discover in a timely manner a nuclear engineer on staff who was at the Three Mile Island NPP (Advanced Boiling Water Reactor, ABWR) during its accident in 1979; failure to put together an international expert accident remediation team; among other shortcomings as noted by several IAEA member states.

To further strengthen nuclear safety and nuclear security, the member states of the Agency need to support the implementation of an integrated 3-S nuclear regulatory approach that was proposed in the middle of the previous decade but opposed by certain states with large nuclear programs. 3-S would build on synergies and interfaces between safeguards, safety, security and liability for nuclear damage.

While IAEA safeguards are mandated by the NPT in non-nuclear weapon states, as noted above IAEA nuclear safety and nuclear security measures have not yet been accepted as binding by its member states – though for those states that have signed and ratified conventions, these becoming binding. The way forward for enhancing the nuclear safety and nuclear security frameworks could be to put in place an overall 3-S nuclear regulatory framework based on: *Safety* > focus: unintended conditions/events leading to radioactive releases from authorized activities, > response: engineered protections, safety management and regulatory oversight; *Security* > focus: intentional misuse of nuclear or other radioactive materials by non-state elements, > response: physical protection and law enforcement; *Safeguards and non-proliferation* > focus: restraining activities by states that could lead to acquisition of nuclear weapons, > response: international legal commitments, transfer controls and safeguards/verification. A 3-S framework also should include computer/cyber security measures.

V. THE IMPACT OF REGIONAL DEVELOPMENTS ON STRATEGIC STABILITY

5.1. STRATEGIC STABILTY AND THE "OTHERS"

***Robert Legvold*[1]**

Can strategic stability, a concept born of the nuclear competition between the United States and the Soviet Union during the Cold War, remain useful and relevant in a world of multiple nuclear actors – three of them (China, India, and the United States) engaged in three-way nuclear competitions? Even in the US–Soviet case, the concept, in the course of a long and slow gestation, never acquired full clarity or buy-in. Generally, it was seen to encompass both arms race stability and crisis stability. But the notion of arms race stability had no clear definition beyond a vague sense that the two countries ought to avoid an expensive and largely futile effort to outdo the other side's every move. At best it had a tenuous association with the sister concept of crisis stability to the extent that the reality that underlay the latter – that is, the near certainty that a nuclear assault on the other country would bring catastrophic devastation to one's own – made any sustained effort to escape it quixotic.

The notion of crisis stability eventually had a more precise meaning, but that meaning remained contested to the end. Once the two countries crossed the threshold banning full-scale national ballistic missile defense in 1972 and each side acquired nuclear forces capable of

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riding out a nuclear first-strike and delivering a devastating counterattack, crisis stability took on its peculiar and distinctly bleak meaning. It featured the disincentive to use nuclear weapons in a political-military confrontation, but out of a mutual recognition that any such use would assure the user's own destruction. Mutual assured destruction, or MAD as it is known, and its corollary, mutual vulnerability, however, were never fully or formally embraced by either government. These concepts persisted more as a reality with which the two countries lived than a guideline they enthroned.

Moreover, in both national defense establishments there were always those who thought it folly to accept the paralyzing implications of mutual vulnerability.[2] Throughout the Cold War and beyond, the US strategic arms community divided among those who never stopped believing the objective should be an ability to win a nuclear war; many, including key US officials, who believed the limited and "discriminate" use of nuclear weapons was possible, even necessary in a world of MAD; and those who believed any use of a nuclear weapons would inevitably escalate to MAD.[3] Russian defense planners yielded much more slowly than their US counterparts to the reality of MAD, but, even when yield they did, "this logic was only superficially accepted at top Russian state and diplomatic levels, and was never consistently incorporated into military programs."[4]

Thus, when wrestling with the role that strategic stability could or should play in a multidimensional multiplayer nuclear world, one starting point is a recognition that the concept as conventionally defined

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2 Milne C.R. Hope Springs Eternal: Perceptions of Mutual Vulnerability between Nuclear Rivals. Princeton Doctoral Dissertation (2018). Milne's dissertation, using additional archival material, is only the latest in a considerable literature that addresses the resistance to ideas associated with MAD. James Acton identifies some of this work in Reclaiming Strategic Stability. In E.A. Colby, M.S. Gerson (eds.). *Strategic Stability: Contending Interpretations*. Army War College Press, 2018. P. 145.

3 Colby E.A. Defining Strategic Stability: Reconciling Stability and Deterrence. In E.A. Colby, M.S. Gerson (eds.). *Strategic Stability: Contending Interpretations*. Army War College Press, 2018. Pp. 47-83. James Schlesinger, Richard Nixon's Secretary of Defense, for example, was in the second category, as is Colby himself, until recently in the Trump administration's Department of Defense.

4 Arbatov A. Challenges of the New Nuclear Era: The Russian Perspective. In L. Brooks, F.J. Gavin, A. Arbatov, *Meeting the Challenges of the New Nuclear Age: US and Russian Nuclear Concepts, Past and Present*. American Academy of Arts and Sciences, 2018. P. 39.

in the US–Soviet context never fully governed the thoughts of US and Soviet defense planners nor did it completely ensure crisis stability or arms race stability during those years. The other starting point is the prospect that for the concept to have any application in this new and more ramified nuclear environment, it may be best not to think of it as a single standard, but one whose content varies as needed in different contexts.

However, to assess the utility of the concept – whatever content it is given – an important distinction should be drawn. Strategic stability thought of as an outcome is not the same thing as strategic stability understood as a policy objective. To say that strategic stability exists or not in the relationship between nuclear powers differs fundamentally from saying nuclear powers are guided by a desire to create a strategically stable environment. The former more often than the latter has served as the touchstone for judging the relevance of the concept, but it may be the goal rather than reality that should be the focus. That is, the stabilizing effect that follows from an effort to enhance arms race and crisis stability may be more important than a reality that never quite arrives.

The criteria for what constitutes strategic stability framed either as arms race stability or crisis stability matter in defining the goal, but the more immediate and reliable benefit derives from the increased transparency, predictability, and trust produced by unilateral and mutual restraint exercised in pursuit of the goal. In short, were the criteria for strategic stability specified, agreed to, and achieved that would be ideal. More realistically the likeliest way to reduce the pathways to nuclear war – that is, to eliminate moments generating an incentive to use nuclear weapons and to diminish the risk of stumbling into nuclear war inadvertently – is by establishing strategic stability as the lodestar for the nuclear postures that countries adopt and the arms control efforts that they make.[5]

5 Indeed, Alexey Arbatov has argued that the Soviet and later Russian nod to strategic stability has been a byproduct of what strategic nuclear arms control agreements required, not fealty to a concept, and when the political context for arms control crumbles, so do Russian efforts contributing to strategic stability. Arbatov A. The hidden side of the US-Russian Strategic Competition // Arms

This happened at one point during the Cold War. In 1990 US and Soviet leaders agreed to guidelines for future nuclear arms control aimed at enhancing strategic stability.[6] In this document they pledged "to ensure strategic stability, transparency and predictability through further stabilizing reductions in the strategic arsenals of both countries." They would do this "by seeking agreements that improve survivability [of their nuclear weapons systems], remove incentives for a nuclear first strike and implement an appropriate relationship between strategic offenses and defenses." These and the other elements in their joint statement, including a commitment to exchange information on future changes to strategic forces, strong verification measures in prospective treaties, as well as steps "to reduce the possibility of an outbreak of nuclear war as a result of accident, miscalculation, terrorism, or unexpected technological breakthrough" then shaped the START I agreement signed a year later. When fully implemented in 2001, the treaty eliminated 80% of the world's existing stockpile of nuclear weapons.

START II, signed in 1993, banned multiple independently targetable reentry vehicles (MIRVs), giving pay to a portion of the Joint Statement that reflected the acceptance of MAD as the core principle sustaining crisis stability. It promised that "the two sides agree to place emphasis on removing incentives for a nuclear first strike, on reducing the concentration of warheads on strategic delivery vehicles, and on giving priority to highly survivable systems." START II, however, never came into force. Although the parliaments of both counties ratified it, Russia withdrew its signature in 2002 in response to the US abrogation of the ABM Treaty the previous fall. The 1972 decision to cut short a nuclear competition between offense and defense by concluding the ABM Treaty and the US–Soviet readiness to eliminate the most de-stabilizing counterforce weapon (MIRVed missiles) two decades later were the two most

Control Association. 2016. No. 9. Available at: https://www.armscontrol.org/ACT/2016_09/Features/The-Hidden-Side-of-the-US-Russian-Strategic-Confrontation.

6 Soviet-United States Joint Statement on Future Negotiations on Nuclear and Space Arms and Further Enhancing Strategic Stability. Office of the Press Secretary. June 1, 1990. Available at: http://www.presidency.ucsb.edu/ws/?pid=18541.

significant steps honoring MAD as the basis for Cold War crisis stability.

The two countries would later negotiate further reductions in deployed nuclear warheads (from 6,000 to 1,550) and launchers (from 1,600 to 700) in SORT and New START, which unquestionably contributed to arms race stability, but in 2001-2002, with the US abandonment of the ABM Treaty and the Russian repudiation of START II, the edifice sustaining crisis stability (understood as first strike stability, mutual assured destruction, and mutual vulnerability) lost its two key struts. Even if this survived as a formal concept, were it to remain a lodestar for policy, the agenda would have to change. A reopened competition between nuclear offense and defense together with technological advances posing a potential threat to the survivability of land-based nuclear forces dictated that. By 2010, when New START was finally signed, Russia and the United States were already a decade late in returning to the objectives outlined in the 1990 Joint Statement and giving them a fresh impetus.

Addressing a multipolar nuclear world

If the spider web of relationships that marks the new multipolar nuclear world is to be made safer, all of its nuclear pairings – some of them now threesomes – will need to take a page from this US–Soviet experience. These countries too will need to consider together what actions and mutual agreements could enhance strategic stability between and among them. They too will need to arrive at joint understandings that emulate the nature, if not necessarily the content, of that between the United States and the Soviet Union.

That the content of such an understanding, in fact, will likely differ from its US–Soviet counterpart brings us to my second starting point: no single standard for what constitutes strategic stability *qua* crisis stability seems possible in this new multipolar nuclear era. What the United States and the Soviet Union agreed upon cannot work – at least, not easily – in all other nuclear relationships for two primary reasons. First, the inequalities and asymmetries in many of these relationships preclude basing crisis stability on each side's assured large-scale retaliatory (nuclear) capability. As Michael Gerson has said of Thomas Schelling, one of the two principal authors of the US–Soviet concept of strategic stability, his notion was "not only having secure and survivable forces for retaliation, but also ensuring that the opponent was equally confident in his ability to retaliate."[7] Given the vulnerability of Pakistan's nuclear forces to Indian attack and, to a lesser degree, those of India to Pakistani attack, neither side can have high confidence in its ability to sustain a large-scale nuclear assault and retaliate with devastating nuclear force. The same will likely be the case in the incipient nuclear competition between India and China. And it is evidently a latent fear on China's part in the US–Chinese nuclear relationship. Indeed, recent US administrations have regarded a Chinese effort to achieve nuclear parity with the United States, were it to materialize, as undermining strategic stability.[8]

Second, when a bilateral nuclear competition becomes trilateral, strategic stability takes on the tremulous character of a desert mirage, depending on the angle from which it is viewed. For example, in the Indian–Pakistani context the rudimentary ballistic missile defense system that India has underway when Pakistan has none creates a potential challenge to crisis stability at one level. In the Indian-Chinese context when BMD is pursued by both sides, but one side – the Chinese – is more advanced, the potential challenge is at another level, particularly when the primary target of China's BMD program is not India but the United States. Indeed, what may contribute to crisis stability in one context – say, China and India's parallel commitment to a no-first use

7 Gerson S. The Origins of Strategic Stability: The United States and the Threat of Surprise Attack. In E.A. Colby, M.S. Gerson (eds.). *Strategic Stability: Contending Interpretations*. Army War College Press, 2018. P. 33.

8 Brad Roberts makes the point in both *The Case for US Nuclear Weapons in the 21st Century* (Stanford University Press, 2016). Pp. 208, 258; and in Strategic Stability under Obama and Trump // Survival. August 2017. No. 59:4. P. 50. Concomitantly officially the United States has long evaded telling China whether it accepts mutual vulnerability as a reality in their nuclear relationship, although Roberts reports that during the Obama administration, Deputy Secretary of Defense Robert Work, in a November 2015 speech, said: "A great power is a state that can take on the dominant power, the United States, conventionally, [and] has a nuclear deterrent force that can survive a first strike. Using that definition, [and referring to China] we have two great powers." (Ibid. P. 53.).

posture – can be undone by the pressure to abandon it in another – in the case of India with Pakistan; in the case of China with the United States.[9] Or one major nuclear actor (say, the United States) may take steps to deal with an outside nuclear threat (say, Iran and/or North Korea) that are not intended to affect strategic stability with a key nuclear competitor (say, Russia and/or China), but that it or they regard as a distinctly relevant threat to it or them.

Not only does this suggest the need for multiple versions of strategic stability adapted to different nuclear relationships, including trilateral relationships, but a different framework from the global bilateral framework inherited from the Cold War. Multiple versions of strategic stability as a *policy goal* may well begin with the same core objective as in the 1990 US–Soviet Joint Statement, *viz.*, to “remove incentives for a nuclear first strike,” but achieving this will require different steps in different contexts. Even striving for arms race stability as a component of strategic stability may require different inspiration in different settings.

A different framework from the global bilateral framework of the Cold War may well best be a regional framework, one that allows multilateral efforts cutting across multiple relationships. If so, the logical regional contexts are East Asia, Indo-Pacific, and Europe. It is there that the risk of accidental or inadvertent nuclear war through miscalculation or even deliberate use is most likely. But in each of the three regions the factors creating this risk vary. As a result, so do elements that need to be considered if enhanced strategic stability is the goal in each.

The East Asian context

Judged narrowly the starkest pathway to nuclear war, particularly inadvertent nuclear war, between the United States and China stems from China’s determination to extend its defense perimeter out across the East and South China Seas to the Philippine Sea. The weapons systems

9 For evidence that the fear already exists, see: Pradhan S.D. Growing Chinese Nuclear Arsenal: Is China Changing Its Doctrine? // The Times of India. 2018. 31 July. Available at: https://blogs.timesofindia.indiatimes.com/ChanakyaCode/growing-chinese-nuclear-arsenal-is-china-changing-its-doctrine/.

and strategy by which it is going about this (a so-called anti-access/area denial [A2/AD] posture), and the US response pose a challenge to crisis stability from two directions.

The first derives from the risk of "entanglement," that is, the entangling either of nuclear and conventional weapons or of one nuclear relationship with another in ways that increase the chance of an unintended nuclear conflict. In this case the danger arises from the lack of transparency around China's missile systems that can be armed with conventional or nuclear warheads and command and control systems that serve both, and that in a US–China military conflict could lead the United States to mistake one for the other. China's investment in anti-satellite weaponry (ASAT) on the assumption that early in a conventional military conflict with the United States it would want to cripple the means by which the United States communicates with its naval forces constitutes another threat of entanglement, because the satellites that would be attacked are also critical to US early warning of a nuclear attack.[10]

On the other side, early US plans to deal with the Chinese A2/AD challenge (the so-called Air-Sea Battle operational concept [ASB]) may have included plans to pre-emptively attack cruise missile sites and support facilities on China's mainland or, at a minimum, "to blind" the PLA's intelligence, surveillance, and reconnaissance assets (ISR), either of which would be escalatory, including potentially across the nuclear threshold. It is not clear if similar planning figures in the ASB's replacement, the Joint Concept for Access and Maneuver in the Global Commons (JAM-GC), but if it may, thinking about crisis stability in East Asia should start here as well as with the risks inherent in the Chinese posture.

10 There is a vigorous debate underway over whether China will any time soon have the capability to destroy early warning and communications systems that are in Geosynchronous Earth Orbit (GEO) and Highly Elliptical Orbit (HEO) at an altitude of 36,000 km – at least, on the scale needed. For the skeptical version, see, Sankaran J. Limits of the Chinese Antisatellite Threat to the United States // Strategic Studies. Winter 2014. Pp. 19-46. For the other side, see, for example, Geertz B. China's Great Leap in Space Warfare Creates Huge New Threat // Asia Times. 2018. 13 September. Available at: http://www.atimes.com/chinas-great-leap-space-warfare-creates-huge-new-threat/.

In tailoring strategic stability *qua* crisis stability to this region, therefore, one building block might be understandings by which China strove to mitigate the risks of entanglement and the United States offered evidence that in a crisis it did not intend to attack preemptively either Chinese air or cruise missile sites or its ISR facilities. Neither would be easy. China regards its lack of transparency and the ambiguity created by comingling and co-locating conventional and nuclear weapons as critical to nuclear deterrence. And to the extent that China relies on a lack of transparency as a safeguard allowing it to adhere to a minimum deterrence posture, it is a stabilizing factor. Nor, while the United States is in the early phases of developing the JAM-GC concept, is it clear that the combined US services know the scope of their joint operations or where limitations might be introduced, let alone conveyed.

But as both countries go forward with the modernization of their forces, the Chinese might weigh the advantages (in terms of crisis stability) of creating a clearer delineation between conventional and nuclear forces. The United States will presumably develop a more comprehensive and elaborate range of capabilities permitting it to carry out military operations in the seas of East Asia necessary to its security commitments without resorting to risky pre-emptive strategic targeting as an option. And, if crisis stability is the stake, both the United States and China should want to limit how far either goes in developing ASAT capabilities.

In the US–China relationship, however, the challenge to strategic stability also has a more abstract dimension that harks back to familiar concerns integral to the US–Soviet Cold War concept. Focusing on US plans for ballistic missile defense and conventional strategic strike weapons, as the Chinese do, implies that they do think of strategic stability as a function of how secure their second strike capability is. Engaging them on the subject, however, has been difficult. Signs are that they regard an effort to define strategic stability in the US–Chinese nuclear relationship as a trap intended to force them into greater transparency, while also accepting a narrow focus that evades their more basic security concerns.

As Brad Roberts has noted, China as well as Russia have come to view strategic stability as not only a matter of nuclear postures that imperil MAD, but a concept that needs to incorporate a broader range of "developments in the global power system that affect their expectations for armed conflict threatening to their vital or core interests."[11] If a "wider angle" sensitive to key geo-strategic trends is the prerequisite required for China, Russia, and the United States to engage the topic of strategic stability, it is doubtless still more essential in the Indo-Pacific context.

The Indo-Pacific context[12]

Elusive as it may be to broaden the criteria by which the concept of strategic stability is conceived to include the state of relations between and among nuclear actors – and, beyond that, the effects generated by their nuclear postures – it may be the only grounds on which India and Pakistan can hope to begin controlling their currently undisciplined nuclear competition and then contemplate steps that would create a safer environment for both. In this case, the issue is not framing a context permitting the sides to engage steps or deliberations leading toward strategic stability. It is facing the reality that, in the volatile and impacted character of relations between the two countries, avoiding nuclear war is far more a function of taking the steam out of the political relationship or, at a minimum, of preventing a military incident from exploding into something larger than of agreeing on a refined concept of strategic stability. There is, in fact, good reason to integrate broader thinking of this kind into all relationships – US–Russian, US–Chinese; and Indian–Pakistani. In all of them the level of tension, not the health

11 Roberts B. Strategic Stability under Obama and Trump… P. 18.

12 Although contested in some quarters, the notion of the Indo-Pacific as a strategic region has gained growing currency. To understand the basic contours of a multi-polar nuclear world it is essential. In part for that reason it is now a regular reference in Australian, Japanese, and Indian official discourse. The US Department of Defense in 2018 renamed its Pacific Command the Indo-Pacific Command. An excellent history of the term is in: Medcalf R. Reimagining Asia: From Asia-Pacific to Indo-Pacific. The Asian Forum. June 26, 2015. Available at: http://www.theasanforum.org/reimagining-asia-from-asia-pacific-to-indo-pacific/.

of concepts, is overwhelmingly decisive in determining the chances of pursuing a more stable nuclear relationship as well as the fate of arms control.

In the Indian–Pakistani nuclear relationship, including by extension the China dimension the most sensible way forward is suggested by the Stimson Center's "off-ramps initiative," generating a variety of ideas that were the three countries to pick and choose would in one respect or another partially defuse the risk of nuclear use.[13] The ideas range from an Indian agreement to forego the development of a ballistic missile defense system in exchange for a Pakistani commitment to shut down plans for MIRVed missiles to a trilateral Asian limited ABM agreement.[14] Some of the ideas are modest, such as the proposal to enhance the 1998 bilateral confidence-building agreement not to attack each other's civilian nuclear installations by including critical infrastructure as also off-limits.[15] Others are simply prudent, such as the establishment of a "hotline-plus" providing around the clock secure communications between the national and nuclear command authorities in the two countries.[16] None of these ideas is on a scale that would significantly mitigate, let alone eliminate either the risk of inadvertent nuclear war or the deliberate use of nuclear weapons. But each, particularly if in combination with others, constitutes a confidence-building measure that weakens the level of political tension that forms the context for a nuclear tragedy.

13 The full list can be found at: https://www.stimson.org/content/off-ramps.

14 The author of the latter idea fully realizes the many obstacles that would have to be overcome, including the US dimension of China's stake in BMD. He writes: "This chain reaction [India reacting to US inspired Chinese BMD efforts] can only be avoided if Washington makes explicit and iron-clad, if not treaty-bound, commitments about its strategic posture in the region. An example of such a commitment could be a unilateral undertaking by Washington that it would not seek to undermine the Chinese deterrent through its missile defense deployments in the region." Happymon J. Time to Consider a Trilateral Asian ABM Treaty. Stimson Center. September 5, 2017. Available at: https://www.stimson.org/content/time-consider-trilateral-asian-abm-treaty.

15 Dalton T. Modernize the South Asia Nuclear Facility "Non-Attack" Agreement. Stimson Center. June 28, 2017. Available at: https://www.stimson.org/content/modernize-south-asia-nuclear-facility-non-attack-agreement.

16 Hannah H.I. A Hotline between National and Nuclear Command Authorities to Manage Tensions. Stimson Center. August 8, 2018. Available at: https://www.stimson.org/content/hotline-between-national-and-nuclear-command-authorities-manage-tensions.

The most substantial of these ideas, however, underscore the intricacies that make contemplating strategic stability in a multilateral setting or envisaging concrete steps leading in this direction so difficult. China, India, and Pakistan are all in the early phases of developing and deploying MIRVed land-based missiles, a ban on which when at this vulnerable stage would seem to be a stabilizing step. China's program, however, is not designed for India, but for the United States. Unless the United States were to remove China's reasons for heading down this path, the likelihood of which is nonexistent, the idea is stillborn. Even a less ambitious parallel proposal runs into the same paralyzing linkages. In three of five critical pairings – India–Pakistan, China–Russia, and the United States–Russia – the sides have agreements requiring prior notification of ballistic missile tests. One benefit of which is to reduce the chance that a missile launch will be mistaken for the start of an actual attack. Frank O'Donnell has proposed that the five countries merge these agreements into a larger enhanced agreement committing each to notify in good time the other four of not only planned ballistic missile tests but of nuclear-capable cruise missile tests as well.[17] Useful as this might be as a stabilizing measure in the Indo-Pacific region, it, as he acknowledges, immediately runs aground over China's refusal to deal with India as peer nuclear rival and engage with it in a discussion of risk-reduction and confidence-building measures or in a larger strategic dialogue.

The European context

The critical nuclear relationship in the European regional context embodies at once the original foundation for the concept of strategic stability and, in this new nuclear era, a reason to rethink that concept. The Cold War, whose central theater and critical stake was Europe, was nonetheless a global contest, engulfing the entire international political system and constituting a permanent face-off between two nuclear superpowers. In this transcendent circumstance the protagonists defined

17 O'Donnell F. Launching an Expanded Missile Flight-Test Regime. Stimson Center. March 23, 2017. Available at: https://www.stimson.org/content/launching-expanded-missile-flight-test-notification-regime.

the problem in apocalyptic terms. Thus, thoughts of strategic stability were first born of the fear on each side of a surprise disarming nuclear strike by the other, which over time evolved into a preoccupation with a large-scale counterforce war. Basing strategic stability on mutual confidence in each side's ability to ride out a massive nuclear attack and retaliate with devastating nuclear force may have made sense in this context, but does it in contemporary European conditions? Or, conceived in these terms, is it too remote and unrefined to obstruct what are today the pathways to nuclear war in Europe?

It is a measure of how much the broader geopolitical landscape that determines the risk of nuclear war has deteriorated that such pathways exist in a way that ten years ago or even five years ago they did not. The points of potential conflagration are easily identified (Ukraine and other unstable areas on the Russian border) and so too the process leading to trouble (the recrudescence of a military confrontation on a new central European front moved closer to Russia). At this level the first step toward crisis stability is reducing the risk of a crisis. That means political choices on all sides that impede the slide toward violence. But it also includes strengthening risk-reduction and confidence building measures, and here, unlike in the other two regions, the parties have experience in negotiating both conventional arms control and CBMS, and, in the Vienna Document and Open Skies Treaty, they have instruments on which, with political will, they can build.

But the concept of strategic or crisis stability (understood as reducing to a low probability the prospect that nuclear weapons will be used in a political-military crisis) needs to address those realms where threat assessment and nuclear weapons come together. One such is the dangerous intersection between the US and NATO fear that Russia's growing A2/AD capabilities will undermine their ability to defend the eastern reaches of the alliance and Russia's increasing preoccupation with US plans for "air–space war" in any future conflict. The weapons systems and operational adjustments that each side is making to deal with its respective fears increase the chance of inadvertent nuclear war.

As a result, at this level, crisis stability in Europe depends on the two countries recognizing the potential hazards in the way each is framing the problem and the weapons choices and operational concepts they are making in response. This doubtless begins with ensuring that strategic decision-makers in both countries, when acting, factor in the escalation risks inherent in their approach to the challenge they see.[18] That awareness will be sounder and more compelling if generated in a direct dialogue between the two sides focused on their respective concerns. These, given the weapons systems and operational concepts capable of producing the miscalculations and misreading leading to inadvertent nuclear war, would presumably include the planned use of non-nuclear weapons, including boost-glide vehicles, against strategic targets, the co-locating of nuclear and general purpose forces, and dedicated anti-satellite weapons designed to destroy satellites in geosynchronous earth orbit and highly elliptical orbit. By this measure, crisis stability in Europe will emerge from the tradeoff between, on the one hand, an awareness of and readiness either unilaterally or by mutual agreement to reduce the most serious escalation risks raised by particular weapons systems, nuclear postures, and operational concepts, and, on the other hand, the felt need for the same weapons, postures, and concepts as essential to effective deterrence. Crisis stability will depend on whether the balance struck significantly reduces the chance of inadvertent nuclear war or, to the contrary, favors it.[19]

Can there be multilateral strategic stability?

In April 2016 the US International Security Advisory Board (ISAB) issued a report prepared at the request of Rose Gottemoeller, the Undersecretary of State for Arms Control and International Security, on "The Nature of Multilateral Strategic Stability." The board's task had

18 These escalation risks, as part of the related threat from "entanglement," are well-discussed in Acton J.M. (ed.), Arbatov A., Dvorkin V., Topychkanov P., Zhao T., Bin L. *Entanglement: Russian and Chinese Perspectives on Non-Nuclear Weapons and Nuclear Risks*. Carnegie Endowment for International Peace, 2017.

19 The Russian and Chinese authors in the Acton volume, *ibid.*, underscore that thinking in these terms will not be easy, since neither Russian nor Chinese defense planners take seriously the idea of inadvertent nuclear war.

been to consider "conceptual frameworks" that might extend "strategic stability beyond the US–Russia Cold War construct" to a world of multiple nuclear actors.[20] The study group concluded that no over-arching concept of what it called "multi-national strategic stability" made sense. Rather, if strategic stability was thought of as reducing "the chances that tensions lead to nuclear war, whether by deliberate decision or unintended escalation," multilateral strategic stability can only be the product of the sum of efforts in critical pairings, and now three-way nuclear relationships, in pursuit of this goal.

To this end the group recommended a set of "characteristics and practices" that, were all nuclear weapons-possessing states to embrace them, would presumably render key bilateral relationships safer and thereby enhance global security. The characteristics and practices were divided into four categories: policy and doctrine; force structure and posture; safety (reducing the risks of nuclear accidents); and security (securing weapons and materials against unauthorized access).[21] The suggestions under each ranged from the practical to the ideal. For example, under the first category, policy and doctrine, they extended from specific mechanisms to "help avoid miscalculation" to ensuring that nuclear forces and command and control are survivable; from disallowing the pre-delegation of release authority to eschewing the use of nuclear forces other than only as a last resort and in extremis. Under the second category, force structure and posture, the suggestions again included both the thinkable and the remote – from avoiding deployments of nuclear weapons, "especially in forward areas, in ways that could lead to a 'use-or-lose' situation" to ensuring that all have a secure second strike capability; from limiting the scale of ballistic missile defense systems to wanting an adversary to have conventional forces adequate to "successful conventional defense."

In a polyglot world of nuclear powers it may make sense to settle for a general set of "characteristics and practices" that, if adopted by key

20 The unclassified summary is: Report on the Nature of Multilateral Strategic Stability. International Security Advisory Board. April 27, 2016.

21 Ibid. Pp. 4-7.

players, would contribute to strategic stability in critical pairings and, therefore, to global security. But as a starting point to base these characteristics and practices on an extension of the "US–Russia Cold War construct," as the ISAB does, may not. Again, that construct featured crisis stability as first-strike stability, and the echo of that in the report's first two categories of characteristics and practices creates standards in other than the US–Russian and perhaps US–Chinese relationship that are at best impractical and at worst illusory.

May it not be better to think in terms of an approach tailored to the diverse aspects of contemporary nuclear reality? First, to recognize that it is better and more realistic to focus on strategic stability, particularly crisis stability, as a policy goal rather as real only when attained. Second, to move away from the over-arching bilateral framework that marked the concept of strategic stability during the Cold War and still does today to one focused on contrasting realities in the different dimensions, particularly geographical regions, of this complex multipolar nuclear world. And, third, to fashion a notion of strategic stability suitable to each of these dimensions by concentrating on highest probability pathways to nuclear war in each, and then considering what would be necessary to impede them.

Not that this approach would be any easier or more assured of success than the one urged by the ISAB or others that might be imagined. It, like all others, will remain hostage to two larger preconditions. First, whether the level of tension and rivalry in key relationships allows or disallows the parties to focus on the threats to strategic stability – however defined – and take steps to mitigate them. It is worth noting, however, that even modest steps in the nuclear sphere, including minor confidence building measures, can help ease tension and over time contribute to a political context more favorable to more fundamental levels of cooperation.

Second, whatever the context – conceptual, political, or practical – progress in defining what strategic stability means in a multipolar nuclear world and designing an approach or approaches fostering it cannot go far unless the United States and Russia joined by China are in the lead. As long as the United States and Russia are waging their new Cold War and, in the process, dismantling what nuclear safeguards they have negotiated over the last 50 years rather than focusing on the complex challenges of a new multipolar nuclear era, and as long as China views itself as free of responsibility for helping to shape this era, the odds that strategic stability can be achieved or even enhanced in any particular relationship, let alone more broadly, seem slim. Still, this does not exempt those in the analytical community in all the nuclear states, including members of the Luxembourg Forum, from striving to conceive a safer nuclear world, including the role that the concept of strategic stability should play in it.

5.2. THE IRANIAN NUCLEAR PROBLEM: PAST, PRESENT AND FUTURE

Vladimir Sazhin[1]

Key milestones in the development of Iran's nuclear capabilities

Iran's nuclear program is over 60 years old. Nuclear research began thanks to the initiatives of the Shah of Iran, Mohammad Reza Pahlavi, as part of plans to turn the country into a major world power.

In the mid-1950s, an Atomic Center was opened at Tehran University.

In 1957, Iran and the USA signed an Agreement for Co-operation Concerning Civil Uses of Atomic Energy. Under the terms of this document, Washington committed to provide Iran with nuclear facilities and equipment, and to train specialists.

In 1958, Iran became a member of the International Atomic Energy Agency (IAEA).

In 1963, the country signed the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water.

In 1970, it acceded to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

From 1967 to 1977, not just the USA, but also France, the United Kingdom, Italy, Belgium and West Germany were actively involved in the nuclear energy development program in Iran.

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In the 1970s, Iran acquired process equipment for enriching uranium and manufacturing fuel cells, and began implementing its nuclear energy program. In 1975 the German firm Kraftwerk Union started construction work on a nuclear power plant 15 km from the city of Bushehr. The plan was for 6-8 reactors to be supplied by the USA and a further 12 – by West Germany and France.

The Islamic Revolution of 1979 shattered all of Iran's nuclear plans. After taking power, the leader of the Islamic revolution, Ayatollah Khomeini, immediately halted construction of the near-complete nuclear power plant in Bushehr and expelled all foreign nuclear specialists from the country. Hundreds of Iranian scientists and engineers emigrated.

The Iran-Iraq war that began in 1980 postponed the decision to restart the nuclear program. However, the Iraqi army's use of chemical weapons against the Iranians forced the Iranian leadership to consider weapons of mass destruction.

Iran drew up a secret directive, signed by former President Ali Akbar Hashemi Rafsanjani, stating that nuclear weapons represented a strategic guarantee for the maintenance of the Islamic regime in Tehran. The directive included the following points: all available means were to be used to acquire the necessary technology to manufacture nuclear weapons; specialists were to be despatched to various countries to collect the necessary information and penetrate nuclear and technological centers to gather intelligence; and secret nuclear centers were to be established: facilities intended not just to complement one another, but also to operate autonomously.

In this way, in the mid-1980s, the program was relaunched – in secret and without IAEA oversight.

In 1985, uranium deposits were discovered in Iran's Yazd Province (with ore quality in line with international standards).

In 1989, an agreement was signed with Pakistan on co-operation regarding uranium centrifuge enrichment. And, just a few years later, with the help of the father of Pakistan's nuclear bomb, Abdul Qadeer

Khan, 500 R-1 centrifuges were purchased in Pakistan and brought to Iran. Technical documentation on the separation of uranium isotopes was also purchased.

Iran's nuclear program developed in two directions. Firstly, Iran's nuclear energy ambitions: to establish in the future several nuclear reactors at nuclear power stations, including in Bushehr, under strict IAEA oversight. This aspect of the program was, and still is, public.

In the early 1990s, there was an increase in Iranian–Russian co-operation on peaceful uses of atomic energy. In 1992, Moscow and Tehran signed an agreement on co-operation regarding the peaceful use of atomic energy and the construction of a nuclear power plant on Iranian territory. Under the 1995 agreement, a contract was signed whereby Russia would complete work on the first reactor in Bushehr (it was launched on 12 September 2011). Currently Russia is building two further reactors at Bushehr.

The second aspect of the nuclear program consisted of a concerted effort by Tehran to establish its own full nuclear fuel cycle, and first and foremost to build industrial infrastructure for enriching uranium. To this end, in recent years, Iran has established major nuclear facilities – there are 27 officially registered locations alone. Many aspects of their work were kept secret even from the IAEA (or there was insufficient transparency).

Of course, such major projects could not remain secret for long. As early as in 1996, CIA staff uncovered evidence that Iran was implementing a secret military nuclear program.

The tensions surrounding Iran's nuclear program reached their peak in 2002, when a representative of the People's Mujahidin Organization of Iran, which opposes the Tehran regime, made a statement revealing Iran's underground nuclear activities at facilities in Natanz and Arak.

In December 2002, photographs of the facilities emerged in the press. As was noted in a report by the Institute for Science and International Security (ISIS), the facilities under construction are dual-use and could be used to produce nuclear weapons.

Grueling negotiations on the Iranian nuclear program

In 2003, talks began with Iran on the “nuclear dossier.” They continued for over 12 years. Initially, they included Iran and three European countries – Germany, France and the United Kingdom. In 2006, China, Russia and the USA joined them. The resulting group of countries, the P5+1, worked to persuade Iran to suspend its uranium enrichment efforts, which could pose a threat to the non-proliferation regime.

In 2003, Iran signed the Additional Protocol to the Nuclear Non-Proliferation Treaty. However, to this day, Iran still has not ratified the document, which gives the IAEA greater access to nuclear facilities and enables unannounced inspections. Nonetheless, Tehran fulfilled its terms until 2006, and has done so again since 2016.

In November 2004, under pressure from the international community, Tehran announced it would suspend its efforts to enrich uranium.

When he came to power in 2005, President Mahmoud Ahmadinejad undid all the positive aspects of what had been done for Iran’s nuclear program thanks to agreements with the international community.

At the start of 2006, Iran restarted nuclear research. In August 2006, Iran’s first heavy water manufacturing plant entered service (part of the nuclear complex in Arak).

In September 2009, Iran sent official notification to the IAEA that it was starting construction work on the Fordow Fuel Enrichment Plant near to the city of Qom. The IAEA demanded a halt to construction work. However, in response, the Iranian government decided to restrict its co-operation with the IAEA and announced plans to build dozens of other plants around the country.

On 11 February 2010, Iranian President Mahmoud Ahmadinejad announced that the centrifuges at the Natanz nuclear center had produced their first batch of uranium enriched up to 20%, and that Iran had the capability to produce uranium with a higher enrichment level still.[2]

2 Nuclear era. Part 10. Topwar. February 3, 2016. Available at: https://topwar.ru/90076-yadernaya-era-chast-10-ya.html.

In August 2011, IAEA experts carried out an inspection of Iran's main nuclear facilities. Based on the outcome of that inspection, it was announced that Iran had continued work on technologies that could be used to produce a nuclear weapon.

The country had pursued its nuclear ambitions unabated, acquiring modern uranium enrichment technologies and increasing the number of operating centrifuges. Whereas in the early 2000s, Iran only had 164 centrifuges, by 2015, this number had increased to nearly 20,000. Furthermore, the quality and capacity of the centrifuges had improved.

In response to this behavior, the international community stepped up pressure on Iran, demanding full transparency regarding the nuclear program and proof of its exclusively peaceful intent. The United Nations Security Council adopted six resolutions, four of which brought in a sanctions regime. Unilateral sanctions by the USA and EU cut Iran off from the world financial system and significantly restricted Iran's oil exports. The Iranian economy slid into a state of crisis.

Against this backdrop, in 2012, secret talks began between the USA and Iran. These did not make substantive progress until August 2013, with the election of Hassan Rouhani as the new Iranian president. He made seeking a resolution to the nuclear issue his central foreign policy priority.

On November 24, 2013, Iran and the P5+1 signed an interim accord known as the Joint Plan of Action, which provided for reduced sanctions in exchange for restricting the Iranian nuclear program. The parties needed another twenty months to finalize all the details of the document. This was due to the complexity of the problem, and the fact that certain forces within Iran and on the international arena were unhappy with the proposed agreement.

On July 14, 2015, the USA, Russia, China, France, the United Kingdom, Germany and the European Union – known as the P5+1 – and Iran agreed upon the Joint Comprehensive Plan of Action (JCPOA, also known as the "Iran agreement" or "nuclear deal"), with the aim of putting an end to the confrontation surrounding Tehran's nuclear program.

Iran's nuclear capacity prior to the JCPOA

Over the course of more than 60 years, Iran had chalked up significant achievements in the nuclear sphere. The Iranians had established research and production that enabled them to create nuclear infrastructure for the full nuclear fuel cycle (NFC), starting with extraction of uranium ore and going right through to the storage of nuclear waste.

The nuclear fuel cycle involves a series of technological manufacturing processes to produce nuclear fuel for a nuclear power plant, followed by the storage of the spent nuclear fuel, in the case of an open nuclear fuel cycle, or, in the case of a closed nuclear fuel cycle, by its reprocessing for further use.

In 1989, it was announced that Iran had found ten sites with uranium deposits that were suitable for uranium ore mining. The largest of them was in Yazd province. The Saghand, Narigan and Zarigan mines were built there. The largest of these – Saghand – contains in the order of 3,000 to 5,000 tons of uranium oxide at a density of nearly 500 parts per million over an area of 100 to 150 square kilometers.

The second major uranium ore deposit is concentrated in the southern province of Hormozgan, not far from the city of Bandar Abbas. The Gachin mine is located there. The uranium ore is extracted through surface mining.

The manufacturing plants near the mines house hydrometallurgical works (enrichment plants with mills) to separate the ore form the surrounding rocks and carry out the first stage of ore processing.

Close to the uranium ore deposit in Yazd province, an enrichment plant is located in the city of Ardakan. The facility is designed to produce 50 tons of uranium per year. The Gachin mine supplies a hydrometallurgical plant capable of processing 21 tons of uranium per year.

Then, the final product of the hydrometallurgical plants – triuranium octoxide (U3O8), known as "yellowcake" – is sent to a conversion facility built in 2005 in Isfahan. There, using a special technological process, the triuranium octoxide is converted into uranium hexafluoride

(UF6)[3] – the basis for separating isotopes U-235 and U-238 using gas diffusion methods and enriching the uranium.

The next step in the nuclear fuel cycle is the uranium enrichment process. To carry out this process, from 2000 to 2011, two major centers were established in Iran: in Natanz (Isfahan province) and Fordow (near to the city of Qom, the capital of the province of the same name).

The production complex in Natanz is the largest gas centrifuge uranium enrichment plant in Iran. It has two main parts: an experimental plant, which entered service in 2003, and an industrial plant that started operations in 2007. The latter is made up of two underground reinforced concrete complexes, each divided into eight units. The plant is reliably protected from airstrikes. Its reinforced concrete roof is several meters thick and covered by 22 meters of earth.

In total, Natanz is designed to house 54,000 centrifuges.[4] By 2015 there were approximately 17,000 centrifuges of various generations and modifications at Natanz.

The enrichment facility in Fordow consists solely of underground industrial plants embedded in the rock at a depth of 80-90 meters. It has two units, each housing 8 centrifuge cascades. By 2015, it had a total of 16 cascades containing 2,710 centrifuges.

In Natanz and Fordow, the vast majority of the centrifuges are first-generation IR-1, a copy of early Pakistani P-1 centrifuges. As well as these, more advanced IR-2M centrifuges have also been installed at these industrial facilities. Their output is 3-5 times higher. The Iranians have also developed even more advanced centrifuge models: IR-4, IR-5, IR-6, IR-7, IR-8 and modified versions thereof. However, these models have only been tested as part of small experimental cascades or as individual machines.

Industrial models of the Iranian centrifuges are grouped into

3 Uranium hexafluoride is a chemical compound of uranium with fluorine (UF6). It is the only highly volatile uranium compound (when heated to 53°C, it immediately turns from a solid to a gas state) and it is used as a raw material for separating isotopes uranium-238 and uranium-235 using gas centrifuge technology and obtaining enriched uranium.

4 Natanz Uranium Enrichment Plant. PIR-Center. Available at: http://www.pircenter.org/sections/view/section_id/141.

cascades, usually with 164-174 centrifuges in each cascade.

The production facilities in Natanz and Fordow were sufficient to produce around 11 tons of 5% enriched uranium (metal equivalent), and around 302 kg of uranium enriched to approximately 20% (metal equivalent). Over half of such uranium is produced at Fordow, and the rest at the experimental plant in Natanz.[5]

Iran's full nuclear fuel cycle is completed by its underground disposal sites for nuclear waste. Such waste disposal sites are located in the city of Anarak in Isfahan province.

Uranium has historically been the main focus of Iran's nuclear activities. Nonetheless, the Iranians have not rejected the plutonium option.

In 2004, on the outskirts of the city of Arak (Markazi province), construction work started on a 40MW IR-40 heavy water reactor. Its launch was planned for 2014. As is well-known, heavy water reactors can be used to turn uranium into plutonium, which can be used in nuclear weapons without further enrichment.

According to specialists, given ideal operating conditions, based on its technical specifications, the IR-40 reactor would be capable of producing up to 10 kg of weapons-grade plutonium. This is equivalent to the quantity of fissile material required for approximately two plutonium-based nuclear warheads, depending on the design of the weapon and processing losses.[6]

It should be emphasized that Iran planned to build a reprocessing plant to extract plutonium from fuel irradiated in the IR-40 reactor. The Iranians explained that this was required to produce medical isotopes, but the IAEA raised the question of the plutonium that would inevitably be produced by the reactor in some quantity and quality. In response, Tehran claimed that its goal was not to extract plutonium, and that, in its opinion, the plutonium produced would not be weapons-grade.

5 Shulga I. The Persian Atom. Atomniy expert. Available at: http://atomicexpert.com/page232270.html.
6 Albright D., Hinderstein C. Iran, Player or Rogue? // Bulletin of the Atomic Scientists. 2003. No. 59:5. Pp. 52-58.

However, as specialists have claimed, in a reactor of this design, the quality of the plutonium, which is defined by the isotope ratio, depends on the reactor operating modes used – and in certain fuel cycles the reactor could be used to produce weapons-grade material in large quantities.

Similar reactors, comparable with the IR-40 in terms of power and design, were at the origin of the nuclear weapons programs of countries like Israel and India. So Iran's plans to build a radiochemical plant with hot cells (chambers with manipulators used for working with radioactive substances) gave rise to objections from the IAEA.

Hot cells can be used to isolate plutonium. In Iran, according to the IAEA's data, a plant was being built adjacent to the Arak reactor with hot cells of unknown production capacity in order to separate radioisotopes.[7]

To support the IR-40 reactor, also in Arak, a heavy water production plant capable of producing 16 tons per year had been built. (To launch the reactor, 80 or 90 tons of heavy water were needed). By 2015, Iran had produced and accumulated 131 tons of heavy water.

The turbulent 60-year history of Iran's nuclear program has been based on targeted, well-organized scientific research. The country has established dozens of major research institutes, laboratories and experimental facilities.

The Tehran Nuclear Research Center (TNRC) is Iran's leading scientific research body in the nuclear field. It brings together several laboratories and research and development facilities.

The TNRC started operations in 1968 subsequent to the installation of an experimental American 5 MWt reactor.

A laboratory at the TNRC produces radioisotopes of molybdenum, iodine and xenon from naturally-occurring uranium oxide irradiated in the reactor. There is also a facility for producing concentrated uranium ore (or "yellowcake"). In 1992, the Jabir ibn Hayyan Multipurpose Laboratories began operation. The complex includes a laser laboratory.

7 Implementation of the NPT Safeguards Agreement and Relevant Provisions of Security Council Resolutions in the Islamic Republic of Iran. GOV/2010/46. IAEA. September 6, 2010.

According to specialists, at the TNRC, Iran engaged in many activities that were not declared to the IAEA.

Since 2002, the TNRC has run the laser center in Lashkar Ab'ad (close to Parchin, 25 km north-west of Tehran), where there was a pilot plant for laser uranium enrichment under the AVLIS program (this type of enrichment does not require bulky centrifuges). In 2008, the IAEA noted that the center's laser equipment had been dismantled, but some of it remained in storage onsite.

The Isfahan Nuclear Fuel Research and Production Center was established in 1974 to provide scientific and technical support to the national civilian nuclear program. After the Islamic revolution of 1979, the center started operating again in 1981 thanks to the assistance of Chinese specialists. Beijing helped to equip the nuclear research center. In 1997, a miniature Chinese 27 MWt (thermal) zero-power heavy water reactor was purchased for it. The center specializes in developing engineering, technical and scientific capabilities to build industrial facilities for atomic energy, including the development of fuel elements for nuclear power stations – nuclear fuel rods.

The center oversees a radiochemical plant and a plant producing zirconium fuel rod claddings in Isfahan.

The Lavizan-Shian Physics Research Center (near Tehran) was founded in 1989. The center's main task was to "prepare for engagement in military action and the minimization of [combat] losses in the case of a nuclear strike or incident at a nuclear facility, as well as to carry out research work for the ministry of defense." In 2002, the Applied Physics Institute was located at the site. Iran allowed IAEA inspectors access to the site in 2004, indicated that 11 types of work were being carried out at the site, and permitted the inspection of two whole-body radiation counters that had previously been installed at the facility. However, it refused to supply a full equipment list. According to the Iranians, there was no radioactive material at the site and no work relating to the nuclear fuel cycle was carried out there.

The Agriculture and Medicine Center in Karaj. Iran initially stated that the Karaj center mainly focused on agricultural research, which, it was claimed, had nothing to do with work relating to the nuclear fuel cycle. In October 2003, when Iran declared the existence of its laser enrichment program, it stated that in May 2003, it had moved laser enrichment equipment from Lashkar-Ab'ad to Karaj. This material included uranium metal and a large vacuum chamber with the appropriate equipment. Mass spectrometry equipment used for carrying out nuclear research with lasers was also stored at Karaj.

The Karaj Nuclear Research Center for Medicine and Agriculture. Two laboratories were set up – a dosimetry laboratory and an agricultural radiochemical laboratory. In 1995, work to build a cyclotron was completed. An electromagnetic separator for isolating non-radioactive (stable) isotopes was purchased from China. Its purpose was to obtain materials for targets which were to be irradiated with neutron beams.

The Yazd Nuclear Research Center. Its main specialization is geophysical and geological research into Iran's uranium deposits. IAEA inspectors have not uncovered any unlawful activities at this facility.

The nuclear research centers in Bonab and Ramsar. The first of these specializes in the use of radioactive isotopes for the preservation of foodstuffs, while the second carries out research into naturally occurring radiation above average levels. The Bonab facility is located in the mountains 80 km from Tabriz (in north-western Iran). The Ramsar facility is located on the banks of the Caspian Sea to the north of Tehran. The IAEA did not find any undeclared or covert nuclear activity there.

The Companies Farayand Technique, Kalaye Electric and Pars Trash. In 2003-2004, IAEA inspectors found new areas irradiated by highly enriched U-235 (to 36%, which is far higher than the 2-3% level needed for a nuclear power plant), as well as uranium enrichment centrifuges obtained from Pakistan, on the site of the company Farayand Technique. As for the Kalaye Electric facility (purportedly a watch factory in Tehran), during a full-scale inspection in 2003, inspectors also found traces of enriched uranium there and established that one of the buildings had been entirely rebuilt. Iran declared that Kalaye Electric had become the main center for developing and testing IR-1 centrifuges after this work was transferred from the Tehran Nuclear Research Center in 1995.

The IAEA stated that in 1997-2002, Iran had assembled and tested IR-1 centrifuges at Kalaye Electric. Iran used 1.9 kg of imported, undeclared uranium hexafluoride to test centrifuge machines at the company's workshops from 1999-2002, before dismantling the centrifuge test facility in late 2002.

However, even after much of the research and development work on centrifuges had been moved to Natanz, Kalaye Electric remained an important scientific research center for centrifuge development.

Parchin is a military production facility. According to western intelligence agencies, Iranian specialists at Parchin carried out research as part of the military component of their nuclear program to simulate the implosion of a detonating nuclear charge. The technical challenge lies in ensuring that the conventional explosive which surrounds the uranium core ignites evenly.[8] This is the only way to start a chain reaction in the core. A series of tests were then carried out with a warhead that had an aluminum casing – everything was "real" except the core. Instead of fissile material, the Iranian technicians had inserted a fine-fiber mass and a set of sensors. This made it possible to measure the force of the blast and record flashes of light on photographic film in a reasonably accurate imitation of the job done by the detonator of an atomic bomb. Such research had, in the opinion of western intelligence agencies, taken place a fairly long time ago, and it was unlikely that the IAEA inspectors would manage to find any traces of the tests. The task was made all the more difficult by the fact that the Iranians had on several occasions carried out renovations and construction.

8 Implosive detonation involves compressing fissionable material using a focused blast wave created by detonating chemical explosives. Devices known as explosive lenses are used to focus the blast wave. The detonation takes place simultaneously, and with great precision, at multiple points. This happens thanks to the detonator wiring: each detonator assembly is connected to the surface of the sphere by a network of explosive-filled grooves. The shape of the network and its branches is designed so that at the end points, the blast wave reaches the centers of the explosive lenses simultaneously through openings in the sphere.

As well as the main nuclear facilities in Iran, the country also has small- and medium-sized private companies that fulfil specific orders, sometimes even without understanding their end purpose. It should be noted that the Iranian nuclear program is overseen by the Islamic Revolutionary Guard Corps.[9]

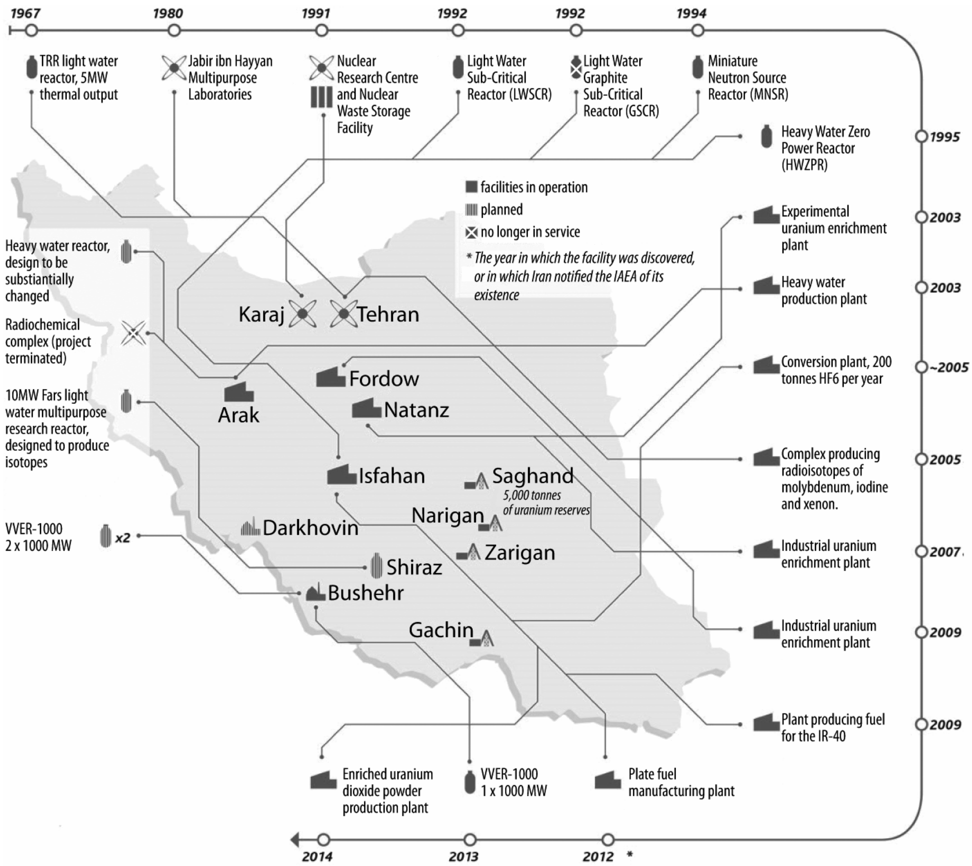

Figure 2. *Iran's main nuclear facilities and year of entry into service.*[10]

9 For more detail on the Islamic Revolutionary Guard Corps, see: Sazhin V.I. The Islamic Revolutionary Guard Corps are a state within a state // Kontury global'nykh transformatsii: politika, ekonomika, parvo. 2017. No. 10(3). Pp. 83-109.

10 Shulga I. The Persian Atom…

Could Iran have built an atomic bomb?

According to the IAEA, during November 2013,[11] Iran bred 10,357 kg of uranium enriched up to 3-5%, of which 7,154.3 kg were warehoused. The remainder was subjected to further processing. 410.4 kg of 20%-enriched uranium was also produced, of which 196 kg were warehoused. The remainder was processed further. On average, Iranian nuclear production bred over 200 kg of 3-5%-enriched and 15 kg of 20%-enriched uranium per month.

It is notable that Iran's reserves of enriched uranium in November 2013 would have been sufficient, if further enriched, to serve as the basis for producing five nuclear devices.[12] Typically, there are four stages of uranium enrichment. The first is up to 3-5%, the second – up to 20%, the third – up to 60%, and the fourth – up to over 90% (which is weapons-grade uranium). However, after each stage, the volume of enriched uranium significantly decreases. Thus, according to calculations by Mark Fitzpatrick, the head of the Non-Proliferation and Nuclear Policy Program at the International Institute for Strategic Studies in London, the 3,917 kg of yellowcake would only produce 37 kg of 93%-enriched uranium after the various stages of enrichment.[13] Using this calculation method, we can see that all the enriched uranium held by Iran in 2013 could have been used to produce around 120 to 130 kg of 93%-enriched uranium, which would have been precisely enough for five nuclear devices.

The then US Director of National Intelligence, James Clapper, noted that the production volumes of enriched uranium in Iran in 2012 were already more than three times higher than the volumes identified prior to the Stuxnet virus attack that had hit Iranian nuclear sites and other

11 IAEA Report on the Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran: Note by the President of the Security Council. S/2013/668. The United Nations Security Council. November 29, 2013. Available at: https://www.securitycouncilreport.org/atf/cf/%7b65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7d/s_2013_668.pdf.

12 Iran Has Enough Uranium for 5 Bombs: Expert // Reuters. 2012. 26 May. Available at: http://www.reuters.com/article/2012/05/26/us-nuclear-iran-uranium-idUSBRE84O0SN20120526.

13 Iran's Nuclear, Chemical and Biological Capabilities: A Net Assessment. The International Institute for Strategic Studies. 2011. P. 73.

facilities in 2010. "Based on the findings of the International Atomic Energy Agency (IAEA), it is clear that Iran could produce a nuclear weapon very quickly should it wish to do so," said Stephen Rademaker of the Bipartisan Policy Center in Washington.[14]

Iranian physicists have so far (to their regret) not been able to obtain high-purity uranium hexafluoride, which is the substance that is enriched in the centrifuges. And at each stage of enrichment, the purity requirements increase. This has clearly delayed Iran's progress in producing highly enriched uranium.

Of course, even 90%-enriched uranium is not, in itself, an explosive device. It is a gas that cannot be used to make an atomic bomb. To make such a bomb, uranium gas needs to be put through a fiendishly complex technological process consisting of at least four or five stages. As a result, the gas turns into a metal which is used to make a nuclear weapon. And specialists doubt that Iran had the advanced technologies and chemically pure substances necessary to convert uranium from a gas state into high-quality metal.

As early as in 2012, prominent Israeli politician Avigdor Liberman said: "If we take together the opinions of all the independent experts and institutes, then a realistic estimate is that Iran will need 10-14 months to get its hands on all the components".[15]

However, "all the components" are not the same thing a bomb, either – less still a warhead for a missile. Iran does not have warplanes capable of carrying nuclear bombs. Therefore, it is developing a missile program with the aim of "combining" it with the nuclear program – and this is an extremely complex technical and technological problem. Solving it will require multiple breakthroughs, many of which depend on more than just the will of those working to build nuclear missiles in Iran. On the basis of these considerations, one could say that the

14 Iran could accumulate sufficient material to make a nuclear weapon within 4 months, say experts // Finmarket. 2012. 21 June. Available at: http://www.finmarket.ru/z/nws/news.asp?id=2965697.

15 Iran could obtain all the components for a nuclear bomb as early as next year, insists Israel // Iran News. 2012. 21 June. Available at: http://www.iran.ru/news/politics/81397/Iran_mozhet_poluchit_vse_komponenty_dlya_yadernoy_bomby_uzhe_v_sleduyushchem_godu_nastaivayut_v_Izraile.

timescales of 84 weeks (Mark Fitzpatrick)[16] or a year (Avigdor Liberman) are again the results of a purely mathematical approach without bearing in mind the full range of external and internal factors at play. We should recall that Pakistan needed around 10 years to go from its first test of a nuclear device to the construction of a nuclear warhead for a missile.

That said, many of the tasks involved in building a weapon can be carried out in parallel and, in part, in secret, which significantly speeds up the whole process. As Gary Samor, a US specialist in weapons of mass destruction emphasized, the timescales of the ultimata issued to Iran by Israel and the USA were essentially dictated by "politics, and not physics." In other words, the actual status of Iran's nuclear program was the last thing to be taken into account. In fact, the "physics" would have provided quite enough time for dialogue – until Tehran took a political decision on the issue.[17]

By all appearances, such a decision was taken. And the evidence of this is to be found in what was known as the Amad project: a secret scientific research area with the goal of building a nuclear warhead for a ballistic missile. The project was established in 2000, although other information does exist indicating that its inception was in 1989. This seems closer to the truth, as shortly before this, Iran drew up a secret directive on nuclear weapons as a strategy for ensuring the continued existence of the Islamic regime.

The Amad project was led by Mohsen Fakhrizadeh-Mahabadi. Work was carried out from 2002 at the physics research center in Lavizan-Shian, as well as at other facilities, including Parchin.

According to the IAEA, the Amad project was suddenly halted in late 2003 after an order to that effect was received from high-ranking Iranian officials. However, initially, the staff working on various research and development projects related to Amad presumably continued to work in

16 Iran's Nuclear, Chemical and Biological Capabilities. A net assessment… P. 72.

17 The West should step up work with Russia on the crises around Syria and Iran – Western experts // Regnum. 2013. 2 April. Available at: http://www.regnum.ru/news/polit/1643734.html.

order to make records and report on the results obtained up until that point. After that, in the period from the end of 2003 until the start of 2004, both the equipment and the workplaces of the staff involved in the project were destroyed in order to leave as few traces as possible that might have hinted at the "delicate" nature of the work that had been carried out. In other words, since 2003, Iran has not had a military nuclear program.

Incidentally, it was the IAEA that was the main source of evidence on the Amad project, as it published a detailed 12-page document on the 'Possible Military Aspects' of the Iranian nuclear program at the end of 2011.

Israel insists that the military element of the Iranian nuclear program still exists. Whether that is the case or not is difficult to say. However, in its recent reports, the IAEA rejects this claim.

Nonetheless, in any case, the Iranian program has given rise to justified concern. The nuclear policies of the administration of radical former Iranian President Ahmadinejad (2005-2013), his confrontation with the international community, and his unwillingness to implement the resolutions of the highest international body – the United Nations Security Council – posed a real threat to global and regional security. And the issue was not even Iran itself. Evidently, in purely military terms, Iranian military power (and the country is genuinely powerful in regional terms), based on its capabilities – and above all its high-tech capabilities – is incomparable with the might of leading world powers. Tehran understood this well. The threat posed by a nuclear Iran was something else.[18]

Firstly, the Iranian example of establishing a national nuclear infrastructure capable of producing not just fuel for nuclear power plants, but also weapons-grade uranium or plutonium, could serve as inspiration to more than a dozen other countries – so-called threshold states – many of which are already or could in future become parties to regional conflicts and, because of this, would not rule out taking the political decision to create their own nuclear weapon. And this would threaten the prospect of the practically uncontrolled usage of nuclear weapons

18 Yevseev V.V., Sazhin V.I. *Iran, uranium and missiles*. Moscow: Institute of the Middle East, 2009. P. 272.

by medium-sized and small countries of what used to be known as the "third world." If events were to take such a turn, we could expect that, if not the whole world, then some of its regions – primarily the Near and Middle East – would be thrown into a state of chaos: nuclear chaos.

Secondly, with the uncontrolled proliferation of nuclear weapons, especially in the Middle Eastern region, the prospect of these weapons or their components falling into the hands of terrorist groups could not be ruled out, which could lead to catastrophic consequences. For terrorists do not have anything to lose (industry, a country, or a population), the threat to which would serve as a deterrent as it did in the cases of the nuclear confrontations between the USSR and the USA, Pakistan and India, or India and China.[19]

Thirdly, the presence of nuclear weapons in Iran, or even the real possibility of their construction in relatively compressed timescales, would make the country's leadership even less compliant and more assertive in its interactions with its regional neighbours. As a result of this, the atomic bomb could be used for blackmail to help Tehran pursue its policy of bringing to life the doctrinal precepts and commandments of Ayatollah Khomeini. This is something that Iran's Arab neighbours in the Persian Gulf are extremely afraid of.

Given this, it is fair to say that the Joint Comprehensive Plan of Action adopted by Iran and international mediators in 2015 represented a crucial milestone on the path to mitigating the nuclear threat emerging from Iran.

The Joint Comprehensive Plan of Action

The Joint Comprehensive Plan of Action (JCPOA) adopted in Vienna on July 14, 2015 by the P5+1 international mediators and Iran was, in all probability, the only way to finally resolve the Iranian nuclear problem.

19 Ganiev T.A., Bondar Yu.M., Tolmachev S.G. *Analysis and prognosis of the military and political situation in foreign countries. The Islamic Republic of Iran*. Moscow: Military University of the Ministry of Defense of the Russian Federation, 2011.

The document (or nuclear deal) significantly restricts, reduces and reforms Iran's nuclear infrastructure, its development program, its stockpiles and the quality of its nuclear materials. It also forbids any activities that could be potentially military in nature.

Under the JCPOA, Iran must co-operate with the IAEA to address past and present outstanding issues, provide the IAEA with additional monitoring opportunities and access to any suspicious facilities, and inform the Agency of stockpiles of natural uranium and centrifuges. For 15 years, any international co-operation in the nuclear domain may only proceed after approval by a specially convened Joint Commission.

On July 20, 2015, the United Nations Security Council adopted a resolution in support of this document. Under its terms, Iran commits to have no more than 300 kg of uranium enriched to 3.67% for 15 years. Tehran will not produce the highly enriched uranium or weapons-grade plutonium needed to build a nuclear weapon. The uranium enrichment plant at Fordow will be repurposed into a technological center. Furthermore, the nuclear complex in Arak will be used for solely peaceful purposes. In addition, all spent fuel from Arak will be shipped abroad for as long as the reactor operates. IAEA experts will monitor the nuclear facilities for 25 years. If the agreement is honored, all international sanctions against Iran will be lifted in 10 years.

The implementation of these measures practically rules out the construction of an Iranian nuclear weapon for the next 10-15 years, as well as any significant clandestine military activities.

On January 16, 2016, Iran was freed from most of the international sanctions that had been imposed upon it. The IAEA presented a report confirming the readiness of the country's authorities to implement the program that had been put together for them during the lengthy negotiations to significantly reduce the country's nuclear capabilities. Later, the EU and USA confirmed that they had lifted economic and financial sanctions that had been imposed on Iran in connection with its nuclear program. This allowed Iran to expand its co-operation with foreign countries on various projects, including the Iranian nuclear program. The Iranian economy started on a path to intensive growth.

The fight for the JCPOA

In spite of US President Donald Trump's harsh pronouncements on the JCPOA, the world hoped that the USA would not exit the nuclear deal. But, alas, Trump struck a blow that could in the long term lead to catastrophic consequences.

The USA's allies – the United Kingdom, France and Germany – the three European members of the P5+1 who pursued tough negotiations with Iran and together with it achieved a genuine success – support retaining the JCPOA, as do the Russian Federation and China.

On September 24, 2018, on the margins of the 73rd Session of the United Nations General Assembly in New York, there was a meeting of the Ministers for Foreign Affairs of the signatories to the JCPOA on the Iranian Nuclear Program (except the USA). Consultations took place attended by the head of the Iranian foreign ministry and co-ordinated by the European Union's chief diplomat Federica Mogherini.

In particular, the joint statement on the outcome of the ministerial meeting states: "The JCPOA participants reconfirmed their commitment to its full and effective implementation in good faith and in a constructive atmosphere. They recalled that the JCPOA is a key element of the global non-proliferation architecture and a significant achievement of multilateral diplomacy endorsed unanimously by the UN Security Council through Resolution 2231."

"The participants recognized that Iran has continued to fully and effectively implement its nuclear-related commitments, as confirmed by twelve consecutive reports by the International Atomic Energy Agency, and reiterated the need to continue to do so. Participants will continue to support the modernization of the Arak research reactor as part of the JCPOA and the conversion of the Fordow facility into a nuclear, physics and technology center. Participants also reaffirmed their support for projects in the area of civil nuclear co-operation on the basis of Annex III of the JCPOA," stated the official document.

"The participants recognized that, alongside implementation by Iran of its nuclear-related commitments, the lifting of sanctions, including the economic dividends arising from it, constitutes an essential part of the JCPOA. […] Participants underlined their determination to protect the freedom of their economic operators to pursue legitimate business with Iran, in full accordance with UN Security Council Resolution 2231," underscored the statement.

In the joint statement, the participants in the meeting also declared that, in the interests of preserving the nuclear deal (which is impossible without countering the USA's anti-Iranian sanctions), the EU will establish a financial mechanism for transactions with Iran, circumventing American sanctions. It was also emphasized that companies that co-operate with Iran will be protected from secondary sanctions by the USA.[20]

We should recall that from the very beginning, the new master of the White House, Donald Trump, was harshly critical of the JCPOA and promised that the USA would withdraw from the deal.

The US president found several main "flaws" in the JCPOA. Namely: the lack of provision for international inspectors to inspect absolutely all facilities, including military sites; the lack of guarantees that Iran would never be able to obtain a nuclear weapon; the limited timescale of the JCPOA to 10-15 years; and the failure to prohibit Iran from producing ballistic missiles capable of carrying a nuclear weapon. In addition, Trump accused Tehran of expansionist endeavours in the Middle East.

These "flaws," Trump demands, must be compensated for in additional agreements to complement the JCPOA. But to what extent do Trump's demands on Iran comply with international legal texts?

On inspections of nuclear activities. Under IAEA provisions, every member of the Agency signs a Safeguards Agreement with the Agency, giving the IAEA the right and obligation to carry out inspections in order to obtain convincing evidence that declared nuclear material is being used by a given country for solely peaceful ends. The Additional Protocol to this Agreement also ensures that a state that has signed a Safeguards Agreement with the IAEA does not have any undeclared

20 Iran. European Union. Foreign economic relations, politics. Iran.ru. September 25, 2018. Available at: https://polpred.com/?ns=1&ns_id=2739941.

nuclear materials or activities. Furthermore, Agency inspectors have the right to announce unplanned inspections and visit any site declared by that country as a nuclear facility.

Since January 15, 2016, Iran has voluntarily fulfilled the requirements of the Additional Protocol. (Iran signed the Additional Protocol in 2013, but the Majlis has not yet ratified it). However, this in no way means that Iran is obliged to make all facilities – even non-nuclear sites – available for inspection.

Guarantees that Iran will never be able to obtain a nuclear weapon can only be given by almighty God: not even the Nuclear Non-Proliferation Treaty (NPT) could ensure this. And the NPT, which was drawn up in the late 1960s, is, alas, imperfect. But who could have predicted 60 years ago that more than 30 nations worldwide would become "threshold" states, in other words, be ready to build, if not nuclear weapons themselves, then at least the infrastructure to make them? However, the issue of modifying the Treaty is not currently on the agenda.

Indeed, the NPT allows any country to develop nuclear technologies for peaceful purposes. This includes establishing a full nuclear fuel cycle, from the extraction of uranium ore to its processing and enrichment, and manufacturing nuclear fuel. And the line between solely peaceful and military is an extremely blurred one. Oversight of all nuclear processes is the very reason why the IAEA's rules were written, placing countries with a nuclear ambition on a short leash. However, countries that are genuinely desperate to get the atomic bomb have a way to do so: leaving the IAEA. This is what North Korea did. In 1974, North Korea joined the IAEA, and in 1985 it signed the NPT. Then, once it had established nuclear infrastructure, it left the Agency in 1994. Fortunately, Iran plans to withdraw neither from the NPT, nor from the IAEA. For the time being. As long as the NPT, the IAEA, and, most importantly, the JCPOA, suit it.

As for the timescales of the JCPOA, in the view of the parties that set them during the nuclear negotiations with Iran, they are entirely sufficient in order to bring the Iranian nuclear program into line with IAEA requirements. An indefinite JCPOA would, according to specialists, run entirely counter to the NPT, which, as was said previously, supports the peaceful development of a nuclear program by any country.

It is worth noting that Iran has repeatedly stated that if all parties conscientiously implement the JCPOA, then Iran will make it the permanent basis for its nuclear activities.

And Trump's final (if this is, indeed, his final) gripe with the JCPOA is with regard to the Iranian missile program. As is universally known, the JCPOA contains no references whatsoever to a prohibition on missile tests, while Resolution 2231 only makes an appeal to Iran to refrain from missile-related activities.

Of course, if we are to be objective, then Iran's missile program could give rise to concerns – especially in around 10-15 years' time, when the JCPOA will cease to apply. For long-range missiles and nuclear weapons are two sides of the same coin: one is not possible without the other. However, in legal terms, these two issues cannot be confused. As EU High Representative for Foreign Affairs and Security Policy Federica Mogherini noted, work to neutralize the Iranian missile program should be dealt with separately from the implementation of the nuclear deal.

The question of Iran's missile program can only be discussed and resolved in the format of special international talks (naturally, involving Iran) and with United Nations approval. There is no doubt that the Iranian missile program should under no circumstances destroy the long-awaited and exceedingly hard-won nuclear agreement with Iran.

Indeed, the JCPOA is not an ideal deal. Indeed, it includes aspects that give rise to questions about Tehran's future nuclear capabilities. Indeed, the JCPOA does not entirely destroy Iran's nuclear infrastructure or knowledge base. And indeed, the JCPOA does not cover issues that are not nuclear-related.

But where in international diplomacy can we find an ideal bilateral or multilateral deal? There is always a compromise between the differing, sometimes opposite, interests of the parties, who nonetheless strive honestly and sincerely to find a positive resolution to a given problem.

So it is entirely appropriate to characterize the JCPOA as a crucial historical document – perhaps the first (aside, of course, from the NPT) since the start of the nuclear era in 1945 – to rein in the nuclear ambitions of a specific state and bring its nuclear program into line with the strict requirements of international law and IAEA regulations. It is a clear example of effective international diplomacy, setting a precedent for genuine trust between the parties in order to maintain the nuclear non-proliferation regime. The JCPOA could become a model for the diplomatic settlement of regional and international crises.

However, President Trump, stubborn in his rejection of the Islamic Republic of Iran, has rejected the views of all of those who insisted on preserving the JCPOA – even when they were his own advisers and allies. Playing on what he claimed were the “flaws” with the nuclear deal, on May 8, 2018, US President Donald Trump announced the US’ withdrawal from the JCPOA and the renewal of the sanctions regime against Iran.

On August 7, 2018, the US initiated the first anti-Iranian sanctions package, including restrictions on the purchase of Iranian cars, gold and metals. The sanctions also affected Iranian companies specializing in aluminum, graphite, coal, steel, and those producing computer programs for industrial applications.

On November 4, 2018, a new sanctions package will be launched, striking a blow to the Iranian energy sector – primarily the oil and gas sector (and related industries), as well as to the Iranian banking system, by targeting large transactions.

This is undoubtedly a serious attack on the Iranian economy. From 2011 to 2016, when similar international sanctions took only a few months to reach their peak, they brought the country to the verge of economic collapse. Today, however, the situation is rather different. The anti-Iranian sanctions declared by Trump are no longer international.

Back then, because of Tehran's "nuclear" intransigence, nearly the whole world stood against it. Today, Trump's anti-Iranian initiative garners no support. The White House can only hope to exert financial and economic pressure on those rebels and contrarians who do not wish to join its campaign against Iran.

Of course, the USA has major financial and economic power and is capable of meting out punishment to any business that might dare to retain or develop its connections with Iran. The Americans are creating a dilemma for major national and transnational companies: either you support the anti-Iranian sanctions and continue to operate on the American and world market, or you choose Iran and leave other markets. It is clear what these companies will choose – major private companies will go where it is most profitable for them to be. With the sword of Damocles (in the form of indirect US sanctions) hanging over them, they prefer Washington: therefore, even before the entry into force of the second, harsher sanctions package, many business players are already leaving the Iranian market.

The European Union is, in its efforts to save the JCPOA, doing everything it can to oppose US pressure.

On August 7, 2018, just after US sanctions were brought in against Iran, the EU adopted what is known as a blocking statute, nullifying American sanctions against Iran on EU territory, and banning European companies from complying with them, or with any rulings by foreign courts based on these sanctions.

The entry into force of this statute also allows all European entities to go to the courts to seek compensation for losses caused by the enforcement of the sanctions from the "person causing them" (meaning the US government).

At the end of August, the EU started discussions aimed at establishing a payment system independent of the USA that would protect European businesses from American sanctions against Iran. The central banks of France and Germany may be involved in the project. As was noted above, back in September, the founding fathers of the JCPOA (apart from the USA, of course) announced in New York that practical efforts were underway to establish such a mechanism.

Furthermore, at the end of August, the European Commission (EC) approved a financial aid package to Iran worth €50 million to address "key economic and social problems" in Iran. The first tranche of €18 million is intended "for projects in support of sustainable economic and social development in the Islamic Republic of Iran," including €8 million of assistance to the private sector. Assistance to the private sector includes assistance for Iranian small and medium-sized enterprise, the development of selected value chains, and technical assistance to Iran's Trade Promotion Organization. The sums are small, but this is an important step.

The EU will support Iran for as long as the country remains committed to "full and effective" implementation of the agreements reached in the nuclear deal, part of which is the lifting of the sanctions, according to the European Union's executive body.

President Trump is placing United Kingdom, France and Germany (and not just them) under extreme pressure to force everyone to follow Washington's orders: to modify the JCPOA or withdraw from it.

If the Americans successfully crush the opposition of the three nations above, then the deal will fall apart. Given that Iran opposes any changes to the text or new talks on its nuclear program, the option of reaching additional agreements can also be ruled out. That means that the only option left will be the collapse of the JCPOA. But there is hope (albeit slim) that the US will fail to pressurize the Europeans and that the situation will end with only the USA withdrawing from the deal. In that case, the JCPOA can be preserved as Iran is, apparently, willing to fulfil all of its obligations if the other parties to the deal, except the Americans, continue to adhere to it. That said, there is no consensus on this issue in Iran, and high-ranking officials express differing opinions on various issues, including on withdrawal from the JCPOA in the event of full collapse of the nuclear deal. The Supreme Leader of Iran, Ayatollah Khamenei, is pessimistic. On August 29, 2018, he stated that Iran should let go of any hope that the Europeans might save the nuclear deal. Furthermore, he added two important things: firstly, that the JCPOA is not a goal in itself, but a means to an end, and that if Iran discovers that the Plan no longer reflects its interests, then Tehran will abandon it. And secondly, Iran does not intend to engage in negotiations at any level with the USA on a new agreement because of the USA's "lack of honesty."[21]

Consequences of the collapse of the JCPOA

The collapse of the deal risks significant negative consequences in international political, legal, economic and military terms.

Its collapse represents a blow to the UN and the United Nations Security Council: in Resolution 2231 of July 20, 2015, which was adopted unanimously, the Security Council approved the JCPOA and stated that its full implementation would contribute to international peace and security. The Resolution underscores that the members of the United Nations are obliged under Article 25 of Chapter 5 of the UN Charter to "accept and carry out the decisions of the Security Council in accordance with the present Charter."

The destruction of the JCPOA also strikes a blow to the international nuclear non-proliferation regime. The JCPOA can be described as a landmark document – the second most important text after the Nuclear Non-Proliferation Treaty – making a major practical contribution to non-proliferation. It has proved in practice that it is possible to rein in the nuclear ambitions of individual countries. If the deal collapses, then several "windows of opportunity" will open up for the approximately 30 threshold states that are prepared to build their own nuclear weapon. North Korea will hardly be likely to believe the USA and agree to fulfil any obligations to limit its nuclear and missile programs.

The collapse of the JCPOA is also a blow to the USA's image – after withdrawal from the JCPOA, it has turned itself into an extremely unreliable participant in international politics and international law.

21 Iran: Khamenei prêt à se retirer de l'accord nucléaire de 2015 // Le Figaro. 2018. 29 August. Available at: http://www.lefigaro.fr/flash-actu/2018/08/29/97001-20180829FILWWW00153-iran-khamenei-pret-a-se-retirer-de-l-accord-nucleaire-de-2015.php.

The collapse of the JCPOA is also a blow to the economy of the European Union. Since the start of the process of removing the previous sanctions against Iran, the EU has been working actively to tap into the Iranian market. Iran's trade with EU member states over the 11 months to November 30, 2017, was worth nearly €18.56 billion – an increase of 57% in comparison to the same period in 2016.[22] The EU has fairly ambitious plans with regard to Iran.

The collapse of the JCPOA is a blow to Iran's president, Hassan Rouhani. The JCPOA is a major victory for the Iranian president, the foundation and the essence of his politics. Rouhani is a deal-making politician who has succeeded in opening up Iran to the entire world.

Rouhani has many political opponents in Iran who are very powerful and who, from the very beginning, opposed the agreement or even negotiations on the Iranian nuclear program. For this reason, the collapse of the nuclear deal could lead to a crisis for Rouhani's government, which could change Iran's domestic politics and foreign policy alike. The extreme radicals focused around the Islamic Revolutionary Guard Corps and Rouhani's opponents could take real power in Tehran. For them, there is simply no question of talks with the USA.

If Rouhani's pragmatic politics come to an end, this could lead to major problems, something that is in the interest neither of the Middle East nor of the wider world.

The destruction of the JCPOA is a gift to radical fundamentalist conservative forces within Iran. They now have genuine hope of pushing out President Rouhani's team and turning the clock back 5-10 years to a stern confrontation with the whole world, first and foremost with the West, while restarting Iran's nuclear program in order to build a nuclear weapon.

Astonishingly, US President Trump and his diplomacy are now playing into the hands of these Iranian radical forces.

The destruction of the JCPOA would lead to an escalation of tensions in the Middle Eastern region and worldwide. An Iran that withdraws

22 Iran's trade with EU member states grew by 57%. Analitikaua.net. January 25, 2018. Available at: http://analitikaua.net/2018/tovarooborot-irana-s-gosudarstvami-chlenami-es-vyiros-na-57/.

from the nuclear deal will, doubtless, resume its nuclear program with even greater fervor than prior to the JCPOA, but without IAEA oversight and without giving a second thought to international agreements or negotiations. Of course, Iran will not be able to re-establish its full nuclear capacity in two weeks, as Tehran so loudly, and clearly propagandistically, threatens. However, considering that work under the JCPOA to decommission Iran's nuclear infrastructure is far from complete and the main facilities and equipment still exist, it would be entirely realistic for the Iranians to return their nuclear program to its 2015 status within six months to a year. Undoubtedly, the nuclear capacity that has existed in one form or another to date can be turned into Iranian nuclear might.

If that happens, an Iran that has re-established and resumed its nuclear program will become an even more unacceptable prospect for the USA, Israel, Saudi Arabia, and its other adversaries than it was prior to the JCPOA.

This would be a path to a new spiral of confrontation with Iran, something that could not only create economic losses, but also lead to the real possibility of an armed conflict capable of blowing up into a large-scale war.