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Proceedings of the XXII Edoardo Amaldi Conference, Accademia Nazionale dei Lincei, Rome, Italy, April 6–8, 2022

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Preface I

In 1980, the US National Academy of Sciences established CISAC (Committee on International Security and Armament Control), to open bilateral contacts with an analogous group at the Soviet Academy of Science. Among CISAC components there was Wolfgang Panofsky, eminent physicist, founder and first director of the Stanford Linear Accelerator Center.

In January 1986, the CISAC meeting on International Security and Armament Control was extended beyond the limitation of a direct link between the USA and the USSR. The possibility of establishing in Europe a group of scientists with a role analogous to CISAC was discussed. As a consequence, in 1987, Edoardo Amaldi sets up SICA (a working group on International Security and Arms Control), at Accademia dei Lincei.

A first informal Workshop was held in Roma, Lincei 23–25 June 1988 under the title *International Security and Disarmament: The Role of the Scientific Academies.* A second meeting followed in 1989.

On 5 December 1989, while preparing the third Meeting, Edoardo Amaldi, then President of Accademia Nazionale dei Lincei, unexpectedly died. The third meeting was held few months later, in June 1990, under the Chair of Giorgio Salvini who had succeeded Amaldi at the Presidency of Lincei. The title was: *Security in Europe and the Transition Away from Confrontation Toward Cooperation.* Participants to the third meeting decided to dedicate future meetings to the memory of Edoardo Amaldi, hence the name Edoardo Amaldi Conferences.

From 1991 to 2011, the Edoardo Amaldi Conferences have been regularly held at Lincei and elsewhere in Europe, essentially as triangular meetings involving scientists from Europe, the United States and URSS, later the Russian Federation. In 2015 and 2017, with the support of Ministero degli Affari Esteri, Edoardo Amaldi Conferences have been extended to important participation from Countries in the Middle East and Asia (China, Egypt, India, Israel, Iran, Japan, Pakistan). SICA (Accademia dei Lincei) and CISAC (US National Academy of Sciences) have Coorganized the 21th and the present, 22nd editions.

As in the past, the 22nd Edoardo Amaldi Conference provides a forum where eminent scientists, diplomats and policymakers will be able to compare national

perspectives and international collaborations. It is a badly needed occasion, given that the past five years have seen a dramatic escalation in the danger of nuclear conflicts. The Conference updates us about the situation on the critical areas (Iran, India-Pakistan, North Korea) and on the important treaties that will come under discussion in the near future, Non-Proliferation, Prohibition of Nuclear Weapons.

The international panorama has worsened considerably after the unilateral denunciation of the US Administration of the Iran agreement (JCPOA) and the cancellation of the USA-Russia treaty on intermediate range missiles (INF, Intermediate-range Nuclear Forces). Difficulties in the periodic, five year, review of the Non-Proliferation Treaty have arisen, due to disagreements between Nuclear Weapon States and Non-Nuclear Weapon States about how to make progress in the reduction of nuclear armaments.

The only positive light has come from the renovation of NewSTART (STrategic Arms Reduction Treaty) between Russia and US, March 2021, that indicates the willingness of the two signatories to consider fruitful the dialog initiated in 1991 by Reagan and Gorbacev and continued with New Start by Obama and Medvedev.

On all that, on February 24 the Russian invasion of Ukraine deflagrated. There is no need to add comments to the horror we saw since then.

The menace of a third, nuclear world war has been evocated several times, a circumstance that leads us to close this presentation with the worlds of the Russel-Einstein Manifesto (July 9, 1955): … *we urge the governments of the world to realize, and to acknowledge publicly, that their purpose cannot be furthered by a world war, and we urge them, consequently, to find peaceful means for the settlement of all matters of dispute between them.*

In conclusion, I would like to thank

- Our sponsors: the Accademia Nazionale dei Lincei, the US National Academy of Sciences and Ministero Affari Esteri, represented here by President Roberto Antonelli, by Prof. Micah Lowenthal, and by Counselor Valerio Negro
- Paolo Cotta-Ramusino and Micah Lowenthal, Co-chairs of the Conference
- Enza Pellecchia Scientific Secretary
- The Conference Board: Francesco Calogero, Carlo Schaerf, Francesco Lenci Alessandro Pascolini, Alberto Quadrio Curzio, Raymond Jeanloz
- Mariella Di Donna, relations with the Press, and RAI TV Cultura for covering our event.

Rome, Italy Luciano Maiani

Preface II

On behalf of the President of the US National Academy of Sciences Marcia Mc-Nutt and the Chair of the Academy's Committee on International Security and Arms Control Raymond Jeanloz, I want to thank Lincei President Roberto Antonelli, Conference Chair Luciano Maiani, and Profs. Paolo Cotta-Ramusino and Enza Pellecchia who have organized this conference much more than we have.

The National Academy of Sciences had a role in the genesis of the Amaldi Conferences. We have been fortunate to participate in these conferences since the beginning, in some cases helping organize them. More than ever, our academy has been actively engaged in recent conferences for several reasons. First, Dr. McNutt has consciously led our Academy to step up international engagements, even as many governments withdrew from internationalism and focused more inwardly. Second, Prof. Luciano Maiani and Prof. Wolfango Plastino have done excellent work in organizing recent conferences. Third, and more pointedly, there is an urgent, growing need for the scientific community to address international problems, both long-term, chronic problems, such as climate change; and emergent problems, such as the displacement of whole populations due to conflict.

The Russian government's attack and ongoing war on its neighbor Ukraine has caused a humanitarian crisis in Ukraine and a refugee crisis in Europe. Our Academy has launched an effort with the Polish Academy of Sciences and others to support Ukrainian researchers who have fled their country. Through this Safe Passage Fund and our Academies' Scientists and Engineers in Exile or Displaced (SEED) initiative, which helped evacuate and resettle a group of Afghan researchers following the Taliban's takeover of Afghanistan, we are working with others in concrete ways on these immediate issues.

Sadly, nuclear arms and related international security issues remain as long-term chronic concerns, yet they are also punctuated by emergent conditions and even crisis. It is crucial at this time for our scientific and technical communities to hold thoughtful, informed, reasoned international discussions on these issues, including with colleagues having policy, military and other important perspectives. It is also necessary for us in the technical domains to inform our governments of any insights in understanding, and opportunities to improve outcomes. As Prof. Antonelli said,

this is especially the case because we in the scientific community are used to working together, communicating and collaborating internationally, while in many cases our governments can find it difficult to talk with each other directly.

Underlying all of these objectives is the observation—and conviction—that well documented facts and reliable analysis serve to improve human society's capabilities and policies. Communication and collaboration is our mission in these three days of the Conference, while we address major issues in international security now confronting society.

We have an outstanding set of speakers, and opportunity for discussions. I don't wish to delay hearing from our distinguished participants, so I will end by reiterating the welcome and thanks of the Academies.

Washington, D.C., USA Micah Lowenthal

About the Conference

The Accademia Nazionale dei Lincei

Founded in 1603, the Accademia Nazionale dei Lincei is the oldest scientific academy in the world which included, among many other prestigious names, Galileo Galilei. The Accademia Nazionale dei Lincei is within the sphere of the Italian Ministry of Cultural Heritage and is considered the highest Italian cultural institution. The Accademia Nazionale dei Lincei is a scientific consultant to the President of the Italian Republic and has recently been granted his High Permanent Patronage. The Accademia Nazionale dei Lincei mission is to promote, coordinate, integrate and spread scientific knowledge in its highest expressions, in the frame of cultural unity and universality. To this end, the Accademia Nazionale dei Lincei organizes national and international conferences, meetings and seminars.

The National Academy of Sciences

Established by an Act of Congress signed by President Abraham Lincoln in 1863, the National Academy of Sciences is charged with providing independent, objective advice to the nation on matters related to science and technology. The National Academy of Sciences is committed to furthering science in America, and its members are active contributors to the international scientific community. Nearly 500 members of the National Academy of Sciences have won Nobel Prizes, and the Proceedings of the National Academy of Sciences, founded in 1914, is today one of the premier international journals publishing the results of original research. The National Academy of Sciences also encourage education and research, recognize outstanding contributions to knowledge and increase public understanding in matters of science.

A Brief History of the Edoardo Amaldi Conferences

In 1980, the United States National Academy of Sciences established a Committee on International Security and Arms Control (CISAC). During the 1980s, with Wolfgang K. H. Panofsky as Chairman, one of CISAC's main purposes was to maintain bilateral contacts with an analogous group at the Academy of Sciences of the Soviet Union. In January 1986, CISAC organized in Washington, D.C. a meeting and about ten scientists from European countries participated. In this meeting questions connected to arms control were discussed, together with the possibility of establishing in Europe a group of scientists with a role analogous to that of CISAC. Discussions on international security and armament control were extended beyond the limitation of a direct link between the USA and the USSR.

Francesco Calogero and Carlo Schaerf took part in this meeting and then reported to Edoardo Amaldi, then Vice President of the Academia Nazionale dei Lincei. He was very much in favor of this initiative and set up a Working Group on International Security and Arms Control (SICA).

The first informal meeting was held in Rome at the Academy on 23–25 June 1988 and was entitled *Workshop on International Security and Disarmament: The Role of the Scientific Academies*. Participants from Belgium, Denmark, France, Federal Republic of Germany, Great Britain, the Netherlands, Sweden and the USA were present at this meeting. On that occasion it was decided to hold an international conference the following year and to invite participants from other European countries, including the Soviet Union.

The second meeting was entitled *International Security and Disarmament: The Role of the Scientific Academies* and was held in Rome in June 1989.

The third conference, entitled *International Conference on Security in Europe and the Transition Away from Confrontation Toward Cooperation*, was held again in Rome in June 1990. The title, the programme, and the specific items had already been established by Edoardo Amaldi (who was President of the Academy at the time) and the SICA group when he died unexpectedly on 5 December 1989. Professor Giorgio Salvini was elected to succeed him as President of the Academy and decided to continue the Amaldi's initiative on disarmament and arms control. The third meeting was devoted to problems of peace, environmental cooperation and measures of effective disarmament in the new international climate. It was at this meeting that the participants decided to dedicate all future conferences to the memory of Edoardo Amaldi, hence the name *Amaldi Conferences*. Since then the Amaldi Conferences continued on a yearly basis up until 2000, and later periodically.

Latest Conferences:

- XIX Edoardo Amaldi Conference on *International Cooperation for Enhancing Nuclear Safety, Security, Safeguards and Non-proliferation*, organized by the Accademia Nazionale dei Lincei and the European Commission—Joint Research Centre (Rome, 30–31 March 2015).
- XX Edoardo Amaldi Conference on *International Cooperation for Enhancing Nuclear Safety, Security, Safeguards and Non-proliferation—60 Years IAEA*

Atoms for Peace and Development—EURATOM Treaty, organized by the Accademia Nazionale dei Lincei and the European Commission—Joint Research Centre (Rome, 9–10 October 2017).

- XXI Edoardo Amaldi Conference on *International Cooperation for Enhancing Nuclear Safety, Security, Safeguards and Non-proliferation*, organized by the Accademia Nazionale dei Lincei and the National Academy of Sciences, USA (Rome, 7–8 October 2019).

Edoardo Amaldi (1908–1989)

Edoardo Amaldi was an Italian Physicist who started his research in Nuclear Physics in collaboration with Enrico Fermi. He has contributed substantially to the current knowledge on artificial radioactivity induced by neutrons and properties of slow neutrons and gave first direct experimental evidence of the diffraction of fast neutrons by nuclei. After the Second World War, Amaldi was instrumental in the reconstruction of the post-Fermi School of Physics in Italy and was co-founder of the Italian National Institute for Nuclear Physics (INFN), of the European Organization for Nuclear Research (CERN) and of the European Space Research Organization (ESRO).

Amaldi supported the Working Group on International Security and Arms Control (SICA) from its inception, organizing the first conference on "International Security and Disarmament: The Role of the Scientific Academies" in Rome from 23 to 25 June 1988. The third conference on "Security in Europe and the Transition away from Confrontation toward Cooperation" was held again in Rome in June 1990. The title, the programme and the specific items had already been established by Edoardo Amaldi (President of the Academy at the time) and the SICA group when he died unexpectedly on 5 December 1989. Participants at this meeting decided to dedicate future meetings to the memory of Edoardo Amaldi, hence the name Amaldi Conferences. Since then the Amaldi Conferences have continued on a regular basis.

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Part I

Chapter 1
Science and Society

Giorgio Parisi

I would like to start quoting a sentence that sometimes is ascribed to Richard Feynman (he was one of the greatest physicists of the century and perhaps the most popular one). Physics is like sex: sure, it may give some practical results, but that's not why we do it.

This phrase reflects very well the subjective passions of scientists. Science is a huge puzzle and every piece that is put in the right place opens up the possibility of placing others. In this gigantic mosaic, each scientist adds tiles, with the knowledge that he has made his contribution, and that when his name is forgotten, those who come after will also climb on his shoulders to see further. The more we explore the universe, the more we discover new regions to explore, each discovery allowing us to formulate so many new questions that previously we were unable to formulate.

But beyond these considerations, it is crucial for scientists to have fun trying to solve the puzzle. My teacher Nicola Cabibbo often said, when discussing what to do, "Why should we study this problem if we're not having fun?" Often among scientists, there is almost an amazement at being paid to do the very thing you most want to do.

However, except in the rare cases in which the scientist was from a wealthy family and research was conducted during long periods of idleness (e.g. Pliny the Elder, Fermat), the scientists always had the problem of finding resources for living and the applications of science were essential for this purpose. Just think of one of the first sciences, in order of time, astronomy. It is difficult to imagine, now that we live in well-lit cities, the enormous prestige and power of those who controlled the flow of the seasons, the motion of the stars, and who knew how to predict the eclipses of the moon (not to mention the terrifying phenomenon that are the eclipses of the sun).

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Even if the motivations of the patrons could only be cultural or of social prestige, certainly the importance of practical applications did not escape the scientists: for example, Galileo proposed to use the occultation of Jupiter's satellites as a method to determine the absolute time without the need of precision clocks and then determine the latitude. Actually Galileo's proposal was too complicated to be used in practice and the problem was finally solved in the next century with the precision chronometer which crowned more than a century of research.

With the passing of the years, science becomes more and more useful to society (economic development is based on scientific progress), but it also becomes more and more expensive and requires more and more complex facilities and organization. World War II marks the first stirrings of mass-based science ("big science"): Vannevar Bush coordinated the war efforts of six thousand American scientists and at the same time fifty thousand people worked on the construction of the first atomic bombs.

Science with its institutions needs to be funded by a society that doesn't give a fig whether scientists have fun or not. This point of view was expressed very clearly by the Soviet delegation at the congress on the history of science and technology held in London in 1931. Bukharin (a political personality of the first rank, extremely popular in the USSR, who was later one of the most illustrious victims of the Stalinist purges) wrote that "the idea that science is an end in itself is naive: it confuses the subjective passions of the professional scientist, who works in a system of a very strict division of labor (…) with the objective social role of this kind of activity, as an activity of practical importance."

All of us here realize that technological development is not possible without a parallel advancement of pure science. Pure science not only provides applied science with the necessary knowledge for development (languages, metaphors, conceptual frameworks), but it also provides another more hidden role of no less importance. Basic scientific activities also function as a gigantic circuit for testing technological products and stimulating the consumption of high-tech goods.

1.1 Science as Culture

Science must be defended not only for its practical aspects but also for its cultural value. We should follow the courageous example of Robert Wilson who, in 1969, in response to an American senator who insistently asked what the value was in building an accelerator at the Fermilab, near Chicago, and, in particular, if it was militarily useful to defend the country, replied "(…) It only has to do with the respect with which we regard one another, the dignity of men, our love of culture. It has to do with those things. It has nothing to do with the military. I am sorry. (…) Otherwise, it has to do with: Are we good painters, good sculptors, great poets? I mean all the things that we really venerate and honor in our country and are patriotic about. In that sense, this new knowledge has all to do with honor and country but it has nothing to do directly with defending our country except to help make it worth defending. (…)".

To promote science as culture, it is necessary to make the population (at least the educated population) aware of what science is, and of how science and culture intertwine with each other, both in their historical development and in today's practices. It is necessary to explain in a non-magical way what living scientists do, and what the challenges of our times are. It is not easy, especially in the hard sciences where mathematics plays an essential role. However, with some effort, excellent results can be achieved.

It is often said that the hard sciences are not easily understood by those who have not studied mathematics. But the same problem also exists with Chinese poetry, which is an inseparable mixture of literature and painting: the original manuscript of poetry is a picture where the individual Chinese ideograms are the pictorial elements that are represented each time differently. This pictorial dimension is completely lost in the translation and its beauty cannot be appreciated by those who do not know Chinese well. Just as it is possible to make people appreciate the beauty of Chinese poems in Italian, it is also possible to make people who do not know mathematics and have not studied science understand the beauty of hard sciences.

Now, it's clear that we have to defend the culture on all fronts and we must avoid losing our ability to pass our culture to the next generation. If we lose our culture, what remains of our civilization?

1.2 The Refusal of Science

This deep integration between science and technology might suggest that science has a bright future in a society that is becoming increasingly dependent on advanced technology (the mobile phones widely used today can reach a computing capacity of hundreds of billions of arithmetic operations per second, like the mammoth supercomputers of twenty-five years ago).

Today the opposite seems to be true: there are strong anti-scientific tendencies in today's society, the prestige of Science and the trust that has been placed in it are rapidly diminishing, astrological, homeopathic and anti-scientific practices are spreading widely, along with voracious technological consumerism. For example the NoVax movement before COVID or the denial of Xylella as the origin of the disease that struck the Apulian olive trees).

Now, we have also seen during COVID, the tragedies that happened to people that were negating COVID in denial. They refused to vaccinate despite millions of deaths. This came from the refusal of science.

It is not easy to fully understand the origin of this phenomenon: this mass distrust in science may also be due to a certain arrogance of scientists who present science as absolute wisdom, compared to other debatable knowledge, even when it is not the case. Sometimes, the arrogance is not in trying to bring to the public the available evidence, but in expecting an unconditional assent based on trust in experts.

The refusal to accept limitations can weaken the prestige of scientists, who sometimes flaunt unfounded excessive security; a stance which the public may somehow

perceive as partial or limited. Sometimes bad propagators present scientific results almost as superior witchcraft, which is understandable only to a selected few. In doing so, non-scientists may be put in a position to take on an irrational viewpoint towards science which is perceived as inaccessible magic and therefore, in turn, have unreasonable expectations: if science becomes pseudo magic, why not choose the real magic rather than its surrogate?

But perhaps the current difficulties have deeper origins that must be understood in depth so that they can be counteracted. We are facing a period of pessimism concerning the future, originating from crises of different natures: economic crisis, global warming, depletion of resources, and pollution. In many countries, there are also increasing inequalities, insecurity, unemployment, and war. While it was once thought that the future would inevitably be better than the present, the faith in progress, in the magnificent and progressive fortunes of human beings has eroded: many fear that future generations will be worse off than the present ones. And just as science received the merit for progress, it now receives the blame for its decline (regardless of whether it is real or just perceived). Science is sometimes deemed to be a bad teacher who has led us in the wrong direction, and changing this perception is not easy. There is great dissatisfaction with all those who have led us into this situation and scientists do not escape reproach.

Science sometimes is deemed to be a bad teacher that leads us in the wrong direction. The change in this perception is not easy. We should not take for granted that the development of science is unstoppable: it is a mistake to think that technological development can always rely on scientific development. The Romans preserved Greek technology without much consideration for Greek science and the Christian fanatics, led by Bishop Cyril of Alexandria, quietly tore to pieces the body of mathematic-astronomer Hypatia, without worrying much about the long-term consequences, and indeed rejoicing at the disappearance of a profane knowledge, considered useless if not harmful.

1.3 The Future of Humanity

There are some practical consequences of science that are very, very important. Science is making great advances and many of the world's problems could be solved using the tools of science put in front of us.

In these days humanity must make essential choices; it must stand firm against climate change. For decades, science has been warning us that human behavior was laying the groundwork for a dramatic increase in the temperature of our planet. Science alone is not enough. Political decisions are needed, especially on the part of the rich countries. We need to go beyond short-sighted national self-interest to solve global problems in the spirit of whatever it takes. COVID has taught us that we are all connected, and what happens in game markets or in the Amazon forest deeply affects all of us.

Unfortunately, the actions taken by governments have not been up to this challenge and the results so far have been extremely modest. In recent years, the effects of climate change are there for all to see: the floods, hurricanes, heat waves, and devastating fires of which we have been astonished spectators are a timid foretaste of what will happen in the future on a much larger scale. Now that climate change is beginning to affect people's lives, there is perhaps a more resolute reaction, but we need much stronger measures and we must not limit ourselves to just saving our conscience. From COVID's experience, we know that it is not easy to take effective measures in time. We have seen how often measures to contain the pandemic were taken late, only at the moment when they could no longer be postponed. I remember one head of government being told "we can't do a lockdown before the hospitals are full, the citizens wouldn't understand".

We all know that the pitiful doctor made the festering sore: we have a duty not to be pitiful doctors. Our generation has to pass through a road full of dangers. It's like driving at night: the science is the headlights, but then the responsibility to not go off the road lies with the driver who must also take into account that the headlights have a limited range.

Even scientists don't know everything. It is laborious work during which knowledge is accumulated one after another and pockets of uncertainty are slowly eliminated. Science makes honest predictions on which a scientific consensus slowly forms. When the IPCF predicts that in an intermediate scenario of reduced greenhouse gas emissions the temperature could rise between 2.1 and 3.5 degrees, this range is what we can best estimate from current knowledge. However it must be clear to everyone that the correctness of climate models has been verified by comparing the predictions of these models with the past; if the temperature increases more than 2° we enter an unknown land where there can be other phenomena that we have not foreseen that can worsen enormously the situation: for example colossal forest fires like the Amazon that would introduce catastrophically enormous quantities of greenhouse gases, but when would they happen? The oceans are currently absorbing many of the greenhouse gases we emit, but will this phenomenon continue in an earth two degrees warmer? The temperature rise is not only controlled by direct emissions but is mitigated by a lot of regulatory mechanisms that could stop working as the temperature rises. While the 2° lower limit is something we can be pretty sure about, it is much harder to figure out what the most pessimistic scenario is: it could be much, much worse than what we imagine.

We are facing a huge problem that needs decisive interventions not only to stop the emission of greenhouse gases, but we also need scientific investments: we must be able to develop new technologies to conserve energy by transforming it into fuels, non-polluting technologies based on renewable resources: not only we must save ourselves from the greenhouse effect, but we must avoid falling into the terrible trap of the exhaustion of natural resources.

Energy saving is also a chapter that needs to be tackled decisively: for example, as long as the internal temperature of our homes remains almost constant between summer and winter, it will be difficult to stop emissions.

Blocking climate change successfully requires a monstrous effort by all: it is an operation with a colossal cost, not only financial but also social with changes that affect our lives. The policy must ensure that these costs are accepted by all: those who have used the most resources must contribute more, to affect the bulk of the population as little as possible; the costs must be distributed fairly and equitably among all countries: decency requires that the countries that currently affect the planet's resources must make the greatest efforts.

1.4 Science and Peace

We must build ties, and bridges among people of different countries, and stress what unifies all human beings beyond nationalism. Science is a worldwide enterprise at it is very well suited. Of course, it takes time, but these are long time process and we have to think from a long-term perspective, which will be the situation 10–20 years from now.

This happened in the past. Europe is a cultural creation done by humanist philosopher scientists that created the European cultural space. Starting from the clerici vagantes (wandering clergy), the foundation of the Universities, Europe has been characterized by a class of highly cultivated people that were in contact among themselves, and moved from one place to the others. In this construction a very important role was played by the scientific academies that were founded in Europe (they still dominate the scientific scene) as the Accademia dei Lincei in 1603, the Royal Society in 1646, the Académie des Sciences in 1666. Let me mention also the American philosophical society that was founded in 1743. This Academy is particularly interesting, it was founded by Benjamin Franklin with the state of the purpose of promoting useful knowledge.

Much time later CERN was founded by 12 European countries in 1954, 3 years before the Rome treaty, where the European Economic Community was founded, with only 6 of the 12 countries of CERN. It is clear that science was ahead of politics also if we consider that many countries, also on the other side of the curtain wall participated in the experiments done at CERN.

Now, we have in recent times, we have seen the creation of Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME), a remarkable laboratory, located in Jordan, that was founded by a few meddle Est countries: Bahrain, Cyprus, Egypt, Iran, Israel, Pakistan and the Palestinian Authority and Turkey, that have a quite different political stance.

Unfortunately not always science is being used for peace: it could be used for war as we have seen in the past. There are still problems at present. Let me recall a declaration of the Academic G7, that happened in Paris in 2019, where there was an important declaration on autonomous weapons signed by all the seven Academies.

AI opens new possibilities for military applications, particularly concerning weapon systems with significant autonomy in the critical functions of selecting and attacking targets. Such autonomous weapons might lead to a new arms race,

lower the threshold for war or become a tool for oppressors or terrorists. Some organizations call for a ban on autonomous weapons, similar to conventions in the chemical or biological weapons realm. Such a prohibition would require a precise definition of weapons and autonomy. In the absence of a ban of Lethal Autonomous Weapons Systems (LAWS), the compliance of any weapon system with International Humanitarian Law should be guaranteed. These weapons should be integrated into existing command and control structures in such a way that responsibility and legal accountability remain associated with specific human actors. There is a clear need for transparency and public discussion of issues raised in this area.

This year we face an enormous tragedy, not only the military killed but also a large number of civilians. We are witness of an incredibly high number of refugees, so high I cannot compare with anything that I have seen. This tragedy should stop now, but we need also to think in the long term We are returning to cold war times and we have heard again the menace of using nuclear arms. Cold war, a confrontation that went on for more than 40 years, was not only cold, but it had also hot periods with millions of deaths. It and I think that now that cold war times are coming back, we should ask a very fundamental question. Why we are alive? Why we have not dyed in the Third War that could be unleashed?

Much of the credit comes from the realization that uncontrolled escalation must be avoided, and that it was essential that the armies of the Warsaw Pact and NATO did not clash militarily. One was and is in a situation of Mutually Assured Destruction (MAD) in the case of the atomic war. We are still in the same situation, the 2000 or so strategic warheads of NATO and the 1600 Russian warheads are capable of completely devastating the northern hemisphere. It was crucial to defuse the conflicts before it came to an armed clash between the respective armies.

Science had a direct role in building peace. "Track II Diplomacy" had a very important role. The first example of this kind of diplomacy where Pugwash Conferences on Science and World Affairs. Pugwash played a useful role in opening communication channels during a time of otherwise-strained official and unofficial relations. It provided background work to the Partial Test Ban Treaty (1963), the Non-Proliferation Treaty (1968), the Anti-Ballistic Missile Treaty (1972), the Biological Weapons Convention (1972), and the Chemical Weapons Convention (1993). Former US Secretary of Defense Robert McNamara has credited a backchannel Pugwash initiative with laying the groundwork for the negotiations that ended the Vietnam War. Mikhail Gorbachev admitted the influence of the organization on him when he was the leader of the Soviet Union. In addition, Pugwash has been credited with being a groundbreaking and innovative "transnational" organization and a leading example of the effectiveness of Track II diplomacy.

As you all know, Amaldi conferences are also another example of the effort in the same way as the "Colloquia on Science and Diplomacy" (program ideated by Wolfango Plastino) that our Academy, is organizing with great success from 2020.

I am very confident that the discussions here (without public) will be extremely useful in constructing a mutual understanding, as can be seen from the proceeding of the previous Amaldi conference and you will see from that the proceedings of this one.

Chapter 2
25 Years of CTBTO

Robert Floyd

I would like to thank the Accademia Nazionale dei Lincei for inviting me to speak at this XXII Edoardo Amaldi Conference on Nuclear Risks and Arms Control, Problems and Progress in the Time of Pandemics and War. The theme of this year's conference is timely.

We are at a pivotal moment in history. The situation in Ukraine continues to be of grave concern. We have heard of nuclear weapons being put on high alert. Fears that the conflict will further escalate and expand are all too real. These events have put our efforts on nuclear non-proliferation and disarmament into a most sobering context and caused me to reflect on the poignant statement of The Elders, a group of world leaders of great renown. They said: "*As long as nuclear weapons remain in existence, it is inevitable that they will someday be used, whether by design, accident or miscalculation.*"

Today, this message is especially resonant, and it is one we should all heed. The road to nuclear disarmament may be long and winding, but I believe that there are simple steps that we can take now that will lead us to a world free from nuclear weapons. One essential step that will bring us ever closer to the world we all aspire to is the CTBT, which will provide a legally binding and verifiable prohibition on nuclear testing.

This keynote address is a journey of 25 years through the history of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) and the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO),[1] including the scientific and technical framework behind its verification regime, starting with an overview of the CTBT.

[1] https://www.ctbto.org/.

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https://doi.org/10.1007/978-3-031-29708-3_2

The CTBT is an important achievement as one can discern by looking at the number of nuclear tests conducted each year between 1945 and the actual signature date of the CTBT. Between 1945 and 1996 more than 2000 nuclear tests were carried out at over 60 locations throughout the world. These had a serious impact on human health and the environment. During this time, the average explosive yield of nuclear tests per year was equivalent to nearly 1,000 Hiroshima sized bombs. Since the CTBT opened for signature in 1996, less than a dozen tests have been conducted by only three States. Only one State has conducted several nuclear tests in this century. This proves to be a remarkable accomplishment that demonstrates the powerful contribution that the Treaty has made to international peace and security.

The journey towards the CTBT was not an easy path. More than four decades passed between the first call for a nuclear testing "standstill" agreement by Indian Prime Minister Jawaharlal Nehru in 1954 and the adoption of the Treaty in 1996. In the current international security context, I believe it useful to reflect upon the experience of the Cuban missile crisis of 1962. This event prompted world leaders to recognize the need to address the inherent risks of nuclear weapons. One such proposal was in fact a comprehensive ban on nuclear testing.

While a CTBT proved too difficult at that time, the Partial Test Ban Treaty (PTBT) was adopted in 1963 banning nuclear testing in the atmosphere, underwater, and in space. It did not, however, prohibit underground nuclear tests and did not include a verification mechanism. Concerns grew about the proliferation of nuclear weapons throughout the 1960's, which resulted in the negotiation of the 1968 Treaty on the Non-Proliferation of Nuclear Weapons (NPT). While some States wanted to include a comprehensive ban on nuclear testing in the NPT, differing views prevented such an outcome. However, the determination to achieve the discontinuance of all nuclear tests is mentioned in its preamble.

There are three pillars of the NPT: Non-proliferation, Disarmament, and Peaceful use of nuclear energy. Article VI of the NPT obligates all States to take effective measures leading to the cessation of the nuclear arms race and disarmament. The duration of the NPT, which initially was prescribed for 25 years, was extended indefinitely by States Parties during the 1995 NPT Review and Extension Conference. One of the crucial elements in a package of agreements that led to the indefinite extension of the NPT was that a CTBT be negotiated no later than 1996.

Three intense years of negotiations took place at the Conference on Disarmament, which were preceded by a decades-long effort by a multilateral Group of Scientific Experts to lay the foundation of a verification regime. The CTBT was finally adopted by the General Assembly on 10 September 1996 and opened for signature on 24 September 1996. We should today be grateful for the result of this long process and efforts which put in place an effective, non-discriminatory verifiable measure of nuclear disarmament and non-proliferation. The CTBT has established a near universal global norm against nuclear testing, and its entry into force will constitute an essential step towards a world free of nuclear weapons. Summarizing the basic obligations of the CTBT (Article I, Paragraph I):

> Each State Party undertakes not to carry out any nuclear weapon test explosion or any other nuclear explosion, and to prohibit and prevent any such nuclear explosion at any place under its jurisdiction or control.

There are now 186 States Signatories[2] to the CTBT, out of which 177 have ratified. However, the Treaty will enter into force only when all States listed in Annex 2 of the Treaty ratify it. States listed in Annex 2 are 44 States that possessed nuclear power or research reactors at the time of the final stage of negotiation of the Treaty at the Conference on Disarmament (CD) in 1996. As of today, there are eight remaining Annex 2 States that still must join the CTBT. China, Egypt, Iran, Israel and the US have already signed but not yet ratified the Treaty while the DPRK, India and Pakistan have neither signed nor ratified.

The success of the CTBT is in large part a reflection of the successful build-up of the Treaty's verification regime. The CTBT verification regime has three pillars: the International Monitoring System (IMS), the International Data Centre (IDC) and On-Site Inspections (OSI).

The IMS, when completed, will consist of 337 facilities worldwide to monitor the planet for any sign of a nuclear explosion. More than 90 percent of these 337 facilities are in place and sending data to the IDC. The IDC at the CTBTO headquarters in Vienna receives the data in near real-time from IMS stations. The data are processed and distributed to CTBT States Signatories in both raw and analysed form. The OSI pillar is being built up to be ready for when the CTBT enters into force. This will enable the dispatching of inspectors to an inspection area of a suspected nuclear explosion to conduct inspection activities and use inspection techniques. Thus, the sole purpose of an on-site inspection will be to clarify whether a nuclear weapons test explosion or any other nuclear explosion has been carried out in violation of the Treaty. Any decision to launch an OSI and decision whether any non-compliance with the Treaty has occurred will be made by the members of a future CTBTO Executive Council, which will serve as the executive organ of the CTBTO. The verification regime also encompasses a Consultation and Clarification process and Confidence-Building Measures.

The IMS employs four technologies—seismic, hydroacoustic, infrasound and radionuclide. Currently, 153 out of 170 seismic stations are certified (certified means a station was installed and meets specific technical requirements). All 11 hydroacoustic stations have been certified. 53 out of 60 infrasound stations are certified and 72 out of the 80 Radionuclide Particulate Monitoring Stations are certified. Of these 80 stations, 40 will have an additional capability for detection of Noble Gas Isotopes, which is an indicator particularly useful for detecting underground nuclear tests. 25 of the Noble Gas monitoring systems have already been certified. The IMS also comprises 16 Radionuclide Laboratories, of which 14 are certified. Italy hosts one seismic station in Valguarnera (Sicily) and Radionuclide Laboratory number 10 at the Italian National Inspectorate for Nuclear Safety and Radiation Protection (ISIN) in Rome.

The IMS collects data from each of the four types of monitoring stations and provides a near real-time picture of the entire globe. The data is processed at the IDC and goes through an automated analysis, after which alerts would be triggered with respective staff at all hours of the day and night should a suspicious event occur.

[2] Status as of 6 June 2022. At the time of the Conference, the number of States Signatories was 185.

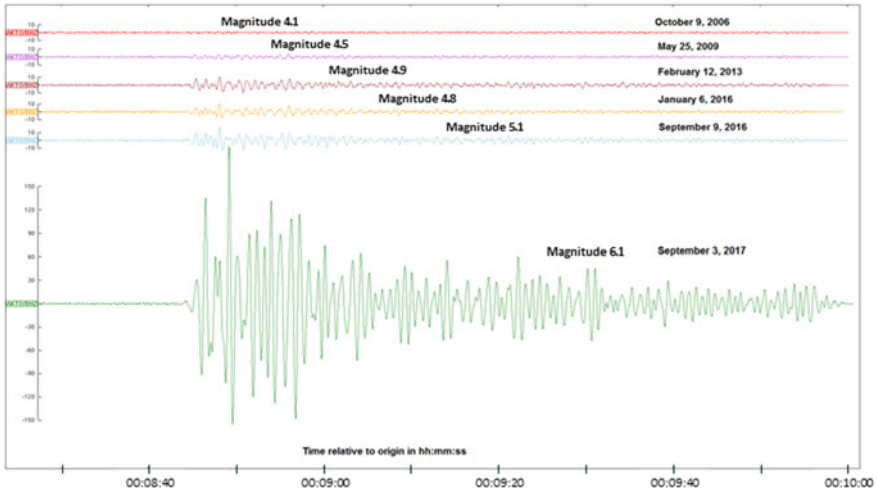

Fig. 2.1 Vertical seismic motion produced by the six DPRK nuclear tests, recorded more than 5000 km from the test site by the IMS Auxiliary Seismic station in Aktyubinsk (Kazakhstan). The curves are all plotted on the same scale. The time axis indicates time relative to the origin in hours:minutes:seconds

I continue to be amazed by how effective the CTBT verification regime is at detecting nuclear tests. All one must do is look at the response of the system during each of the six announced DPRK nuclear tests (Fig. 2.1). Within hours of the event occurring, the IDC processes the data and makes initial information available about the location, magnitude, and time of these Treaty-relevant events to Member States. Over the years, the number of stations detecting these events went from 22 to 134 as the IMS build-up progressed, and the body wave magnitude computed by the IDC increased from 4.08 to 6.07 for these events (Table 2.1). It's noteworthy that the size of the area within which the event is located with 90% confidence, called the confidence ellipse, obtained with less than half of the IMS network in place at the time of the first DPRK nuclear test in 2006, which was estimated to be less than one kiloton, was only 880 km^2. The size of this area is well within the 1000 km^2 Treaty requirements for launching an OSI. In 2017, with the IMS nearly 90% complete, the confidence ellipse improved to 109 km^2 (Fig. 2.2). Numerous small seismic events, tectonic in nature, and known to have originated near the DPRK nuclear test site at Punggye-ri after the 2017 test have been detected and localized by the IMS and have continued until recently (as of June 2022).

The extraordinary sensitivity of the sensors deployed at the more than 300 IMS stations strategically located all around the globe allows us to achieve a detection capability far better than expected from the original design. But what I find particularly exciting about the verification regime is the vast potential for the data to be used in civil and scientific applications. It is so encouraging that the CTBTO has agreements for providing reliable real-time IMS data to tsunami warning centres in 19 States Signatories. The tsunami related agreement with Italy was signed in 2019.

Table 2.1 Dates, seismic body wave magnitude, number of IMS stations detecting and 90% confidence ellipse parameters for each of the six DPRK tests

Date	m_b Final (preliminary)	Stations detecting (used in location)	Confidence area (semi-major × semi-minor axes)
09 Oct 2006	4.08 (4.04)	22 (22)	20.6 km × 13.6 km (880 km^2)
25 May 2009	4.51 (4.53)	61 (59)	9.6 km × 8.8 km (265 km^2)
12 Feb 2013	4.92 (4.96)	96 (88)	8.1 km × 7.1 km (181 km^2)
06 Jan 2016	4.82 (4.88)	102 (83)	8.4 km × 7.3 km (193 km^2)
09 Sep 2016	5.10 (4.90)	108 (97)	7.6 km × 6.4 km (153 km^2)
03 Sep 2017	6.07 (5.90)	134 (125)	6.7 km × 5.2 km (109 km^2)

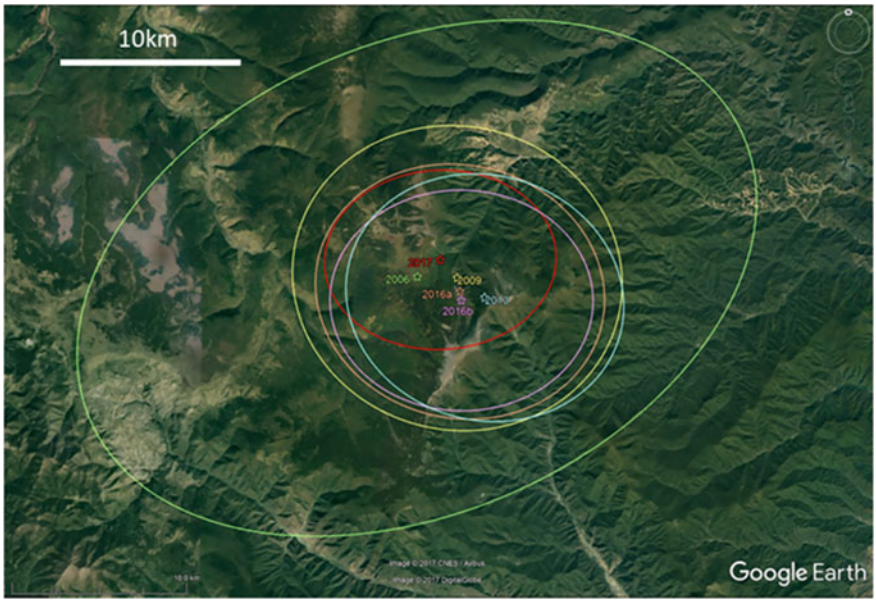

Fig. 2.2 Graphical representation of the six DPRK test detection confidence ellipses

I expect that more and more countries will take advantage of this opportunity to benefit from additional uses of our monitoring data.

Our seismic technology contributes to studies on earthquakes and volcanic eruptions, seismic hazard assessments, studies on the internal structure of the earth, the melting of glaciers, and tsunami warning systems.

Hydroacoustic technology contributes to the monitoring and location of underwater volcanic events and undersea earthquakes, some of which trigger tsunamis. Another exciting area where hydroacoustic technology can be useful is monitoring changes in sea temperature and signs of global warming through variation in acoustic signal travel time (ocean acoustic thermometry studies). There is also extensive research being undertaken on ocean processes and marine life.[3] I was particularly intrigued by the discovery of a new population of pygmy blue whales by researchers studying the acoustic signals collected by our hydroacoustic network.,[4,5]

Hydroacoustic data from IMS Hydrophone stations were also used to assist the Argentine Authorities when the submarine ARA San Juan was lost on 15th November 2017.[6] Tragically, all crew members lost their lives. Upon request from the Argentine Authorities, the CTBTO provided assistance, analysing its data in search of any signal which could be potentially related to the disappearance of the submarine. An impulsive hydroacoustic signal was detected by two IMS hydrophone stations, the location calculated for this event was not far from where the submarine had its last contact with the base. The time of the event determined from the acoustic signal travel time was also not long after the submarine had its last known communication. The two stations which detected this signal were located about 6,000 km and 7,700 km from the event, respectively. After a long search operation, on 17th November 2018, Argentine Authorities confirmed that the San Juan was found on the seafloor at 900 m depth, at less than 20 km distance from the event location estimated from CTBTO hydroacoustic data.

Infrasound technology contributes to the detection of volcanic eruptions which can have significant effects on civil aviation. It can also be used to support atmospheric and meteorological studies, tracking of storms, detection of meteors disintegrating in the atmosphere, and studies of signals generated by avalanches, among others.

Many of you will recall in January this year the explosive eruption of the Hunga Tonga-Hunga Ha'apai volcano in Tonga. This catastrophic explosive eruption and tsunami generated infrasound, seismic and hydroacoustic signals that were recorded by the IMS.[7] What you might not be aware of, is that this eruption was the largest event ever detected by the IMS infrasound network. As the pressure waves created by this violent interaction of magma and seawater spread throughout the atmosphere, our infrasound stations, all around the world, began to light up one by one. Before long, every one of the 53 certified infrasound stations recorded signals from the

[3] J.L. Miksis-Olds, et al. "Two unit analysis of Sri Lankan pygmy blue whale song over a decade," J. Acoust. Soc. Am. 144 (2018).

[4] E.C. Leroy, et al. "Multiple pygmy blue whale acoustic populations in the Indian Ocean: whale song identifies a possible new population," Nature Scientific Reports 11:8762 (2021).

[5] N. Pinto, T.K. Chandrayadula, "Long-term frequency changes of a potential baleen whale call from the central Indian Ocean during 2002–2019," J. Acoust. Soc. Am. Express Letters 1, 021,201 (2021).

[6] P.L. Nielsen, et al. "CTBTO's Data and Analysis Pertaining to the Search for the Missing Argentine Submarine ARA San Juan," Pure and Applied Geophysics 178 (2021).

[7] S. Matoza et al., "Atmospheric waves and global seismoacoustic observations of the January 2022 Hunga eruption, Tonga," Science 10.1126/science.abo7063 (2022).

event. But this is not the most impressive part. The IMS infrasound stations recorded pressure waves generated by this event that propagated around the globe for at least the first four days after the eruption. This breath-taking example of the sensitivity of the system testifies to both its incredible nuclear test detection capability, as well as its enormous value for civil and scientific applications.

The CTBTO Radionuclide network is also an incredible resource. The CTBTO is a member of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), a network that facilitates and coordinates cooperation between relevant international organizations to respond effectively in the event of an emergency such as a nuclear accident in which radioactive materials are released[8], our radionuclide network is always ready to support in the response to radiological emergencies, such as was the case in the aftermath of the Fukushima (Japan) nuclear accident in 2011. Furthermore, data from radionuclide stations can help to increase understanding of the long-range exchange of pollutants, monitoring the stratosphere/troposphere exchange and validating global climate models, and determining the quantity of dust and pollens present over a certain period of time.

One aspect of Radionuclide technology-related scientific applications that I find especially noteworthy is the study of the Beryllium-7 (^{7}Be) Isotope in relation to meteorological phenomena.[9] This research has contributed to understanding long-term global change in the atmosphere, and even predicting the onset of monsoons with a lead-time of about 30 days.[10] To briefly explain this latter example: this isotope is generated in the upper layer of the atmosphere, and "seeps" through adjacent atmospheric circulation cells to reach the earth's surface where it can be measured. When the circulation of these large atmospheric cells changes, this causes the ^{7}Be concentration measured at two IMS Radionuclide Particulate Stations in Russia & Australia to change. Detection of these changes makes it possible to predict the onset of the monsoon in India with about 30 days lead-time ahead of meteorological forecasts.

To conclude this technical part of the keynote, let me give you a quick impression of the data flow: data collected from stations are transferred by satellite to Vienna. From there, the information is also passed on to all authorized users in the National Data Centres. In Vienna, the data are analysed by the IDC processing data-stream and reviewed by teams of human analysts. Automatically generated and human-reviewed event bulletins are produced and distributed to Member States. Italy has a National Data Centre (NDC) for waveforms located in a facility of the Italian Institute of Geophysics and Volcanology (INGV) in Rome, and one NDC for Radionuclide data at the National Agency for New Technologies, Energy and Sustainable Development (ENEA) in Bologna. There are currently more than 1700 authorized users

[8] https://www.ctbto.org/our-work/civil-andscientific-applications/nuclear-emergency-response

[9] L. Terzi, et al. "Radioisotopes demonstrate changes in global atmospheric circulation possibly caused by global warming," Nature Scientific Reports 10:10,695 (2020).

[10] L. Terzi, et al. "How to predict seasonal weather and monsoons with radionuclide monitoring," Nature Scientific Reports 9:2729 (2019).

in 143 countries. Data from our sensors are also available free of charge for scientific research to scientists and researchers via the virtual Data Exploitation Centre (vDEC).[11]

The examples provided here highlight the additional value of the verification regime beyond the core mission of nuclear test monitoring. Be it tsunami early warning, contributing to earthquake detection or climate change research, the range of applications of these data is astonishing. I believe we are only scratching the surface on how these data can be utilized for the benefit of humanity.

To conclude on a high-note: let us have a look at where the CTBT is at after 25 years. There is near-universal adherence to the CTBT's prohibition on nuclear explosions. The norm against nuclear testing established by the CTBT is strong, but until the Treaty enters into force and is universal, the risks of nuclear testing will persist. Every ratification counts and I believe that everyone has a role to play. The 25th anniversary year of the Treaty is a time for us to engage and create momentum towards universalization to put an end to nuclear testing by anyone, anywhere, for all time. We are undertaking strategic and multi-tracked outreach to advance the goal of universalization and I have set a target for us to achieve at least five additional ratifications by the end of the anniversary year this September.

Thank you.

Acknowledgements Disclaimers The views expressed in this paper are those of the authors and do not necessarily reflect the views of the organizations that the authors represent.

The use of particular designations of countries or territories does not imply any judgement by the Commission as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

[11] https://www.ctbto.org/specials/vdec/.

Chapter 3
The Nuclear Conundrum in the Ukraine Crisis

Rose Gottemoeller

Dmitri Medvedev, former President and Prime Minister of the Russian Federation, took to social media on February 25, 2022 to post a chilling message: Russia may be ready to give up the New START Treaty, and it may be ready to cut diplomatic ties with the United States and other Western countries. As Medvedev said, "*As for diplomatic relations, well, there is no great need for them… It's time to hang huge padlocks on the embassies. We can continue our contacts looking at each other through binoculars and gun sights."*

Medvedev certainly did not post without checking whether the message would be welcome. His words, therefore, presage the possibility that Russia will cut itself off from everything that it has accomplished to control and limit nuclear weapons. Since the Cuban Missile Crisis, sixty years ago this year, the USSR and then the Russian Federation have played a proud and generally positive role in preventing nuclear proliferation, halting nuclear testing, and reducing nuclear stockpiles. Even as Russian tanks rolled into Ukraine, experienced Russian negotiators in Vienna were working with the United States and other partners to resuscitate the Iran nuclear deal. Another irony of this blazing crisis.

It is not too much to say that Russia has been a giant of the nonproliferation regime. The major treaties of the twentieth century have all benefitted from the skills of Russian negotiators and the intellect of Russian experts. The Non-Proliferation Treaty itself was the product of problem-solving ideas from senior Soviet and American diplomats, Ambassadors Roland Timerbaev and George Bunn, at a time when the United States and USSR were otherwise facing off over the Middle East and Vietnam. Tensions were so high that in 1967, the U.S. nuclear alert level was raised during

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a solar storm. Somehow, no matter how bad the crisis, the two countries continued talking to get nuclear weapons under control and prevent their spread.

Now, on the back of the invasion of Ukraine, this proud tradition is breaking asunder. What can we expect? The main options seem to be two: First, Russia isolates itself, becoming a pariah state unwilling to play any responsible international role. This seems to be the message of Medvedev's threat to leave the New START Treaty and shutter the embassies in Moscow. Alternatively, Moscow picks some arenas where it wants to continue to pursue its objectives with mutual benefits to its partners at the negotiating table, for the sake of global stability and its own security.

Let's consider the options as they relate to nuclear diplomacy. If Russia isolates itself, then further progress on nuclear non-proliferation becomes difficult. The Non-Proliferation Treaty Review conference, repeatedly postponed due to the COVID pandemic, is now scheduled to take place in August 2022. Normally, Russia would join the four other nuclear weapons states—US, UK, France and China—to defend its record and bolster continuing progress on the disarmament pillar of the treaty. Just in January 2022, the P 5 nuclear weapons states joined in reiterating the statement of Presidents Reagan and Gorbachev that nuclear war cannot be won and must never be fought. This was meant to be the centerpiece of a positive P 5 disarmament agenda at the review conference, which would also extend to bolstering action on nuclear nonproliferation and supporting peaceful uses of the atom. We will have to see if the P 5 can hold together to pursue these goals.

China's role will be an interesting one, and vital. China has hidden behind Russia and the United States for many years, arguing that the much larger U.S. and Russian strategic nuclear arsenals handed Washington and Moscow the leadership of the nuclear nonproliferation and disarmament regimes. Now China's own strategic arsenal is growing and it seems inclined, at least in the context of the NPT nuclear weapon states, to play a leadership role.

If Russia absents itself from nuclear diplomacy, will China be willing to step up to help lead? And will the United States be willing to admit it to leadership, given the animus between Washington and Beijing? The two capitals should be pondering these questions now, while we watch the disaster unfold in Ukraine. Of course, it is still a fact that the U.S. and Russian nuclear arsenals are a lot larger than China's, and China's ongoing modernization will not change that fact any time soon.

Therefore, the primary purpose of cooperation between the United States and China in the immediate period should be to work together closely to shore up the Non-Proliferation Treaty regime and ensure a successful review conference. They should also work to preserve other existing mechanisms such as the Organization for the Prohibition of Chemical Weapons (OPCW) and the Comprehensive Test Ban Treaty Organization (CTBTO). Otherwise, Russia may begin to play a wrecking role.

The United States and China might also consider working to constrain weapon systems where they have some equality of capability, such as INF missiles or direct ascent anti-satellite weapons (ASAT). U.S. Vice President Kamala Harris announced a unilateral U.S. ban on testing destructive ASAT systems in April 2022 and invited other countries to join. China may wish to take up that offer, in order to convey a responsible attitude toward sustaining space operations. If China and the United

States can show early ability to work together and produce results, then the world will breathe a collective sigh of relief that we are not heading into a free-for-all involving weapons of mass destruction and other critical systems.

However, I have to say that with Vladimir Putin threatening nuclear use in the Ukraine crisis, a productive NPT review conference in August seems a faint hope. If Putin decides to proceed to nuclear use, then we are entering territory untrodden since Hiroshima and Nagasaki, over seventy- five years ago.

If this happens, then the global community would react with horror. It would doubtless scramble to minimize the damage, succor the victims, and up the deterrence ante to prevent escalation. The moral burden of using nuclear weapons in wartime would land squarely on Russia, shifting from where it has rested since 1945, on the United States.

If stability is somehow restored, the question will then come: what next? Is it even worth trying again to ensure nuclear peace at the negotiating table?

In the first place, I believe that we will have to work hard to preserve the Nonproliferation Treaty regime, because the horizontal proliferation pressures emanating from the crisis will be strong. Again, the P 5 should try to hold together to preserve the NPT, with China perhaps taking a more prominent role than it has in the past.

If Russia refuses to play, then it will be setting itself up as a very large nuclear pariah state.

Let us hope for the other option, i.e., that Russia draws back from the nuclear brink and wants to return to the negotiating table, working with the P 5 to preserve the nonproliferation regime. In this situation, other countries, the United States included, will have to consider whether the benefits are worth the costs of dealing with Moscow.

Let me address this question as follows: Where nuclear weapons are concerned, the U.S. and its allies have tried for real progress at the negotiating table since the Cuban Missile Crisis in 1962. That crisis brought home the alternative—the existential threat that nuclear weapons pose. A Russian nuclear use in 2022, sixty years later, would renew that urgency and presumably, the necessity of negotiating with Russia. It would be an existential necessity, not a reward to Russia for its bad behavior.

Looming over all these considerations is Vladimir Putin and his role as chief Russian decision-maker in the continuing crisis. The President of the United States has called him a war criminal, and the Kremlin has shot back that such language is unwarranted and unforgivable. Although war crimes are a matter for the international courts to decide, the civilian deaths in Ukraine—at Bucha, Mariupol and other sites—are accumulating much evidence.

In these circumstances, the return of Russia to any negotiating table will be hard, never mind a bilateral nuclear one with the United States. First and foremost, the two Presidents will have to be willing to resume nuclear talks, even if they are not willing to engage each other directly. They will have to issue instructions to their negotiators.

Then, confidence will have to be renewed between the negotiators themselves. The negotiators know each other and have been working steadily together, for example,

on renewing the Iran nuclear deal, so perhaps renewing confidence will not be insurmountable.

In my view, and I stress I am speaking only for myself: before nuclear talks resume, first, a stable ceasefire must be in place in Ukraine; second, the withdrawal of Russian troops behind a ceasefire line agreed with the Ukrainians must be complete; and third, the reconstruction of Ukraine must be underway. In other words, a peace process must be well in train before we return to nuclear stability talks with Russia.

A Russian nuclear use in the Ukraine crisis would heighten these dynamics and cause the United States to think long and hard about what it can achieve at the negotiating table. In my view, as always, the U.S. national security interest must be paramount. If nuclear negotiations serve it in countering this existential threat and preventing a nuclear arms race, then the United States should be ready to talk.

In the end, the crisis in Ukraine may be the sharp shock that boots us into redoubling our efforts to constrain nuclear weapons. If we do not seize the chance, then we may be heading back to Cold War nuclear arms racing. Vladimir Putin has been threatening a crisis worse than the Cuban Missile Crisis. He meant it.

Chapter 4
Ending the 'Perpetual Menace' of Nuclear Weapons: The Nuclear Non-proliferation Treaty

Tariq Rauf

Hiroshima Peace Memorial, Photo: © Yuko Baba, UNITAR Hiroshima (used with permission)

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4.1 Introduction

On 16th July 1945, at 05:29 AM, the secrets of the atom were unlocked by detonating the world's first nuclear explosive device dubbed "The Gadget". Robert Oppenheimer, the scientific leader of the multinationally staffed and supported Manhattan Project to develop atomic weapons, lamented that, "*We knew the world would not be the same. Now I am become Death, the destroyer of worlds*", and his colleague Leó Szilárd[1] remarked, "*That night I knew the world was headed for sorrow*".[1]

The atomic bombing of Hiroshima and Nagasaki a mere three weeks later, on 6th and 9th August 1945, respectively, clearly demonstrated the revolutionary and catastrophic power of nuclear weapons on human beings and the environment and ushered in a dramatic revolution in military affairs that legitimized attacking civilian targets that was later formalized as "nuclear deterrence". However, one may recall that civilian targeting was proposed by General Giulio Douhet in his seminal treatise, "The Command of the Air" (1921)[2] and the related concept of the independent air force that reached its zenith in the fire bombings of cities such as Dresden, Hamburg and Tokyo – the fire bombing of Tokyo remains history's deadliest air raid exceeding in prompt fatalities even those of the atomic bombing of Hiroshima and Nagasaki.

Returning to the Trinity test of 16th July 1945, nuclear scientist Leó Szilárd observed that, "*Almost without exception, all the creative physicists had misgivings about the use of the bomb*" and further that "*Truman did not understand at all what was involved regarding nuclear weapons*".

Later Szilárd recalled that "*In March 1945, I prepared a memorandum which was meant to be presented to President Roosevelt. This memorandum warned that the use of the bomb against the cities of Japan would start an atomic-arms race with Russia, and it raised the question whether avoiding such an arms race might not be more important than the short-term goal of knocking Japan out of the war*?".

Following the death of Roosevelt, Szilárd drafted a petition to President Harry Truman opposing on moral grounds the use of atomic bombs against the cities of Japan.

Several years later, Szilárd astutely observed, after the atomic bombing of Japan's two cities, that the United States lost the argument of the immorality of using atomic bombs against the civilian population.

Once the concept of atomic fission had been scientifically demonstrated and its application utilized to destroy cities in Japan, Albert Einstein belatedly took full responsibility for the dire consequences of the letter of 2nd August 1939 that he and fellow scientist Leó Szilárd had jointly sent to US President Franklin Delano

[1] Leo Szilard was a Hungarian-American physicist and inventor. He conceived the nuclear chain reaction in 1933, patented the idea of a nuclear fission reactor in 1934, and in late 1939 wrote the letter for Albert Einstein's signature that resulted in the Manhattan Project that built the atomic bomb.

[2] Giulio Douhet observed that no longer can areas exist in which life can be lived in safety and tranquillity, nor can the battlefield any longer be limited to actual combatants. On the contrary, the battlefield will be limited only by the boundaries of the nations at war, and all of their citizens will become combatants, since all of them will be exposed to the aerial offensives of the enemy.'

Roosevelt warning against the dangers of Nazi Germany developing atomic weapons and recommending that the United States initiate a nuclear weapon development programme–that led Roosevelt to commission the Manhattan Project.

Less than a year after the atomic bombing of Hiroshima, Einstein lamented that, "*The unleashed power of the atom has changed everything save our modes of thinking and we thus drift toward unparalleled catastrophe*". Later Einstein called it "*the greatest mistake*" and in 1947 he told Newsweek magazine that "*had I known that the Germans would not succeed in developing an atomic bomb, I would have done nothing*".

4.2 Promoting Nuclear Disarmament

Emerging from the ashes of the Second World War, the very first resolution adopted in 1946 by the newly formed United Nations called for the "elimination of atomic weapons".

Thus, the first seeds were planted warning about the catastrophic humanitarian and environmental consequences of the use of atomic weapons and the first call issued to prohibit nuclear weapons.

To atone for his mistake, Einstein joined with philosopher Bertrand Russell and other atomic scientists to issue the "Russell-Einstein Manifesto", on 9th July 1955, that issued a clarion call:

> "Shall we put an end to the human race; or shall mankind renounce war? No one knows how widely lethal radio-active particles might be diffused, but the best authorities are unanimous in saying that a war with H-bombs might possibly put an end to the human race. Although an agreement to renounce nuclear weapons as part of a general reduction of armaments would not afford an ultimate solution, it would serve certain important purposes".

Despite efforts by many scientists to abolish nuclear weapons, other scientists unfortunately were successful in persuading their political leaders to develop thermonuclear weapons with much greater destructive force than simple atomic weapons. Indeed, in 1958 there even was a short-lived US effort, Project A-119, to detonate a thermonuclear nuclear device on the surface of the Moon. The rationale was to produce a very large mushroom or radioactive cloud and a brilliant super flash of light clearly visible from Earth—that would be an obvious show of strength to the Soviet Union. Fortunately, the project was cancelled, the Moon was spared and the "Moon Treaty" of 1979 prohibits all types of nuclear tests on the Moon and other celestial bodies. This to highlight just one of the follies of humankind to misuse nuclear energy for destructive purposes and the ever-present risks of nuclear weapons. Today there are more than 13,000 nuclear weapons, held at 107 locations in 14 States—nine nuclear-armed States and five non-nuclear-weapon States.

Today, some seven decades after the end of the Second World War, we again are facing a situation where nuclear weapons use is being threatened and again a country—this time Ukraine—has been invaded. Mohamed ElBaradei, former IAEA

Director General and 2006 Nobel Peace Prize laureate, in this regard recently commented that, "*A global order that is shaky, selective, and full of holes and double standards has brought us to this point*".

This is not the first time that nuclear weapons use has been threatened; during the 1962 Cuban missile crisis the survival of the world was put at risk by two nuclear armed-States, nuclear weapons were invoked again during the 1973 Middle East war, and threats of "all options on the table" made repeatedly against some States (in particular Iran and North Korea). In this regard, we have been lucky to have escaped thus far nuclear weapons use by accident or misadventure over the past seven decades.

The Elders, former internationally respected world leaders, have warned that, "*As long as nuclear weapons remain in existence, it is inevitable that they will someday be used, whether by design, accident or miscalculation*". United Nations Deputy Secretary General, Jan Elliason has remarked, "*There are no right hands for wrong weapons, and Weapons of Mass Destruction are simply wrong*".

Today, four months before the 77th anniversary of the atomic bombing of Hiroshima, and two years after the 50th anniversary of the entry into force of the nuclear Non-Proliferation Treaty, it is important to recognize that no sentient human being who has met or seen the *hibakusha* (survivors), or visited the hypocentre, or looked at the photographic evidence of the destruction of the two devastated Japanese cities, can avoid being shocked and horrified by the devastation that nuclear weapons inflicted on those two unfortunate cities.

During the next decades more than 2,050 nuclear test detonations were carried out in all environments: In the atmosphere, on the surface of the Earth, underwater, underground and even in near space, and tests carried out at national test sites (Nevada, Semipalatinsk, Lop Nor, Pokhran, Chagai, Punggye Ri) and in indigenous peoples ancestral lands in Australia, Algeria and the South Pacific led to radiological contamination of vast swaths of lands and seas, as well as long lasting genetic damage to humans and the environment. As the CTBTO Executive Secretary Robert Floyd said at the Conference on Disarmament last month, "*our collective efforts to further increase adherence to the Comprehensive Nuclear-Test-Ban Treaty will continue to strengthen the Treaty, and solidify the already powerful international norm against nuclear testing*".

It is surprising and deeply disappointing that leaders of the "cabal" (and I use the term advisedly) of nine (9) countries with nuclear weapons and their "allies"—more appropriately the "captive nations" of nuclear deterrence—still continue to blindly ignore the devastating effects of nuclear weapons, are not fulfilling the nuclear disarmament obligations of the NPT, and blatantly reject the Treaty on the Prohibition of Nuclear Weapons (TPNW) supported by 122 States pursuant to a UN General Assembly resolution, now signed by 86 and ratified by 60 States.

On a positive note, the TPNW entered into force on 22 January 2021 and thereby establishes a *jus cogens* rule (fundamental principle under international law) creating an *erga omnes* (obligation) for all States to renounce nuclear weapons. In this context we might recall Einstein's prophetic words that, "*Our defence is not in armaments,*

nor in science…Our defence is in law and order"—something in short supply today at the international level.

The first meeting of States parties to the TPNW will be held in Vienna on 21st-23rd June 2022 and preceded on 20th June by the fourth international conference on the Humanitarian Impact of Nuclear Weapons—the first was in 2013 in Oslo, second in Nayarit (Mexico) in 2014 and third in Vienna in December 2014. It is encouraging that chinks are appearing in the phalanx of opposition in NATO to the TPNW, as Belgium, Germany, Netherlands and Norway and reconsidering their position and likely will attend the TPNW conference in June much to the consternation of other alliance members.

This "cabal" of 'nuclear' States and the "captive nations" of nuclear deterrence now also are back-tracking from measures agreed to implement nuclear disarmament and risk reduction consensually agreed at the 1995, 2000 and 2010 nuclear Non-Proliferation Treaty (NPT) review conferences.

4.3 Impact of COVID-19

The unfortunate coronavirus (COVID-19) pandemic has clearly and unambiguously shown misplaced priorities and wasteful investments on nuclear deterrence and military interventions amounting to trillions of dollars by the "axis" of nuclear-armed States and the "captive nations". Their historic severe under-investments in health care have led to the unacceptably high levels of infections and fatalities in most of their countries. It is truly tragic and contemptible that some of these States have selfishly opposed generic variants of effective anti-corona vaccines developed with tax-payer funding, commandeered excessive quantities of corona medical supplies and instead of collaborating internationally to jointly develop an effective and affordable vaccine they engaged in tribalism, bitter competition and propaganda that amounts to "vaccine nationalism" and "vaccine tribalism" of "my country first" (*über alles*, with all its perverse implications!). This is not surprising because just as the advocates of nuclear weapons and deterrence lack the mental acuity to comprehend the global catastrophe of any use of nuclear weapons, they also fail to understand that defence against a pandemic cannot be contained within any one country.

It is obvious that those non-nuclear-weapon States that did not waste national resources on nuclear weapons and foreign military interventions are the ones that have been coping much better with the pandemic.

4.4 Collapse of Nuclear Arms Control

Unfortunately, the vision of ridding the world of nuclear weapons is receding as the nuclear arms control architecture patiently built up over the past 50 years is collapsing before our eyes.

The 1996 Comprehensive Nuclear-Test-Ban Treaty (CTBT) still not in force, also is under threat of resumption of explosive nuclear testing and re-opening Pandora's Box of nuclear weapon test explosions. The supporters of the CTBT have miserably failed to make it a requirement for India—a non-proliferation pariah—when they were giving it an "exception" in 2008 to enable it to buy nuclear technology and fissile material in flagrant contravention of UN Security Council resolution 1172 of 1998 and of the so-called "guidelines" of the self-anointed Nuclear Suppliers Group (NSG).

In the negotiations and discussions on the denuclearization of North Korea and the Korean Peninsula, again no requirement was stipulated for North Korea to accept the CTBT.

The bi-annual CTBT "facilitating entry-into-force conferences" have become a sad joke of repetitive platitudes.

Thus, the prospects of the CTBT ever entering into force recede with each passing year and the likelihood of this treaty becoming a fossil of nuclear arms control are enhanced.

The architecture and fundaments of bilateral and multilateral nuclear arms control have been eroded by the United States withdrawal in 2002 from the crucial Anti-Ballistic Missile (ABM) Treaty followed by the Russian Federation.

On 2 August 2019, the United States formally withdrew from the 1987 Treaty on Shorter- and Intermediate-Range Nuclear Forces (INF)—foreshadowed in July 2019 by the Russian Federation suspending its compliance with the treaty. Under the INF Treaty, by May 1991, 2692 ballistic and cruise missiles with ranges between 500 and 5500 kms had been verifiably eliminated, 1846 by the USSR and 846 by the United States under mutual verification—and nearly 5000 nuclear warheads removed from active service.

This leaves only one nuclear arms reduction treaty in force between Moscow and Washington—the New Strategic Arms Reduction Treaty (New START)—that was signed on 8 April 2010, entered into force on 5 February 2011. By 4 February 2018 both Russia and the United States had verifiably met the central limits of 1550 accountable deployed strategic nuclear warheads and 700 deployed launchers (land-and sea-based intercontinental ballistic missiles and long-range bombers). In fact, on 1 July 2020, under New START, Russia had 485 deployed launchers carrying 1326 nuclear warheads, and the United States had 655 warheads on 1372 launchers warheads; the latest data from September 2021 shows that Russia had 1458 warheads on 527 deployed launchers, and the United States had 665 on 1389 deployed launchers.

New START set to expire on 5 February 2021, was extended on 3 February this year for five years until 2026 by the Presidents of the Russian Federation and the United States. New START involves mutual intrusive verification and technical weapons data exchange modalities for transparency, which is an important area of cooperation between especially in these times of heightened tensions.

For the first time in the history of Soviet/Russian-United States nuclear arms control not only have existing agreements been dismantled but both sides are modernizing nuclear arsenals unchecked and have lowered the threshold of nuclear weapon

use in their declaratory and operational policies. Furthermore, in blatant disregard of important Cold War risk reduction measures such as the Agreements on Nuclear Accidents (1971), Prevention of Incidents at Sea (1972), Prevention of Nuclear War (1973), Dangerous Military Activities (1989), De-targeting and Information Sharing (1994), over past years and continuing today air and naval forces of NATO and Russia, and the United States and China, have been engaging in dangerous and provocative actions especially in areas adjacent to territorial wars and airspace. Though there are attempts at deconfliction the danger of accidents remains high, especially now in the European and Arctic theaters of operations. It is time to recall the 1958 Surprise Attack Conference and take steps to hold a similar conference as soon as possible.

Doctrines of some nuclear-armed States now posit first or early use of nuclear weapons. The United States Defence Department's new nuclear weapons guidance, *Nuclear Operations* (11 June 2019) clearly posits that "using nuclear weapons could create conditions for decisive results and the restoration of strategic stability."

For its part, Russian military doctrine envisions what some have called "escalation to de-escalate" in countering superior NATO conventional forces, that is early but limited use of nuclear weapons.

In South Asia, both India and Pakistan also contemplate use of nuclear weapons in a regional conflict. Recently, India is under pressure domestically to invoke its nuclear capabilities to defend against China in the context of their revived conflict in the Ladakh region in the high Himalayas.

It is highly disturbing that when nuclear weapon use is discussed, the vocabulary used is very often conveniently sanitized. The destruction by thermonuclear war and resulting humanitarian and environmental consequences are downplayed and substituted by antiseptic concepts of nuclear deterrence. Alfred Wohlstetter in analyzing *The Delicate Balance of Terror* in 1958, noted that the existence of nuclear weapons does not automatically prevent a nuclear war but increases the danger of accidental wars particularly during a crisis, although this risk can be mitigated by arms control measures.[3]

Worrisomely, it is the view of many erstwhile defence experts, such as William Perry, former United States defence secretary, among others, that in today's world the dangers of inadvertent, accidental or even deliberate use of nuclear weapons is higher than it was during the height of the Cold War. Perry published his new book in July 2020 entitled, *The Button*, because in his words, "*Our nuclear weapons policy is obsolete and dangerous. I know, because I helped to design it, and we have to change it before it is too late.*" He warns that the "*awesome ability to launch hundreds of thermonuclear weapons in mere minutes*" creates grave dangers of blundering into Armageddon.

This year the *Bulletin of the Atomic Scientists* set the clock (which puts into context how close we are to nuclear catastrophe) at 100 s to midnight; closer to catastrophe than any year of the Cold War, one of the darkest years of the Cold War, when it was set at two minutes.

[3] Alfred Wohlstetter, "The Delicate Balance of Terror," P-1472, RAND Corp., 1958, https://www.rand.org/pubs/papers/P1472.html.

In January, UN Secretary General Guterres in his message to the NPT review conference noted that, *"….the end of the Cold War also left us with a dangerous falsehood: that the threat of nuclear war was a thing of the past. Nothing could be more mistaken. These weapons are not yesterday's problem. They remain today's growing threat. The risk that nuclear weapons will be used is higher now than at any point since the duck-and-cover drills and fallout shelters of the Cold War … The nuclear landscape is a tinderbox. One accident or miscalculation could set it alight*.

The Gorbachev-Reagan understanding of December 1987 that a "*nuclear war cannot be won, and must never be fought*" is no longer in the forefront of the minds of today's leaders and nuclear war planners. On 3 January 2022, in the current climate of hostilities we were surprised to see a *Joint Statement by the Leaders of the Five Nuclear-Weapon States on Preventing Nuclear War and Avoiding Arms Races.* Correctly the Joint Statement was labelled as from the Five Nuclear-Weapon States, and not P-5 States—though the US issued is as from the P-5 and then hastily corrected its mistake. The Joint Statement noted *inter alia* that France, China, the Russian Federation, the UK and the UK "*consider the avoidance of war between Nuclear-Weapon States and the reduction of strategic risks as our foremost responsibilities. We affirm that a nuclear war cannot be won and must never be fought. As nuclear use would have far-reaching consequences, we also affirm that nuclear weapons—for as long as they continue to exist—should serve defensive purposes, deter aggression, and prevent war*".

While the five NWS affirm that a nuclear war cannot be won and must never be fought, they did not affirm the full complement of the Reagan-Gorbachev commitment that: (a) they should not fight any war between themselves nuclear or conventional; and (b) for none of the NWS to seek nuclear or military superiority. The Joint Statement repeats the language from Article VI of the NPT, and it reaffirms the importance of complying with their bilateral and multilateral nuclear arms control and disarmament agreements and commitments; though in reality some of their actions do not support such a reaffirmation claim. The five NWS then say that they have the "*desire to work with all States to create a security environment more conducive to progress on disarmament with the ultimate goal of a world without nuclear weapons with undiminished security for all*"; repeating the buzz words and undefined concepts of "creating a security environment" and "undiminished security for all" with the "ultimate" aim of a nuclear-weapon free world. Nor are their actions thus far conducive to "creating a security environment" for nuclear arms control and disarmament.

Belatedly, one hopeful sign emerged with the initiation of direct discussions held in Vienna between the Russian Federation and the United States in June and August 2020. The NSVT (nuclear, space and verification talks) focused on three baskets of nuclear arms control issues cover: nuclear weapon doctrines; space weapons and arms control; and transparency and verification.

Following the June 2021 Putin-Biden meeting in Geneva, the two sides set up a Strategic Stability Dialogue (SSD), that met in July and September last year and in January this year. After the September dialogue, two working groups were established, one on "principles and objectives for future arms control" and the other on "capabilities and actions with strategic effects".

Both sides are divided over the inclusion of China as preferred by the US; and inclusion of France and the UK if China is included as preferred by Russia. None of the other three nuclear-armed States—China, France, and the United Kingdom—have expressed any enthusiasm in joining Russia and the US in starting multilateral talks.

The United States and Russia appear to have different priorities for the dialogue. The US wants to focus on the very complex set of nuclear arms issues that face the two countries, such as what may come after New START, how to deal with Russia's new nuclear systems, non-strategic nuclear weapons, and space and cyber weapons. Russia wants to address strategic stability including nuclear and non-nuclear and offensive and defensive weapons, as well as missile defence. How to deal with strategic non-nuclear weapons is an important matter not on the table.

Given the risks of nuclear weapons, some States and civil society actors have been promoting the concepts of "no first use" of nuclear weapons; and "sole purpose" that is to use nuclear weapons only in response to a nuclear attack. The USSR claimed to have a no first use policy, but the United States never gave it much credence. Among the five nuclear-weapon States, only China has a longstanding non first use policy—none of the other eight nuclear-armed States endorses it.

In 2017, Joe Biden wrote in Foreign Affairs that the sole purpose of the US nuclear arsenal should be deterring—and, if necessary, retaliating against—a nuclear attack, and as president he would "work to put that belief into practice, in consultation with the U.S. military and US allies".

Now, late last month, as President, Joe Biden has stepped back from his campaign promise and approved a National Defence Strategy (NDS) that includes the Nuclear Posture Review (NPR) that reaffirms an old Obama-era policy that allows for a potential nuclear response to deter conventional and other non-nuclear threats in addition to nuclear ones.

For its part, Russia's nuclear strategy also calls for nuclear retaliation to threats against the existence of the State.

In my view, while both no first use and sole purpose policies are good at the declaratory level, but at the operational level there is no way to verify or to assure that these policies are implemented. Expending effort on them would not lead to one less nuclear weapon or a lowered alert status; rather the nuclear-weapon States could score an easy political win by declaring support without necessarily reducing nuclear dangers. Fewer and eventually zero nuclear weapons are the best assurance for non-use.

4.5 Non-Proliferation Treaty Review Conference

The nuclear Non-Proliferation Treaty (NPT) marked its 50th anniversary in July 2020; given the perilous relations between nuclear-armed States alarm bells have been ringing warning about impending failure of the 10th NPT review conference

postponed (four times thus far) now scheduled to be held from 1st to 26th August this year because of the SARS COVID-19 pandemic.

With regard to nuclear disarmament in the context of the NPT, the field is now crowded with several disorganized competing approaches: the Non-Aligned Movement (NAM) NPT States favour a three-phase time bound "plan of action", in contrast the Western States stand by a "step-by-step" approach which has been slightly modified by a cross-cutting group called the Non-Proliferation and Disarmament Initiative (NPDI) that calls for "building blocks"; while another such group, the New Agenda Coalition (NAC) supports a "taking forward nuclear disarmament" approach; Sweden has proposed "stepping stones"; and the United States has advanced the concept of "creating the environment for nuclear disarmament" (CEND).

A sober assessment of the CEND approach suggests that this initiative is geared to transfer the focus and responsibility for the "environment" and "conditions" for nuclear disarmament from the nuclear-armed to the non-nuclear-weapon States. In fact, the dystopian CEND approach and nuclear policy as presently formulated is serving the cause of "creating conditions to *never* disarm".

It would be appropriate to characterize CEND approach as being based on "dreaming of rainbows, butterflies and unicorns to appear magically and sprinkle fairy dust leading to a new fantasy world of nuclear arms control". Faithfully implementing nuclear disarmament obligations in the framework of the NPT is the only way forward to salvation.

The Stockholm Initiative on stepping stones to nuclear disarmament started off on a good footing but has lost steam as it prioritizes nuclear risk reduction over nuclear disarmament. The NPDI no longer attracts much support as it largely has been overshadowed by the Stockholm Initiative. As for the Non-Aligned Movement's time bound framework for nuclear disarmament, opposition by the nuclear-weapon and allied States deprives it of traction.

4.6 Treaty on the Prohibition of Nuclear Weapons

Since the last NPT review conference, there now is an "elephant in the salon" of the NPT and this is the TPNW that opened for signature in September 2017 and entered into force in January 2021. It has become something of a lightning rod between its proponents and opponents at the NPT Preparatory Committee sessions in 2018 and 2019 and will be so at the review conference in August.

The opponents of the TPNW have raised a number of concerns and shortcomings and critics claim that the TPNW does not:

(a) define a nuclear weapon: this is correct it does not—but neither does the NPT—the Treaty of Tlatelolco has a definition (article 5) that has been utilized by the four other NWFZ treaties;
(b) constitute an "effective measure" for nuclear disarmament under NPT article VI—in fact, the TPNW is an "effective measure" as called for in NPT Article VI

on nuclear disarmament, in parallel with the 1996 Comprehensive Nuclear-Test-Ban Treaty (CTBT), the bilateral USSR/Russia-US treaties such as 2010 New START, 1987 Intermediate-Nuclear Forces Treaty (INF) even though these were concluded for national security not NPT reasons; and the five nuclear-weapon-free zone (NWFZ) treaties operational in Latin America and the Caribbean, South Pacific, Southeast Asia, Africa and Central Asia; the NPT is not a self-implementing treaty, it requires enabling actions, for example, safeguards agreements by NNWS with the International Atomic Energy Agency IAEA to verify non-proliferation commitments under Articles II and III of the NPT; NWFZ treaties are required to implement Article VII, while nuclear cooperation agreements are needed to implement Article IV of the NPT on peaceful uses of nuclear energy;

(c) include the latest IAEA safeguards (Additional Protocol)—to be precise, Article 3 of the TPNW stipulates that each NNWS party "shall, at a minimum, maintain its [IAEA] safeguards obligations in force at the time of entry into force of this Treaty, without prejudice to any additional relevant instruments that it may adopt in the future"; while it is indeed unfortunate that the IAEA's Board of Governors has been unable to agree to make the 1997 Model Additional Protocol (AP)(INFCIRC/540) an essential component of the IAEA NPT comprehensive safeguards agreement (INFCIRC/153) for NPT NNWS, and the IAEA General Conference in its annual safeguards resolution has said that "it is the sovereign decision of any State to conclude an additional protocol"; the TPNW requires adhering NNWS to maintain, as a minimum, their existing safeguards agreements and provides for further strengthened safeguards, thus for the 80% of NPT NNWS with APs in force the TPNW secures the current de facto standard of non-proliferation verification, which is higher than the one stipulated by the NPT; and

(d) include verification of nuclear disarmament—this is correct, but neither the NPT nor NWFZ treaties include the technical details of verification, this is left to the "Agency's [IAEA] safeguards system", in reality, the IAEA collaboratively with its Member States during 1970–1971 drew up (INFCIRC/153) comprehensive safeguards after the entry into force in 1970 of the NPT and the Additional Protocol (INFCIRC/540) during 1993–1997; TPNW/IAEA States, at the first meeting of States Parties to be convened within one year of the entry into force of the TPNW (now 21–23 June 2022) should invite the IAEA to set up a technical working group to develop verification approaches and to this end sponsor a resolution at the 2022 IAEA General Conference; and unlike the 1972 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (BTWC) that has acquired customary international law status and has no provisions for verification, the TPNW does in fact stipulate an approach to verification.

Other criticisms, for example, include that:

(a) the TPNW is inconsistent as it allows for States with nuclear weapons to adhere to it and it also allows States to join that had nuclear weapons but have disarmed—it is instructive to recall that the Chemical Weapons Convention (CWC) allows both declared chemical weapon possessor States as well as those that have previously destroyed their CW stocks to adhere to the CWC; hence the TPNW follows similar logic, States with nuclear weapons can adhere to the TPNW and then proceed to verifiably destroy them under auspices of a competent international authority to be designated by States parties;
(b) the TPNW "demonstrates that there is no legal norm on non-possession of nuclear weapons"—one of the purposes of the TPNW is to establish a legal norm against the possession of nuclear weapons, much along the lines of the BTWC and CWC outlawing biological and chemical weapons respectively;
(c) the TPNW will establish a "competitor regime to the NPT" and may entice "defections from the NPT"—the Treaty of Tlatelolco was the first to "prohibit" nuclear weapons in its zone of application and the subsequent four NWFZ treaties renounce nuclear weapons, but none are regarded as competitors or alternatives to the NPT, rather they are considered as complementary; and it is spectacularly illogical to suggest that a TPNW State party could "defect" from the NPT to "shirk" its non-proliferation obligations because as already noted above the TPNW itself requires each State party to "at a minimum, maintain its International Atomic Energy Agency safeguards obligations in force at the time of entry into force of this Treaty, without prejudice to any additional relevant instruments that it may adopt in the future" (article 3); and
(d) the TPNW would "delegitimize extended deterrence alliance relationships" and thus incentivize alliance NNWS to develop indigenous nuclear weapon programmes—such a claim calls into question the integrity and commitment of alliance NNWS to the NPT and suggests that their non-proliferation credentials may be suspect as their fealty to the NPT is only because of reliance on extended nuclear deterrence thus a case of "having one's cake and eating it too", i.e. to benefit from nuclear weapons, including in cases where such weapons are stationed on their territory, without actual possession, and also to preach non-proliferation to other NNWS and result in effectively undermining trust in the NPT.

4.7 Attacks on Nuclear Facilities

Armed attacks on nuclear facilities are not new—on 30th September 1980, Operation Scorch Sword, was a surprise airstrike carried out by Iran Air Force on an almost-complete nuclear reactor (Osirak) near Baghdad; eight months later on 7th June 1981, the Osirak reactor was destroyed by Israel (Operation Opera). In retaliation for Iran's

raid on Iraq's Osirak nuclear reactor, Iraq attacked the Bushehr nuclear power plant seven times during the war, leaving the plant in ruins.[4]

On 6th September 2007, Israel bombed a site et al. Kibar (Dair al Zour) (Operation Outside the Box / Operation Orchard) in Syria that later the IAEA concluded was "very likely" a nuclear reactor (though not operational). In Iran over the past few years, acts of sabotage involving use of explosives and cyber attacks have been carried out at uranium enrichment facilities in Iran, for which Iran blames Israel—the last such sabotage, a year ago, at the TESA Karaj centrifuge assembly plant completely destroyed one IAEA surveillance camera and damaged another one.

Now in Ukraine, the Chornobyl and Zaporizhye nuclear power stations are in the midst of military hostilities. The reactors at Chornobyl are decommissioned but spent nuclear fuel is in wet and dry storage and there are many tonnes of highly radioactive corium in the destroyed Unit 4. At Zaporizhye there are six operational nuclear power reactors—it is the largest nuclear power station in Europe.

This matter of attacks on nuclear facilities has been taken up by the IAEA Board of Governors and at the review conference of the Amended Convention on the Physical Protection of Nuclear Material (A/CPPNM), both last month, and most assuredly will feature at the upcoming NPT review conference. Although Article 2.4 (c) of the CPPNM affirms that "nothing in this Convention shall be construed as a lawful authorization to use or threaten to use force against nuclear material or nuclear facilities States failed to strengthen the Convention used for peaceful purposes", the States Parties failed to strengthen this provision.

Attacks against nuclear facilities have been prohibited under several resolutions of the IAEA General Conference as well as by NPT States Parties in their 1995/2000/2010 review conference agreed documents.

In late February, the IAEA Director General stressed that the Agency's General Conference—the annual gathering of all the organization's Member States—had adopted a decision in 2009 on the "Prohibition of armed attack or threat of attack against nuclear installations, during operation or under construction" that affirmed that "*any armed attack on and threat against nuclear facilities devoted to peaceful purposes constitutes a violation of the principles of the United Nations Charter, international law and the Statute of the Agency*".[5]

[4] The nuclear installations in Bushehr were attacked on the following dates: 24 March 1984; 12 February 1985; 5 March 1985; 12 July 1986; 17 November 1987; 19 November 1987; and 19 July 1988. For more on the history and effects of attacking nuclear installations, see Sarah E. Kreps and Matthew Fuhrmann, "Attacking the Atom: Does Bombing Nuclear Facilities Affect Proliferation?" *Journal of Strategic Studies* 34, no. 2 (2011): 161–87, http://dx.doi.org/10.1080/01402390.2011.559021.

[5] IAEA GC(53)/DEC/13, "Prohibition of armed attack or threat of attack against nuclear installations, during operation or under construction", Decision adopted on 18 September 2009 during the eleventh plenary meeting.

4.8 Nuclear-Powered Submarines and IAEA Safeguards

A looming challenge for Agency safeguards is that of safeguarding the naval nuclear cycle in States with comprehensive safeguards agreements (CSAs) in force. Presently, nuclear reactors for naval propulsion are either under development or envisaged for nuclear-powered submarines in at least three CSA States—Australia, Brazil and South Korea—and also could be considered in the future by additional States such as Argentina, Canada, Iran and Japan among others. Paragraph 14 of INFCIRC/153/Rev2 type safeguards agreements allows for the "Non-Application of Safeguards to Nuclear Material to be used in Non-Peaceful Activities", generally interpreted to refer to nuclear-powered ships and submarines, military space vehicles, and nuclear reactors and radio-thermal generators (RTGs) for military bases or isolated radar stations, etc. However, there is no definition or concept of "non-peaceful or non-proscribed nuclear military activities" as this has never been tested at the IAEA Board of Governors or at NPT Review Conferences.

The IAEA Board of Governors has had fractious discussions on this matter in late November 2021 and early March 2022, involving Australia, China and Russia. The Board missed an opportunity to set up a consultation process with its member States and experts to define what is needed to safeguard naval nuclear fuel; and whether the "loophole" should be closed in the Agency's comprehensive safeguards agreements that allows for "non-application of safeguards" on "non-proscribed" military activities such as nuclear-powered submarines. Despite the objections of States involved in the contemplated sharing of naval nuclear propulsion technology, it is now clear that this matter will be controversial at the Tenth NPT Review Conference in August 2022 in discussions in Main Committee II on IAEA safeguards.

4.9 Eleventh NPT Review Conference in Vienna

It is sometimes not well understood that NPT review conferences are *not* UN conferences—rather, they are conferences of the States parties to the NPT, paid for by them separately from UN membership dues and are governed by their own rules of procedure (RoP). Thus, while the President-designate and States parties need to take into account the advice of the UN secretariat which is always given in good faith, they are not bound in any way to accept it and are fully empowered to make their own decisions under the RoP for NPT review conferences taking into account international political developments.

Contrary to popular belief in some circles, the UN formally has nothing to do with the NPT as it was written and adopted in 1968—this is not a criticism of the UN which does valuable work internationally but merely a factual observation. The only international organization to which the Treaty accords a formal role is the IAEA—the role of implementing safeguards or verification of the non-proliferation obligations of non-nuclear-weapon States (NNWS) parties (article III). The inalienable right of

States parties (article IV) to utilize nuclear technologies for peaceful purposes by NNWS, especially developing countries, in practice has come to be implemented through the technical cooperation programme of the IAEA.

The IAEA is an autonomous international organization subject to its own governance structure, and like most international organizations the Agency has a relationship agreement with the UN on a common system for personnel management and related administrative functions.

The UN capably and professionally has been providing services to review conferences and PrepCom sessions, such as, secretary-general of the conference, meeting rooms, interpretation, summary records, and secretarial services including officers to support the president and the chairs. While the UN provides the official secretary to main committee I (nuclear disarmament), credentials and drafting committees, and prepares the elements of their draft reports; the IAEA covers main committees II and III (non-proliferation and peaceful uses) and prepares their draft reports—though the UN also covers items such as regional issues, universality, and the review process, but it is not the secretariat for the NPT, nor is one needed.

In 1995, the NPTREC was moved to New York on the claim that all UN Member States have representation there and thus would enable the maximum number of States parties to participate in the conference's main objective—to decide on the Treaty's extension. A review of the record of participation by States parties shows that in various years up to 30 or more States do not take part or only show up for one or two sessions in order to be registered in the list of participants. Therefore, the argument of participation is not a sufficient reason to keep the review conference in New York.

Starting in 2007, the first session of the PrepCom was moved to Vienna (from New York) in commemoration of the 50th anniversary of the IAEA and its contributions to the implementation of the NPT. The UN has successfully organized PrepCom sessions in Vienna in 2007, 2012 and 2017—thus there is no compelling reason why it would be unable or find it difficult to organize the review conference in Vienna with the assistance of the conference services offices of the UN Office in Vienna (UNOV) and of the IAEA at the Vienna International Centre and its adjoining Austria Center Vienna.

The accountability for compliance with the NPT's non-proliferation obligations is not done in the NPT review process but it is done in Vienna by the IAEA and the assessment is released in the annual Safeguards Implementation Report—the latest report was issued by the IAEA in April 2021 and the next one likely will be issued later this month or in early May this year. The IAEA's annual reports on nuclear safety, nuclear security, technical cooperation programme, and nuclear technology are reviewed in Vienna at the Board of Governors meetings in March and April each year and also in the General Conference in September.

The Preparatory Commission for the CTBT Organization (CTBTO) is the logical venue to discuss any issues related to nuclear weapon testing, even though the CTBT has yet to enter into force.

The reality is that of the present 173 member States of the IAEA, 165 are NNWS party to the NPT. Though some in the EU are propagating the claim that peaceful uses

of nuclear energy are not well known or appreciated; the fact is that currently, at the IAEA there are 848 active technical cooperation projects underway covering development priorities in areas such as human health and nutrition, food and agriculture, water and the environment, nuclear safety, nuclear security, nuclear power generation, nuclear waste disposition, nuclear sciences, industrial applications, nuclear knowledge development and management, and legislative assistance (nuclear law); as well as to develop solutions for future energy needs, and standards for radiation safety and nuclear security worldwide. Presently, the Agency is assisting developing Member States with real time reverse transcription–polymerase chain reaction (real time RT-PCR) methodology for detection of COVID-19 infections in people—previously, RT-PCR technology was utilized by the IAEA to diagnose diseases such as Ebola, Zika, MERS-Cov, SARS-Cov1 and other major zoonotic and animal diseases.

Given its direct relationship to the NPT, it is now time for NPT States parties to relocate the review conference to Vienna to be closer to the Agency without whose verification and technical cooperation programme the NPT would be reduced to a hollow shell. The Eleventh NPT Review Conference likely will be held in 2026 and the Twelfth NPT Review Conference in 2030. Now it is imperative for NPT States Parties to regularize NPT review conferences in Vienna where they logically belong, starting in 2026.

4.10 Possible Recommendations: NPT 2022

The following is a non-exhaustive list of possible recommendations.

1. Reaffirm relevant viable elements of the 1995/2000/2010 NPT agreed outcomes in an updated "concrete actions" to 2026—to be reviewed and updated at the 2026 review conference.
2. Recommit to and undertake to secure ratification of the CTBT by the remaining two nuclear-weapon and three non-nuclear-weapon States parties to the NPT by 2025, as well as to redouble regional and global efforts to achieve entry-into-force of the CTBT by 2026.
3. Note the fact of the entry-into-force in January 2021 of the TPNW; the nuclear-weapon States and their allies undertake to attend the first conference of TPNW States parties as observers and to table their views on achieving nuclear disarmament as envisaged pursuant to Article VI of the NPT; and all NPT States parties undertake to facilitate and resume civility in dialogue on this matter.
4. Affirm the continuation of the consultation process involving the five NPT nuclear-weapon States (aka "P-5" process) to focus on implementation of specific measures to reduce risks of deliberate, inadvertent or accidental use of nuclear weapons, as agreed in the 2000/2010 NPT outcomes and supplement with additional steps such as: data exchanges on nuclear weapon holdings; "managed" technical briefings on new advanced systems deployed or being

tested; clarification on doctrines; and understandings on not using cyber capabilities to target or interfere with nuclear weapon command and control systems and associated early warning networks, among other such measures as proposed at recent review conferences.

5. Development and deployment of "non-nuclear strategic weapon" systems can be highly destabilizing and even provocative; the five NPT nuclear-weapon States undertake to avoid destabilizing actions and engage in transparency exchanges amongst themselves.
6. At the review conference, and preparatory committee sessions, the five NPT nuclear-weapon States undertake to provide informative technical briefings in Main Committee 1 and cluster 1, respectively, jointly and separately, on the items noted in §4-§5 above.
7. By 2026, all non-nuclear-weapon States undertake to conclude and bring into force Additional Protocols to their (NPT) comprehensive safeguards agreements, especially those categorized by the IAEA as having "significant nuclear activities"; and for all remaining States with small quantities protocols (SQPs) based on the old standard text to amend or rescind them as called for in 2005 by the IAEA Board of Governors and the Director General.
8. Call on all parties to the JCPOA to implement the agreement in full and on Iran to further extend its cooperation with the IAEA on safeguards implementation.
9. Reaffirm full implementation of the 1995 Resolution on the Middle East taking into consideration developments at the UN Secretary General's conference on the Middle East zone free of nuclear and other weapons of mass destruction and call on Israel to accede to the NPT as a NNWS.
10. Call on India and Pakistan to implement UN Security Council resolution 1172 (1998) and call on the DPRK to freeze its nuclear-weapon and missile programmes; to sign and ratify the CTBT and cease further development of nuclear weapon programmes.
11. Reaffirm the NPT 2000/2010 understandings that nuclear cooperation for peaceful purposes must be provided to non-nuclear-weapon States, as defined in the context of the NPT, only under IAEA comprehensive safeguards as a condition of supply.
12. Support multinational approaches to the sensitive elements of the nuclear fuel cycle, and in this regard to encourage States to utilize the low enriched uranium resources of the IAEA LEU Bank at Oskemen (Kazakhstan) and the IAEA LEU Reserve at Angarsk (Russian Federation) for their nuclear fuel requirements.
13. Peaceful uses of nuclear energy much pre-date the NPT, however, the Treaty has facilitated international cooperation in the peaceful uses of nuclear energy through the IAEA and this is well understood and recognized—currently 140 States benefit from 848 IAEA technical cooperation projects across the broad spectrum of peaceful applications of nuclear technology—accordingly, all States parties undertake to facilitate peaceful uses under applicable IAEA safety, security and safeguards measures, without discrimination in accordance with the Treaty.

14. The review process for the Treaty as strengthened in 1995 and improved in 2000 works well when States parties cooperate in good faith to strengthen the authority and integrity of the Treaty; accordingly States parties undertake to carry out the review process as provided for in the 1995/2000 documents and commit to cooperate in assisting the President in preparing a concise review conference final document, covering all three pillars, regional issues, universality and implementation of the 1995 Middle East resolution, for adoption as a whole by consensus, in recognition of the NPT being the cornerstone for nuclear non-proliferation, nuclear disarmament and cooperation in peaceful uses of nuclear energy.
15. Relocate NPT Review Conferences to Vienna starting from the Eleventh NPT Review Conference, likely to be convened in 2026.

4.11 Epilogue

General Lee Butler, former commander of the US Strategic Air Command, insightfully observed that nuclear proliferation cannot be contained in a world where a handful of self-appointed nations both arrogate to themselves the privilege of owning nuclear weapons and extol the ultimate security assurances, they assert such weapons convey.

At an event that I attended in Ottawa (Canada), on 11 March 1999, addressing the Canadian Network Against Nuclear Weapons, as noted in the header (to this article), General Butler cited WWII General Omar Bradley, who had said on Armistice Day 11 November 1948 that, "*We live in an age of nuclear giants and ethical infants, in a world that has achieved brilliance without wisdom, power without conscience. We have solved the mystery of the atom and forgotten the lessons of the Sermon on the Mount. We know more about war than we know about peace, more about dying than we know about living. If we continue to develop our technology without wisdom or prudence, our servant may prove to be our executioner*".

The reason for recalling this admonition is a disturbing new tendency starting around 2013 for some States, especially some of the NWS, to push back on implementing agreed commitments on nuclear disarmament of 1995/2000/2010 while insisting on full implementation of NNWS commitments on safeguards, export controls, nuclear safety and security, among others. They posit that for nuclear disarmament it is important to take into account the international security situation, revived great power competition and regional instabilities, and to focus instead on nuclear risk reduction, motivations to hold nuclear weapons and on international arms control institutions. Furthermore, it is even argued that the NPT review process may no longer be fit for purpose as regards nuclear disarmament unless it takes account of the considerations noted above.

The NPT cannot resolve every problem related to the international security environment and strategic stability—that is not and never has been the purpose or objective of the Treaty or of its review process. The NPT review process included in the Treaty at the insistence of NNWS was and remains to ensure accountability for

the implementation of its provisions and obligations. As discussed above, the 1995 NPTREC in deciding on indefinite extension instituted a strengthened review process that was further elaborated in 2000 to ensure "permanence with accountability". The NPT is not the forum to discuss and review international relations or disputes, the appropriate venues for these are the UN Security Council and the General Assembly.

Other negotiations in other forums will be needed to address advanced emerging technologies, cyber and space weapons, and other related political-military and technological developments. The NPT is not the appropriate forum to negotiate on these matters, but it is the forum to negotiate on measures to further strengthen the authority and integrity of the Treaty across its three pillars and to review their implementation along with Treaty provisions.

The NPT is the only multilateral nuclear arms control treaty on the books that commits the NWS to nuclear disarmament and the NNWS to non-proliferation—it is the only multilateral forum in which the NWS are prepared to discuss their nuclear weapon policies with the NNWS, albeit within limits. If the foundations of multilateralism are attacked and weakened, the NPT will not escape its effects.

A key element for success at the next review conference will rest on clear acknowledgement of the continuing validity of the relevant elements of 1995/2000/2010 outcomes that along with the Treaty itself can be considered the "triptych" of the *acquis communautaire* of the NPT community. The *Berlin Declaration on The NPT at Fifty* got it right when it stated that: "We underline that past NPT commitments remain valid and form the basis for making further progress in fully implementing the treaty and achieving a world free of nuclear weapons". Characterizing reaffirmation of existing past commitments as "conventional wisdom that is at least a generation out of date" wins no friends, not to mention is disingenuous.

Finally, the COVID-19 pandemic will have significant impact on how we think about "national security" and should lead to rethinking about the role of nuclear weapons in international security and to resurrecting concepts such as "our common future", "human security", "cooperative security", "common security", "collective security" (not the NATO version) and the like that were advanced in the 1970s, 1980s and 1990s during times of perceptions and realities of existential threats to achieve a more secure world.

An international order anchored in legal norms and treaties offers the best hopes for survival. In this regard the Treaty on the Prohibition of Nuclear Weapons could establish a "right to nuclear peace" and stop nuclear weapons becoming a "perpetual menace". Sometimes the most penetrating wisdom comes out of the "mouths of babes", in this case a child at the United Nations kindergarten in New York who aptly observed: "Why a country that makes atomic bombs would ban fireworks?".

We need to heed the call of Pope Francis when, during his visit to Japan in November 2019, he clearly voiced his demand that world powers renounce their nuclear arsenals. He declared that both the use and possession of atomic bombs an "immoral" crime and a dangerous waste. I end by recalling Pope Francis' lament at the Hiroshima Peace Memorial, "*How can we propose peace if we constantly invoke the threat of nuclear war as a legitimate recourse for the resolution of conflicts? May the abyss of pain endured here remind us of boundaries that must never be crossed*!".

Notes

1. Tariq Rauf, is a Director of Atomic Reporters; former member of the Eminent Persons Group for Substantive Advancement of Nuclear Disarmament established by the Foreign Minister of Japan; former Head of Nuclear Verification and Security Policy at the International Atomic Energy Agency (IAEA) in Vienna, former Alternate Head of the IAEA Delegation to the nuclear non-proliferation treaty (NPT) Review Conferences; Senior Advisor on nuclear disarmament to the Chairs (nuclear disarmament) at the 2015 NPT Review Conference and 2014 NPT PrepCom; long time Expert with Canada's NPT delegation until 2000. *Personal views are expressed here.*

Chapter 5
Lessons Learnt from the Fukushima Nuclear Accident

Tatsujiro Suzuki

Abstract Even after 11 years, the Fukushima accident is not completely over yet. Technological challenges for decommissioning of Fukushima are unprecedented. Economic, social, and humanitarian impacts are huge and will remain for a long time. The Fukushima nuclear accident completely changed the energy picture in Japan. Nuclear energy is no longer most reliable, least expensive, "main" power source in Japan. Japan's long-term energy policy is self-inconsistent, stating "Japan will reduce its dependence on nuclear power as much as possible," but maintains it as an important option for carbon neutral policy. But mainly due to poor economics, role of nuclear power in carbon neutral policy could be limited. Given the Ukrainian crisis, international community must strengthen international law and norms to protect all nuclear facilities, in particular, sensitive facilities, against military attack. Finally, lessons learned from the Fukushima accidents are: (1) Think unthinkable (2) Engineering risk assessment is not enough (3) Need for independent scientific advice/policy review organization (4) Public trust is essential.

5.1 Introduction

11 years have passed since the Fukushima Daiichi nuclear accident in 2011. Still, there is no clear prospect for decommissioning of the crippled Fukushima reactors and other radioactive wastes generated by decontamination of the land. While evacuation zones have been shrinking steadily, still more than 30,000 people are away from home. Impact of nuclear accident on Japan's energy profile has been quite significant, and public trust has not been recovered yet. The Japanese government maintains its self-inconsistent energy policy, i.e. reducing dependence on nuclear energy as much as possible, while keeping nuclear power as an important option for policy of "carbon–neutral by 2050". This paper summarizes the current status of the Fukushima accident (which is not over yet), and draw lessons from the accident.

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5.2 Fukushima Update: The Accident Is Not Over

Many on-site and off-site challenges remain even 11 years after the accident. Here is the short summary of those challenges.

(1) On-site challenges

The removal of spent fuel from cooling pools of Unit 1–4 is the first step to reduce potential risks at the site. So far, removal of spent fuel from Unit 3 and 4 was completed in December 2014 and February 2021 respectively. But spent fuel removal from Unit 1 and 2 has not started yet, and it is currently expected that all spent fuel from both units will be removed by 2031.[1]

The biggest short-term on-site challenge is management and disposal of "contaminated water". Due to continuous cooling of fuel debris at reactors 1–3 and continuous inflow of underground water into the reactor site, contaminated water has been generated and been stored on-site. Through various measures, such as pumping up water by sub-drains, the construction of land-side frozen walls, generation of contaminated water has been gradually decreasing from 350 to 130 m^3/day. Still, it means that almost every week a new 1,000 m^3 tank is needed.

The plan is to remove most of the radioactive substances (except tritium) by a multi-nuclide removal equipment called Advanced Liquid Processing System (ALPS) and store the "treated water" in tanks. Currently, about 1.3 million m^3 of treated water is stored in 1,020 tanks. Although ALPS is supposed to separate most of the radionuclides except tritium, 34% of treated water (total of 1.3 million m^3) satisfies regulatory standards and two thirds (about 855,000 m^3) of treated water need to be re-purified.[2] On April 13, 2021, the government decided that treated water containing tritium (and other radionuclides under regulatory standards) will be discharged into the ocean. The treated water needs to be diluted further (at least 100 times or more) so that the tritium concentration after dilution should be below 1,500 Bq (Bq) per liter which is said to be far below the regulatory standard for discharged tritium water.[3]

Still, before TEPCO can begin with the implementation the discharge plan, local consent will be needed based on pledge made in 2015 that Tokyo Electric Power Co. (TEPCO) would not discharge the water "without gaining an understanding from stakeholders".[4] On 5 April 2022, a major fisheries group in Japan told Prime

[1] Ministry of Economy, Trade and Industry (METI), "Status Update of Fukushima Daiichi Commissioning", March 2022, see https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/pdf/1f_status_20220307.pdf.

[2] Tokyo Electric Power Co (TEPCO) Holdings, "Treated Water Portal Site", as of June 9, 2022. https://www.tepco.co.jp/en/decommission/progress/watertreatment/oceanrelease/index-e.html.

[3] This is reported to be 1/40 of regulatory standard for discharged tritium water. But that statement is somewhat misleading. As the treated water contains other nuclides, 1,500 Bq/L is a regulatory standard for discharge of contaminated water at Fukushima plant, considering the sum of possible exposures from other radioactive nuclides.

[4] *Asahi Shimbun*, "Japan to release 'treated water' from Fukushima plant into the sea", 13 April 2021, see https://www.asahi.com/ajw/articles/14329854, accessed 16 June 2022.

Minister Kishida that they still firmly oppose the discharge of treated water into the sea due to concern over negative impact on the industry.[5] International concern over discharge of treated water also remains. For example, in April 2022, South Korean Representative Seo Sam-seok made a statement at an international conference, saying "The contaminated water released into the ocean will spread across the entire Pacific Ocean in 10 years and affect almost all of our sea".[6]

In order to reduce both domestic and international concern, the Japanese government asked International Atomic Energy Agency (IAEA) to review the overall plan. The IAEA Task Force published its first report on 29 April, 2022 and it concluded the risk associated with overall discharge plan is expected to be very low.[7] Despite such efforts, there is no clear evidence that domestic and international concerns have disappeared.

The most difficult, long-term challenge is what to do with fuel debris. Internal investigation of fuel debris inside the reactor vessels of Unit 1–3 has been postponed several times due to malfunction of remotely operated vehicle (ROV) which is expected to visually confirm existence of fuel debris. There is no clear prospect about what to do with fuel debris at this moment.

(2) Off-site challenges

According to Fukushima Prefecture, as of March 2022, still 32,404 residents are away from home, although the number of evacuees decreased from the peak of 164, 865 in May 2011.[8] Evacuation order has been lifted little by little, and on June 12, 2022, for the first time, the order was lifted for a district designated as "difficult-to-return" zone (an area with high level of radiation higher than 50 mSv/year).[9] And on June 30, evacuation order was also lifted for the first time for a part of a town, Okuma, which hosts the Fukushima nuclear power plant. The area was designated as "reconstruction and revitalization area" which received special government fund for reconstruction.[10] But it was reported only 13% of residents of Okuma town responded to a survey that they would like to go back to the town.[11]

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[5] *Kyodo News*, "Fisheries group conveys to PM opposition to Fukushima water release", 5 April 2022, see https://english.kyodonews.net/news/2022/04/493cfc399008-fisheries-remain-opposed-to-fukushima-water-discharge.html, accessed 16 June 2022.

[6] CGTN, "Int'l community voices concerns over Japan's wastewater release plan", April 14, 2022. https://news.cgtn.com/news/2022-04-14/Intl-community-voices-concerns-over-Japan-s-wastewater-release-plan-19ehhSrxsg8/index.html.

[7] IAEA, "IAEA Releases First Report on Safety of Planned Water Discharge from Fukushima Daiichi Site", Press Release, 29 April 2022, see https://www.iaea.org/newscenter/pressreleases/iaea-releases-first-report-on-safety-of-planned-water-discharge-from-fukushima-daiichi-site.

[8] Fukushima prefecture official statistics, March 2022. https://www.pref.fukushima.lg.jp/site/portal/list271.html.

[9] NHK News, "Evacuation order lifted in part of Fukushima 'difficult-to-return' zone", 12 June 2022, see https://www3.nhk.or.jp/nhkworld/en/news/20220612_11/.

[10] World Nuclear News, 29 June 2022.

[11] The Japan News (Yomiuri Shimbun), "Govt lifts evacuation order in part of Okuma", June 30, 2022. https://japannews.yomiuri.co.jp/society/general-news/20220630-41883/.

Nationwide inspection for food contamination continues. In FY 2021, total of 41, 361 samples analyzed and only 157 samples (0.38%) was found to exceed the legal limits.[12] Import restrictions of Japanese food due to the Fukushima accident have been relaxed gradually. On February 8, 2022, it was reported that Taiwan would relax a ban on Japanese food imports,[13] and on June 29, 2022, the UK government announced that it would also lift food import restrictions from Japan.[14]

The biggest issue associated with decontamination work is what to do with huge amount of contaminated soil shipped to interim storage sites. The government designated total of 1,600 ha of area as "interim storage site", and as of May 2022, 79.6% of the area (1,273 ha out of 1,600 ha) has been "contracted" for the establishment of a storage facility.[15] As of the end of May 2022, total of about 13 million m^3 of contaminated land was transferred to interim storage facilities.[16] However, there is no clear plan regarding the final disposal of such contaminated soil after interim storage. The government plans to reuse some of the contaminated land which was verified as "below regulatory standards" and started the demonstration program and plan to issue guidelines by FY 2024. But not a single prefecture backs such reuse plan.[17] It shows that there is still a lack of public trust in government plan.

(3) Cost associated with the Fukushima accident

The total cost of the Fukushima accident includes the cost of decommissioning of Fukushima reactors, treatment and disposal of contaminated water, final disposal of radioactive waste, and compensation to victims of the accident. The earliest cost estimate was done by the Committee on Management and Financial Affairs of Tokyo Electric Power Company set up after the accident in 2011. The report, published on October 3, 2011, estimated that total costs would be ¥5.7 trillion. This estimate did not include any expenses for decontamination nor any costs of final disposal of radioactive waste.[18] The second estimate was made in 2014, and its total cost estimate

[12] Ministry of Health, Labor and Welfare, "Sum up of radionuclides monitoring data reported in Japanese fiscal year 2021 (from April 2021 to March 2021)", as of March 2021, see https://www.mhlw.go.jp/english/topics/2011eq/dl/Sum%20up_March_2022.pdf.

[13] *Reuters*, "Taiwan to relax Japan nuclear disaster-related food import ban", as published in *Asahi Shimbun*, 8 February 2022, see https://www.asahi.com/ajw/articles/14543355.

[14] World Nuclear News, 29 June 2022.

[15] Ministry of the Environment, "Chukan chozo shisetsu no gaiyou (Outline of Interim storage facilities)", xx (in Japanese), see http://josen.env.go.jp/chukanchozou/about/#section03, accessed 18 June 2022.

[16] Ministry of Environment, "Jokyo dojo nado no yuso (Transportation of contaminated land)" (in Japanese), see http://josen.env.go.jp/chukanchozou/transportation/index.html, accessed 18 June 2022.

[17] *Asahi Shimbun*, "Survey: Not a single prefecture backs reuse of radioactive soil", 28 March 2021, see https://www.asahi.com/ajw/articles/14311546, accessed 18 June 2022.

[18] The Committee on Management and Financial Affairs of Tokyo Electric Power Co., "Iinnkai Houkokusho (The Committee Report)", October 3, 2011 (in Japanese), http://www.cas.go.jp/jp/seisaku/keieizaimutyousa/dai10/siryou1.pdf.

was ¥11.6 trillion,[19] and the third estimate made in 2016 done by a "Committee for Reforming TEPCO and Overcoming 1F Challenges" established by the Japanese government was ¥22 trillion yen.[20]

In 2017, the Japan Center for Economic Research (JCER) came up with their own cost estimate based on a different methodology and assumptions from the ones made by the government. The report concluded that the total cost could rise to ¥50–70 trillion.[21] In 2019, JCER updated their analysis based on different assumptions and concluded that the cost could go up to ¥30–80 trillion.[22]

On 13 July 2021, METI released its latest cost estimates for various power generation sources, including nuclear power.[23] In its report, new estimate of total accident costs was also published. The total cost now included so-called "government administration cost" which is a tax money spent on nuclear power, and was estimated to be ¥23.8 trillion. Other costs were slightly changed but almost the same as 2016 (Fig. 5.1).

In short, the estimates done by the government is neither comprehensive nor up to date and clearly underestimate the total costs. The biggest difference between the government and JCER estimates comes from the fact that the government estimate does not include final disposal costs for radioactive waste generated by decommissioning and decontamination.

(4) Legal cases against TEPCO or the Government

There are many legal cases on the responsibility of the Fukushima accident, and on the re-startup of existing nuclear power plants. The results are mixed, while some are against TEPCO and/or the government some are in favor for them. And there are some decisions to stop operation of existing nuclear power plants while some allowed utilities to start the operation of nuclear power plants.

In 2022, there were two historic court decisions, which can bring significant impacts on future nuclear policy and on nuclear industry, in particular, on operators (utility companies) of nuclear power plant.

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[19] NHK News, "Shinsai 3 nen, genpatsu jiko no songai-gaku 11 chou-en ni (3 years after the earthquake, total cost of the nuclear accident will reach over 11 trillion yen)", (in Japanese), March 11, 2014. http://www3.nhk.or.jp/news/genpatsu-fukushima/20140311/1516_songaigaku.html.

[20] The Committee for Reforming TEPCO and Overcoming 1F Challenges, "Recommendations for Reforming TEPCO", 20 December 2016.

[21] Japan Center for Economic Research (JCER), "Accident Cleanup Costs May Rise to 50–70 Trillion yen: It's Time to Examine legal liquidation of TEPCO", March 7, 2017. https://www.jcer.or.jp/english/accident-cleanup-costs-may-rise-to-50-70-trillion-yen.

[22] Japan Center for Economic Research (JCER), "Accident Cleanup Costs Rising to 35–80 trillion yen in 40 years: Considering the postponing of decommissioning with 'Confinement-managing' scenario as a possible option. Urgent need for measures to manage contaminated water", July 3, 2019. https://www.jcer.or.jp/english/accident-cleanup-costs-rising-to-35-80-trillion-yen-in-40-years.

[23] Ministry of Economy, Trade and Industry, Working Group on Power Generation Cost Assessment, "Kihon Seisaku Bunnkakai ni Taisuru Hatudenn Kosuto To No Kensho ni Kansuru Houkou" (Report on Power Generation Costs etc. to the Basic Policy Committee), 13 July 2021 (in Japanese). https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/2021/045/045_005.pdf.

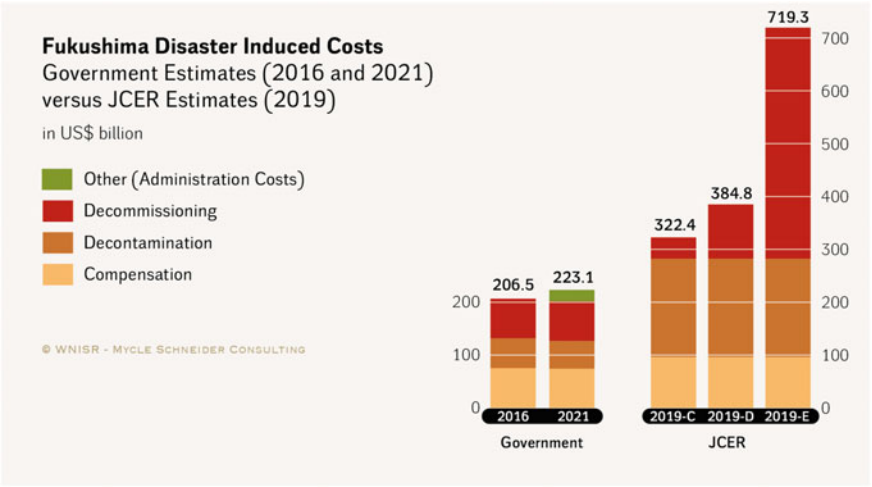

Fig. 5.1 Total cost of Fukushima accident: comparison of government and JCER estimate. *Source* Mycle Schneider et al., "World Nuclear Industry Status Report: 2021", September 2021. https://www.worldnuclearreport.org/-World-Nuclear-Industry-Status-Report-2021-.html

One was the Supreme Court decision made in June 2022, which dismissed the argument that the Japanese government (regulatory agency) was responsible for the accident.[24] But the same Supreme Court in March 2022 ordered TEPCO to pay compensation of ¥1.4 billion to about 3,700 people who were heavily affected by the Fukushima accident. This was the first time that the Supreme Court made decisions on the responsibility of the accident.[25]

The other was the decision made by the Tokyo District Court on July 13, 2022. The Tokyo District Court ordered former executives of TEPCO to pay ¥13 trillion in damages to the operator of the Fukushima Dai-ichi nuclear power plant. The case was brought by TEPCO shareholders and the ruling was the first time a court has found former executives responsible for the nuclear accident. The criminal case against former executives of TEPCO resulted in a different decision that they were not responsible for the accident.[26]

These rulings mean that a utility company or executives of the operator of nuclear power plants could be legally liable for serious accident, but not the government (or regulator). In fact, under the Japanese nuclear accident compensation law, the

[24] *Kyodo News*, "Japan's top court rules state not liable for Fukushima disaster", 17 June 2022, see https://english.kyodonews.net/news/2022/06/e3802f4efbc6-breaking-news-japans-top-court-rules-state-not-liable-for-fukushima-disaster.html.

[25] *Kyodo News*, "Court orders TEPCO to pay 73.5 million yen over Fukushima crisis", 2 June 2022, see https://english.kyodonews.net/news/2022/06/2ece2b577eea-court-orders-tepco-compensation-over-fukushima-crisis.html.

[26] *Reuters*, "Tokyo court orders ex-Tepco execs to pay $95 bln damages over Fukushima disaster", July 13, 2022. https://www.reuters.com/business/environment/tokyo-court-orders-ex-tepco-execs-pay-95-bln-damages-over-fukushima-disaster-nhk-2022-07-13/.

operator company is responsible for all compensation costs without any cap. But the law also says that the government should assist the operator to pay all related costs. The rulings, however, go beyond the government policy and guidelines for compensation, and it could be interpreted that financial/legal risk of operating nuclear power plants could be much higher than currently expected.

5.3 Impact on Japan's Energy Policy

The Fukushima accident has caused fundamental shift in Japan's energy structure.

Before the Fukushima accident in 2011, 54 nuclear reactors (48.9 GWe) were operating, supplying about 26% of total electricity supply in Japan (2010). Now, only 10 reactors (10.0 GWe) are operating (as of March 2022) and the share of nuclear power dropped to only 3.9% in 2020. Instead, the shares of fossil fuels and renewable energy have increased significantly. Coal's share increased from 28 to 31%, natural gas from 29 to 39%, and renewable energy from 9 to 20% (all from 2010 to 2020).[27]

Impact on public opinion was also quite remarkable. According to a public survey done by a nuclear industry-affiliated organization, the share of public opinion who thinks "nuclear power is necessary" dropped dramatically from 87.4% in September 2010 to only 24.9% in December 2013. The latest opinion survey done by the same organization shows that public support for nuclear power is still very low; the share of public who thinks "nuclear power should be maintained" is 9.1% and "nuclear power should be expanded" is only 2.2%, while the share of public who thinks "nuclear power should be phased out" is 52.8% and "nuclear power should be shut down immediately" is 7.9%.[28]

Japan's basic energy policy has also shifted reflecting public opinion but only partially. According to the METI's Strategic Energy Plan published in 2014 (the first Plan published after the Fukushima accident) said in the beginning; "Japan will minimize its dependency on nuclear power. Needless to say, that is the starting point for rebuilding Japan's energy policy", but at the same time it also said "Nuclear power is an important base-load power source as a low carbon and quasi-domestic energy source, contributing to stability of energy supply–demand structure", reversing the previous government's decision to phase out nuclear energy by 2030s.[29]

The latest METI's Strategic Energy Plan published in 2021 maintains its somewhat "self-inconsistent" policy of "reducing its dependence on nuclear power as much as possible" while keeping nuclear power as "an important base-load power source as a

[27] Ministry of Economy, Trade and Industry (METI), News Release, November 26, 2021. https://www.enecho.meti.go.jp/statistics/total_energy/pdf/gaiyou2020fyr.pdf.

[28] Japan Atomic Energy Relations Organization (JAERO), "Public Opinion on Nuclear Power: 2021 edition", February 2022 (in Japanese) https://www.jaero.or.jp/data/01jigyou/pdf/tyousakenkyu2021/results_2021.pdf.

[29] Ministry of Economy, Trade and Industry (METI), "Strategic Energy Plan", April, 2014. https://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/4th_strategic_energy_plan.pdf.

Table 5.1 Power generation cost estimate for newly constructed power plant (2021)

Power source	Coal	Natural gas	Nuclear	Solar PV (industry)	Solar PV (home)	Wind (land)
Ave. power gen. cost (¥/kWh)	**13.6–22.4**	**10.7–14.3**	**11.7–**	**8.2–11.8**	**8.7–14.3**	**9.9–17.2**
Life time and capacity factor	40 yr 70%	40 yr 70%	40 yr 70%	25 yr 17.2%	25 yr 13.8%	25 yr 25.4%

Source METI, Cost Verification Working Group Report, August 2021 https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/mitoshi/cost_wg/2021/data/07_05.pdf

low carbon and quasi-domestic energy source".[30] The government's target of nuclear share is 20–22% by 2030, which seems impossible to achieve.

One of the noted difficulties that nuclear power is facing is its economic competitiveness. The most recent nuclear electricity cost-estimate by the government (METI) was carried out in 2021 and average power generation cost of newly built nuclear power plant was estimated at >¥11.7/kWh. This included estimated costs associated with Fukushima accident and assumed then those total costs would be limited to ¥23.8 trillion. It was translated into ¥15.7 trillion for a model plant. As a result, for the first time, nuclear power is no longer the cheapest power generation source in Japan. According to the new government estimates, solar PV as the cheapest source at ¥8.2–14.3/kWh followed by LNG at >¥10.7–14.3/kWh[31] (Table 5.1).

5.4 Ukrainian Crisis and Its Implications

Russian invasion of Ukraine and subsequent attack on nuclear power plants was a shocking event for nuclear safety and security. According to the Article 56 of Additional Protocol of the Geneva Convention, along with dams and dykes, "nuclear electrical generation stations shall not be made the object of attack." It should be noted that such protection "shall cease if it is used for other than its normal function and in regular, significant and direct support of military operations".[32] So it is critically important that the nuclear power plant is used exclusively for peaceful purpose and under international safeguards.

[30] Ministry of Economy, Trade and Industry (METI), "Strategic Energy Plan", (outline in English), October 2021. https://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/6th_outline.pdf.

[31] Working Group on Power Generation Cost Assessment, "Kihon Seisaku Bunnkakai ni Taisuru Hatudenn Kosuto To No Kensho ni Kansuru Houkou" ["Report on Power Generation Costs etc. to the Basic Policy Committee"], METI, 13 July 2021 (in Japanese), see https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/2021/045/045_005.pdf.

[32] International Committee of the Red Cross (ICRC), "Protocol Additional to the Geneva Conventions of 12 August 1949" https://www.icrc.org/en/doc/assets/files/other/icrc_002_0321.pdf.

It is also important to point out that the above article is not applicable to non-power generating nuclear facilities, such as research reactors or, more significantly, fuel cycle facilities, including uranium enrichment, reprocessing facilities, spent fuel storage facilities. In particular the latter two facilities could cause substantial radioactive releases, if attacked. The IAEA General Conference adopted a resolution regarding Protection of Nuclear Installations against Armed Attacks, including those non-power generating facilities.[33] While it is important to keep this international norm but it certainly does not have an enforcing power. It is important thus legal protection of nuclear facilities against military attacks must be enhanced to include non-power generation facilities especially reprocessing plant and fuel-storage facilities.[34]

5.5 Lessons Learnt Updated

Given the current situations described above, I update the lessons learnt from the Fukushima accident as follows.

1. Think Unthinkable: This is one of the most important lessons learnt from the Fukushima accident. It is natural that operators and policy makers tend to take actions based on "wishful thinking", i.e. denying possible failure. This could lead to "unpreparedness" for unexpected events and crisis. In order to prepare "unexpected" events, it would be necessary for operators and policymakers to try hard to "think unthinkable" events. The Ukrainian crisis has proven that this lesson is critically important.
2. Engineering Risk Assessment is not good enough: Engineering Risk Assessment is based on probability and possible consequences. The Fukushima accident taught us that the risk assessment methodology is not good enough. First, its probability is not reliable. Second, its consequences may not be quantifiable easily. Social, ethical and cultural impacts should also be included as possible consequences. It is thus necessary to include social scientists and even the public to assess the risk of nuclear power.
3. Need for independent scientific advice and oversight organization: As is well known, Japan's regulatory agency before Fukushima accident was not truly "independent". Now Japan's new Nuclear Regulation Authority (NRA) is legally "independent" organization. But Japan still lack an independent scientific advice and policy oversight organization. That is probably one of the major reasons that public trust in government policy or nuclear industry has not been restored.

[33] International Atomic Energy Agency, "Protection of Nuclear Installations Against Armed Attacks", GC(XXXI)/RES/475, 25 September 1987. https://inis.iaea.org/collection/NCLCollectionStore/_Public/40/082/40082631.pdf?r=1&r=1.

[34] Tatsujiro Suzuki, "Implications of Ukraine nuclear crisis for nuclear non-proliferation, security and safety", The Korea Times, March 30, 2022. https://www.koreatimes.co.kr/www/opinion/2022/03/137_326389.html.

4. Public Trust is essential: Finally, the most important lesson is that public trust is essential for any public policy implementation. Even if policy is scientifically reasonable, it will not be easy to implement a policy without public trust. Scientific community itself needs public trust too. The Fukushima accident and the following events described above proved that lack of public trust is a major problem for most of the issues discussed. In order to restore public trust, transparency, independent oversight, and public participation in decision making is necessary.

5.6 Conclusion

11 years have passed since the Fukushima nuclear accident. While there has been significant progress in reconstruction of Fukushima area, lack of public trust is still a major problem for most issues associated with the Fukushima accident. Decommissioning of the Fukushima reactors are moving steadily but much slower than expected, and treatment and disposal of contaminated water has become a major socio-political issue. Cost estimate of Fukushima accident by the government is not reliable and is underestimated as it does not include final disposal cost of radioactive waste. Many legal cases brought by citizens and shareholders continue and the results are mixed. But some critical court decisions may affect future of nuclear policy and nuclear industry operations quite significantly. Impact of the Fukushima accident on Japan's energy picture is also significant, and most importantly, nuclear power is no longer most reliable, least expensive power source in Japan. Although the government would like to maintain nuclear power as an important energy source for its carbon neutral policy, it is probably safe to say that future of nuclear power is uncertain at best, but is likely to play only a marginal role in Japan's carbon neutral policy.

Chapter 6
International Cooperation to Tackle Future Pandemics

Emilio Parisini

As of March 2022, the official figures of the COVID-19 health crisis have hit the stunning level of nearly 500 million cases and over 6 million deaths worldwide (source https://www.worldometers.info/coronavirus). To paint such a bleak picture as accurately as possible, since the beginning of the pandemic national health authorities have more or less diligently provided the world community with daily information on new cases and deaths within each country, thus allowing the monitoring of surges and declines of infection waves. Such crucial information has clearly been instrumental in the decision making process that has been put in place on a global scale in the effort to curb the problem. However, in early 2022, the Lancet published one of the first studies where the estimated excess mortality (defined as the observed all-cause mortality minus the expected mortality) in each country in the years 2020 and 2021 was calculated relative to pre-pandemic years [1]. Interestingly, the study provided a rather different picture from the official figures in terms of actual COVID-19-related deaths in all countries. Indeed, the study showed that most countries had largely underestimated, albeit to different extents, their reported COVID-19-related deaths, suggesting that the overall death toll of this pandemic around the world could be even three times as high as the official figures suggest. In other terms, the impact of the pandemic has quite clearly been greater than the reported deaths due to COVID-19 alone, some of which caused directly by the SARS-CoV-2 infection and other by collateral (or indirect) consequences. Interestingly, a paper published in Nature Medicine more or less in the same period analyzed the quality and the extent of essential health services such as for instance cancer screening, HIV testing, maternal health services and others in several countries during the COVID-19 pandemic, both

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in poor and in rich countries [2]. To provide unbiased results, the study analyzed the effect of the pandemic on 31 health services in 10 different countries: two low-income countries (Ethiopia and Haiti), six middle-income countries (Ghana, Laos, Mexico, Nepal South Africa and Thailand) and two high-income countries (Chile and South Korea). The study found that cancer screenings, TB screening and detection and HIV testing were most affected (26–96% declines), while total outpatient visits declined by 9–40%, maternal health services showed a 5–33% disruption and routine childhood vaccinations were also severely disrupted. This general picture is now emerging also by a number of similar studies conducted in all parts of the world. Clearly, as major health services declines are likely to have severe global health consequences, because of the COVID-19 crisis most governments will need to invest in restoring their disrupted health systems and provide their citizens with adequate sanitary infrastructures, in order not to compromise on life expectancy and quality of life. Moreover, what has become clear is that the world needs to prepare for future pandemics and that we must learn from the COVID-19 crisis in order to react swiftly and efficiently when the next pandemic will occur.

Among the top initiatives aimed at preventing the possible catastrophic consequences of future pandemics is the establishment of the Coalition for Epidemic Preparedness Innovations (CEPI). CEPI is a global coalition of public, private, philanthropic and civil society organizations that was set up in Davos (Switzerland) in 2017 with the goal of coordinating and financing vaccine R&D for emerging infectious diseases. The scope of the coalition is to identify priority threats, to build capabilities for rapid response to unknown threats and to move vaccine candidates through preclinical and clinical studies. So far, CEPI has received a global financial commitment from a number of donors, both at the national governments level and at the level of philanthropic organizations such as the Bill and Melinda Gates Foundation and the Wellcome Trust, to name just a few. CEPI is working toward the so-called "100 Days Mission", whose aim is to put in place the necessary technologies and infrastructures to allow the production of safe and effective vaccines within 100 days of a new epidemic. To this end, CEPI is focusing on several known infectious diseases for which a vaccine could potentially be developed, such as Middle East respiratory syndrome-related coronavirus (MERS-CoV), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), Nipah virus, Lassa fever, Ebola, Marburg fever, Zika, and Rift Valley fever. Moreover, CEPI aims to develop suitable vaccine technologies and approaches (mostly mRNA-based) against any potential new infectious disease that may arise unexpectedly ("Disease X"). Since its inception, CEPI has helped creating a large number of COVID-19 vaccines and has made billion of doses equitably accessible to most countries via the COVID-19 Vaccines Global Access (COVAX) initiative. Further essential components of the 100 Days Mission are the establishment of an international surveillance network for the early identification of unusual cases of flu, the development and the production of accurate and rapid diagnostic tests and the activation of a global manufacturing network to produce accurate diagnostic tools, therapeutic agents and vaccines on a global scale. In essence, the most important lesson that we must learn from the COVID-19 crisis is that international cooperation is key to reacting swiftly to emerging diseases. In

this respect, it is worth mentioning that the first laboratory in the world that identified the SARS-CoV-2 Omicron variant is in Gaborone (Botswana), a laboratory established through a Harvard-Botswana partnership and funded by the NIH and by the government of Botswana.

Population growth, climate change, ecosystem degradation, industrialization, conflicts, mass migrations can all facilitate the (re)-emergence of infectious diseases. Due to the existential threat that these challenges pose on humanity, it is vital that we take a "One Health" approach to achieve optimal health outcomes on a global scale. The One Health concept is not new (it was first developed in the 1960s), but it has lately been re-discovered and widely praised by policy- and decision-makers alike as key to protect our global ecosystem and, ultimately, our own existence. In recognition of the interconnection between humans, animals, plants and the environment, the One Health approach supports the notion that human medicine, public health, veterinary medicine, ecology, ecotoxicology and all related disciplines must come together in an integrated approach to solve global scale problems. Obviously, this can only be achieved when the maximum level of international cooperation is adopted, as shown for the rapid development of effective vaccines against SARS-CoV-2.

In the last two years, since the beginning of the COVID-19 crisis, news and discussions on vaccine development and vaccine efficiency have dominated the public COVID-19 narrative. It is however worth remembering that the whole scientific community, represented also by those scientists who are not directly involved in vaccine development studies, has focused on gathering every possible piece of information to figure out ways to fight against the SARS-CoV-2 virus. In this respect, there are some analogies between the COVID-19 epidemic and the first phase of the HIV-AIDS epidemic in the 1980s, for which it became immediately clear that it would have been difficult to develop a vaccine. In the quest for alternative approaches, the 3D structures of key viral proteins (such as the HIV protease and reverse transcriptase) provided the crucial templates for a structure-based drug discovery approach that led to the development of effective drugs against HIV in a remarkably short time. SARS-CoV-2 is very different from HIV, as it belongs to a wider family of coronaviruses that feature key trimeric proteins (the "spike" proteins) on their surface that enable the virus to attach to a receptor protein that is found on cells of the human respiratory system (the ACE2 receptor). In addition, the virus has two proteases that are very interesting potential targets for drug design. Within a few weeks from the onset of the COVID-19 pandemic, scientific cooperation had already led to the determination of the 3D structure of vital SARS-CoV-2 virus proteins using either X-ray crystallography or cryo-EM. Among these, the main protease [3], the spike protein [4, 5], the viral RNA polymerase [6] and the human ACE2 receptor [7]. These structures allowed the mapping of the interaction of the SARS-CoV-2 spike protein with the ACE2 receptor and, in turn, the mapping of the effects of critical mutations on the SARS-CoV-2 protein. In essence, in a remarkably short time, the scientific community was able to react to the onset of the COVID-19 pandemic and to provide crucial information and technologies that led to a global unprecedented response to the most severe public health crisis of the last 100 years. This clearly indicates that open, participatory and collaborative science is the only way forward to fight not

only against future pandemics but also against the multiple existential threats that humanity will have to face in the years to come.

Finally, I would like to end my talk by paying tribute to the late Dr. Paul Farmer, whose premature death this year has left a huge void in the public health arena. The seminal work that Dr. Farmer has done in Haiti, Rwanda and in other developing countries through his "Partners in Health" organization will remain as a testimony of the power of public health approaches that put the health of the entire global community, no one left behind, at the center of the political discourse.

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Chapter 7
From NPT to TPNW: From Non-proliferation to Prohibition of Nuclear Weapons

Barbara Gallo

The Nuclear dossier has been a hot topic since 1945 and after more than 80 years it is far from being closed.

After the tragic events of Hiroshima and Nagasaki, which provoked destruction and the death of more than 300.000 innocent people, in January 1946 there was the first inaugural session of the UN General Assembly to address the danger and the risk of the use of atomic devices. The resolution called for the elimination of these lethal weapons and all those suitable for mass destruction. However, with the oncoming tension between the U.S and the Soviet Union and the start of the Cold War, this fundamental issue was disregarded.

In March 1950, thanks to a large mobilization of the Civil Society the World Peace Council issued the "Stockholm appeal", calling for a ban on nuclear weapons, which was signed by nearly 2 million people. Seven years later, scientists from all over the world created the Pugwash conferences in order to evaluate and address the threats posed by nuclear weapons.

The tension climax was reached during The Cuban crisis, but its positive side was that in many governments and in the academic world the awareness of the dangers of these weapons re-emerged considering that, in every place and at every moment, a political and military confrontation between the great powers could turn into a tragedy for humanity as a whole. It was for these well-founded fears that, a few years later, in 1970, the Non-Proliferation Treaty came into force, which up to today has represented the milestone of the entire nuclear non-proliferation regime since the Cold War.

It counts 191 member states and the only countries that have not signed it are Israel, India, Pakistan, South Sudan and North Korea which withdrew in 2003.

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The Treaty is based on three pillars: non-proliferation; nuclear disarmament and finally the promotion of international cooperation relating to the peaceful use of atomic energy.[1]

In general, the NPT identifies a division of competences between nuclear and non-nuclear states and, since its adoption, the nuclear states have been obliged, under Article VI, to adopt measures aimed at favoring the end of the arms race and, at the same time, the beginning of the process of disarmament.

The NPT, although it continues to be the most important legal instrument in the field of nuclear weapons control, has nevertheless shown evident weaknesses over the years, the most evident being the non-commitment of nuclear states towards the provisions of Article VI of the treaty itself, in which states are required to adopt concrete measures that discourage the arms race and, above all, favor a real process of nuclear disarmament which appears to be an increasingly difficult objective to achieve.

So the NPT has disregarded the hope of achieving a world free of nuclear weapons at the moment and the general disappointment of non-nuclear states over the lack of disarmament policies is one of the parts that has most damaged the legitimacy of the nuclear non-proliferation regime.

Although historically the NPT has significantly reduced nuclear warheads, which went from 70,300 during the Cold War, to around 13,150 in 2021, this reduction cannot be considered a real progress in terms of disarmament and actually this result has been largely contested by non-nuclear states, especially because the sharp decrease in quantitative terms, has been accompanied by an improvement in qualitative terms, giving the impression that the real priority of the nuclear powers is therefore the modernization of their arsenals rather than the adoption of concrete disarmament policies.[2]

Currently the USA has 5.600 nuclear weapons while Russia has about 6.257. In particular, nearly 9,500 world nuclear warheads are intended to be used through missiles, planes, ships and submarines 3,650 of them are in a state of alert, ready to be launched at any time.

Most of them are much more powerful than the atomic bombs dropped in 1945. These new nuclear weapons, if detonated in a large city, would be capable of killing millions of people with devastating effects on both human health and catastrophic consequences on the surrounding environment. Their harmful effects could persist for decades. This has been aided by constant technological progress with a qualitative upgrade of all weapon systems, both nuclear and conventional.[3]

This spread of nuclear know-how also increases the risk of uncontrolled development of nuclear devices. According to the experts, the unpredictable combination of technological modernization and the persistence of military doctrines based on deterrence, lower the threshold for the use of nuclear weapons in the event of a conflict.

[1] Giuliani, 2019.

[2] FAS, 2019.

[3] Pascolini, 2022.

The US, Russia and China are continuing to modernize and increase their nuclear arsenals. Even in the Indian Sub-continent there are programs of extension, but these plans aren't monitored by International Law since neither India nor Pakistan, the 2 nuclear states of the region, are part of the NPT.[4]

The NPT hasn't been successful in freeing the world from nuclear weapons.

The failure to implement Article 6 has created, over time, contrasts and differences of perspectives between non-nuclear states and nuclear states, especially regarding the conditions and methods of the disarmament process. The nuclear states promote a gradual approach in order to reconcile nuclear disarmament with the strategic and security needs of the current international scenario, and underline the results obtained in terms of downsizing of the arsenals, stating that the possession of nuclear weapons has essentially only a defensive and safety purpose. But the arsenal modernization programs are in clear contrast with the provisions of the NPT and the step-by-step approach could be seen as just an attempt to postpone the commitment to disarm.[5]

This unclearness and lack of respect for legitimate nuclear powers on one hand has encouraged a dangerous nuclear proliferation of countries such as Israel, India, Pakistan and North Korea who have over time developed nuclear weapons outside the NPT,[6] on the other hand these divergences have slowly but steadily increased a climate of distrust among the non-nuclear states.

Since the deterrence claim has always played a useful role for the nuclear powers, there was a need for a different point of view and that is why the Norwegian government decided to launch the humanitarian initiative which, from then on, has emphasized the catastrophic humanitarian effects of these weapons.

Three Conferences were therefore organized to focus on the humanitarian impact of nuclear weapons: in Oslo, Nayarit and Vienna.

The main conclusions achieved were:

- no state or international body would be able to deal with the humanitarian emergency caused by nuclear detonations.
- nuclear weapons have immediate and long-term devastating effects on the ecosystem, with regional and global effects.[7]

The first took place in Oslo in April 2012 which saw the participation of 127 governments, UN agencies, international organizations and Civil Society. This Conference is considered a milestone for the issue of the use of nuclear weapons, because it brought out the need for stronger preventive measures and, at the same time it underlined the importance of involving the civil society and its role in the humanitarian aspects rather than the security issues.

It must also be said that the Conference was intentionally boycotted by all five nuclear states which claimed they couldn't attend because they recognize the NPT as the only valid treaty. The only countries present were India and Pakistan.

[4] Simoncelli, 2020.

[5] Giuliani, 2019.

[6] Simoncelli, 2020.

[7] Abbate, 2013.

The second one was held in February 2014 in Nayarit (Mexico). Even in this one the focus was on the humanitarian impact in the political discussion on nuclear disarmament. The main topic was the damage and negative repercussions of a nuclear explosion, as well as the enormous resources destined to maintain and modernize nuclear arsenals.[8]

The third one took place in Vienna with the participation of the United States and Great Britain. Among the various issues there was the one about the absurdity of nuclear weapons when it comes to the principles of human dignity and International Humanitarian Law. Despite the distrust of nuclear powers, the meetings on humanitarian impact have attracted the attention of other countries and civil society groups.

Pope Francis himself, in his message to the Vienna Conference, declared the need for nuclear weapons to be banned once and for all.

Another aspect of this last Conference was the questioning of the central role of the NPT as a reference framework for disarmament and non-proliferation and the most significant achievement was that 44 out of the 58 states that participated in Vienna called for a treaty to ban nuclear weapons because unlike other weapons of mass destruction (chemical and biological), nuclear weapons had not yet been banned by an international treaty.

These three conferences were key to the creation of a working group on disarmament which, in December 2016, during The UN General Assembly, adopted a resolution to convene the negotiating conference, sponsored by Austria, Brazil, Ireland, Mexico, Nigeria, and South Africa.

This resolution emphasized on the need to have a prohibition treaty which could be complementary to the nuclear Nonproliferation Treaty (NPT), since it could partially fulfill its Article VI.

A decisive push in this direction came from both The International Campaign to Abolish Nuclear Weapons (ICAN) and the International Red Cross. ICAN, a coalition of non-governmental organizations, is among the top promoters since it has proposed itself as an "umbrella organization" for many international anti-nuclear groups it has been actively present in the humanitarian conferences, in the working groups and during the treaty negotiations which worked alongside governments to achieve the strongest, most effective treaty possible.

ICAN was awarded the Nobel Peace Prize in 2017 for the "work to draw attention on the catastrophic humanitarian consequences of any use of nuclear weapons"[9] and for "ground-breaking efforts to achieve a treaty-based prohibition of such weapons.". It has always worked alongside the Red Cross which pointed out that "The use of nuclear weapons has the potential to make the humanitarian mission, for which the movement was born, impossible."[10]

In the same year (November 2017), for the first time in its history, the Holy See organized the International Conference "A world free from nuclear weapons"

[8] Daveri, 2014.

[9] https://www.nobelprize.org/prizes/peace/2017/ican/facts.

[10] https://www.icrc.org/en/document/humanitarian-impacts-and-risks-use-nuclear-weapons.

with the main objective of highlighting the inhuman and immoral aspects of nuclear weapons.

This significant mobilization of non-nuclear states, Civil Society, the Holy See and International Red Cross, paved the way for the implementation of the Treaty of Non Prohibition Nuclear Weapons, which was approved in 2017 with 122 votes in favor, 1 against (The Netherlands), and 1 abstention (Singapore). The TPNW entered into force in 2021 becoming part of the international legal framework on disarmament together with the Non Proliferation Treaty (TNP).

The TPNW bans all activities related to nuclear weapons including manufacturing, testing, transferring, stationing, using, receiving nuclear weapons and assisting in their creation or threatening their use.

The Holy See was among the first to sign and ratify the TPNW and it has shown leadership in promoting the universalization of the Treaty as a vital part of the global nuclear disarmament architecture, together with the NPT and Pope Francis became the first Pope, in the nuclear era, to take a complete stand against nuclear weapons, even as a form of deterrence.

In the last year, eight ratifications have been added by Cambodia, the Philippines, the Comoros Islands, Chile, Mongolia, Guinea Bissau and Peru for a total of 59 signatory states, but on the other side, the nuclear powers and their main allies strongly opposed both its adoption and its entry into force, highlighting its weaknesses especially the prohibition for each state party not to assist, encourage or induce in any way a country to undertake any activity relating to the use of nuclear power.[11]

The non-assistance provision actually was condemned both by countries allied with nuclear states and by those under the so-called American nuclear umbrella, but also by states that have or seek access to nuclear materials and technologies for the peaceful use of nuclear energy.

However the entry into force of the TPNW provoked reactions also within the North Atlantic Security Council which, in December 2020, issued a statement regarding the entry into force of the TPNW underlining its commitment to arms control, in order to achieve an international environment without nuclear weapons but reiterating that the NPT is the only and credible legal treaty on nuclear disarmament. The criticism raised by NATO mainly refers to the fact that the TPNW is weak in terms of strict and clear verification mechanisms and on the contrary insists much more on political objectives than on the technical process of denuclearization. Furthermore, the TPNW would not be signed by any state that possesses nuclear weapons and furthermore its entry into force would risk undermining five decades of efforts by the entire international community.[12]

If it is true that one of NATO's objectives has always been to have a world free from nuclear weapons, as stated in its preamble, it is also a fact that in 2010 its strategic concept was released and NATO decided to adopt the definition of a nuclear alliance confirming that as long as nuclear weapons exist, NATO will remain a nuclear alliance. Furthermore, it is worth remembering that, even if all NATO members have

[11] Simoncelli, 2021.

[12] Putzolu, 2019.

joined the NPT, it is also true that, despite the commitments made in the context of reducing nuclear weapons and limiting their prospects for use, the three nuclear states of NATO (the USA, France and the UK) are modernizing and expanding their arsenals.[13]

The European Union itself showed its skepticism towards the TPNW so much so that only thirteen States participated in the Treaty drafting process and only five (Austria, The Holy See, Ireland, Malta and San Marino) were among the first fifty to ratify the TPNW.[14] In November 2021, during the Council of the European Union on the 10th NPT Review Conference, the need to fully implement and universalize the NPT with some other notable proposals was underlined but in the final document there was no reference to the NPT.[15]

Yet the European Union has always positioned itself as a world leader against the proliferation of weapons of mass destruction and in 2003 the European Union strategy against the proliferation of weapons of mass destruction came into force. In reality, the attitude of many member states has often been contradictory and ambiguous regarding this issue since France is a nuclear state, and Belgium, Germany, Italy and the Netherlands host American nuclear weapons. Furthermore, most of the security policies of the EU Member States are closely related to cooperation with nuclear powers, given that 21 EU Member States are also NATO allies and finally from 2003 to date no serious review has been carried out, to adapt to the profound geopolitical changes and technological progress linked to the military field.[16]

Despite the numerous criticisms and doubts raised above all by the nuclear powers, the TPNW can rightly be considered the first legal instrument that bans nuclear weapons and makes them illegal and a milestone for disarmament policies.

The TPNW finds its strength in having created a strong legal opposition to these armaments as part of a long-term plan for their abolitions. As R. Gibbons says "The renewed focus on the humanitarian and environmental impacts of nuclear weapons constitute a deliberate effort to devalue, delegitimize, and stigmatize nuclear weapons."[17] Furthermore the risk of an accidental detonation constitutes a global threat for humanity since the sites dedicated to the production and storage of nuclear weapons could be cyber attacked or robbed by non-state actors.

According to, national president of the Italian Red Cross, this "first instrument of international humanitarian law, legally binding, is an unprecedented reminder that, despite and above all in the light of the many global tensions, we can and must intervene in defense of life."

Actually, the most revolutionary message contained in the TPNW is its change of perspective from strategic to human security, based on the life of people as well as the emphasis on the idea of an ever wider participation of civil society and public awareness on nuclear and disarmament issues. It is exactly the public opinion which could play a fundamental role in the future. In recent decades its role has grown considerably and even if those in power would prefer to circumvent or influence it,

[13] Ibid.

[14] Onderco, Jimez, 2021.

[15] Misak, 2022.

[16] Onderco, Jimez, 2021.

[17] Rebecca David Gibbons, 2021.

today it is clear that it should not be ignored considering the strong popular opposition to the war in Iraq (2003). International public opinion is now considered the second world superpower.[18]

With respect to the nuclear agenda, although most European states seem opposed to the adoption of the TPNW, the results of polls conducted by YouGov and commissioned by the International Campaign for the Abolition of Nuclear Weapons (ICAN) and its European partners, an overwhelming rejection of nuclear weapons was evident. The opinion poll was conducted in the four European countries hosting US nuclear weapons: Belgium, the Netherlands, Germany and Italy. In each of them, the vast majority of people interviewed (from 56 to 70%, depending on the case) said they were in favor of removing nuclear warheads from their territory and agreed (from 66 to 72%) with the hypothesis that its own State signs the Treaty which completely prohibits them.[19]

Regarding our country, most Italian people want a world free from nuclear weapons; 72% of citizens said they were in favor of joining the UN Nuclear Weapons Prohibition Treaty, while 65% declared that the US nuclear warheads currently present in Ghedi and Aviano should be eliminated from our territory.[20]

In conclusion just over 1 year has passed from the entry into force of The TPNW and sadly today an astonished world is witnessing a new dramatic global scenario where the strategic and geopolitical balances have deteriorated in the space of a few weeks.

On 27 of February 2022 President Vladimir Putin ordered Russian nuclear forces to move to a higher state of alert, inserting nuclear weapons into the Ukraine conflict, breaking the tabu of the use of these armaments. The famous phrase "a nuclear war cannot be won and must never be fought," coined during the darkest days of the Cold War, nowadays seems to have been erased as well as the huge efforts made behind the entry into force of the TPNW.

We are now experiencing a war that could easily turn into a nuclear one. Despite all the legal and humanitarian efforts towards a world free from nuclear weapons we still live in one where most States use and abuse nuclear weapons as a safety issue. Unfortunately the TPNW hasn't been globally embraced ad many European countries as well as all the nuclear weapon states haven't signed this fundamental treaty which could lead to disarmament and a truly safe world in contrast to a public opinion that asks their national governments to sign the TPNW.

Nuclear deterrence is a crucial right for all states and all human beings since we could all be affected and pay the consequences considering that the effects of the exposures do not respect borders.

The tragic events in the Ukraine conflicts, remind us that now, more than ever, an act of bravery from those states out of the TPNW would be desirable.

It is true that it wouldn't prevent future conflict, but it could prevent the world from coming to an end and as Ban Ki- moon said, "Nuclear disarmament is one of the greatest legacies we can pass on to future generations."

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[18] Battistelli, 2009.

[19] https://www.archiviodisarmo.it/sondaggio-ican-yougov-sulle-armi-nucleari-italia.html.

[20] Ibid.

Chapter 8
Domestic Debate in Russia About Arms Control and Nuclear Weapons

Nadezhda Arbatova

8.1 Introduction

Let me start with several remarks about the general political context of the nuclear weapons debate in Russia and single out several factors that are shaping this debate.

First, the end of bipolarity had a paradoxical impact on the nuclear arms control. On the one hand, having removed the threat of a global conflict it opened the way to big arms control treaties, first and foremost START I. On the other hand, it marginalized the very process of arms control.

Second, the end of East–West confrontation brought to power a new generation of politicians and military experts who either do not know the history of arms control or do not consider it important. Unlike their predecessors who lived through several serious international crises, first and foremost the Cuban missile crisis, the new Russian political elite is quite ignorant about the past and has an easy going-attitude to arms control.

Third, the last but not least, after the collapse of the USSR the new Russian leadership became obsessed with the loss of the great power status. It is nuclear weapons and Russia's permanent seat in the UN SC that are viewed as the main attributes of the great nuclear power status equal to the US.

The combination of these factors—marginalization, disregard and status problem created a particular or rather unfavorable climate for arms control, the crisis of which is now recognized at the highest state level of the leading powers of the world.

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8.2 The Main Russian Schools of Thought

Against the background of the crisis, three schools of thought have formed in Russia. Two of them represent diametrically opposed approaches. One of them is "idealistic", the second opposite school can be called "revisionist" and in the midst there is a third school of thought which can be defined as a school of strategic realism. The main debate is going not between two extremes—idealists and revisionists but between revisionists and strategic realists because the main idea of idealists—to end the nuclear threat in one fell swoop—nowadays looks utopian in the world where hard power is coming back to the international security agenda. Unfrortunately, the Treaty on the Prohibition of Nuclear Weapons (JNW) approved in 2017 by the UN General Assembly remains a beautiful strategic dream.

The opposite "revisionist school is not homogeneous and includes experts with very different, if not opposite, ideological views. Russian nationalists and pro-US liberals found common ground in the belief that nuclear multipolarity and the latest weapon systems have abolished the old principles of arms control. The underlying motives of liberal revisionists have been based on fear that differences between Russia and the West on arms control are an obstacle to good relations between them. They propose to abandon old practices and principles that include parity, quantitative levels and sublevels, weapons counting and verification methods. They want to put all this in the scrap along with the arms control treaties. In exchange, they propose a multilateral dialogue (primarily between Russia, the United States and China) on new vague principles of strategic stability, military transparency and predictability. Their goal is not to proclaim arms limitation, but to strengthen mutual deterrence and prevent any conflicts of great powers. Although there are differences and nuances within the revisionist school its majority is quite responsive to the dominant moods and leanings of the high rank Russian officials. Therefore they build their arguments around these prevailing sentiments.

1. Their main argument is that nuclear weapons are still needed because they saved the humanity from the threat of the III world war and even played kind of civilizing role for political elites of the leading countries, having inspired them to focus their actions on prevention of a nuclear war.

Strategic realists, their main opponents, say that although it is impossible neither to accept, nor to dismiss this argument, it is well known that nuclear weapons were created and used in 1945 not for deterrence and political containment but for total destruction of an adversary in case of a new war.

The idea of the nuclear weapons deterring role as a means of political containment was accepted by the US and NATO only in the 60 s and by the USSR in the 70 s. They remind that the most dangerous crisis between the West and the East—the Caribbean crisis of 1962—was initiated by the deployment of nuclear missiles in the UK in 1958 and in Italy and Turkey in 1961. And the paradox is that the crisis, which in the eyes of the opponents of the nuclear disarmament was resolved due to the very existence of the nuclear weapons, in fact was provoked by the existence of nuclear weapons.

The strategic relists also say that if nuclear deterrence has worked in the bipolar world there is no guarantee that it will continue to work in the future. With the removal of the fear of escalation of any nuclear weapon use to a global catastrophe, all nuclear weapon states became much more arrogant, irresponsible and "easygoing" in contemplating initiation of actual combat employment of nuclear weapons to perform various military missions, including selective use of nuclear weapons. In any case without strategic arms control negotiations the international situation won't be safer in the multipolar world.

The current Ukraine crisis is the most telling evidence to this assumption. The Russian special operation in Ukraine has acquired a nuclear dimension before President Putin's decision to elevate the nuclear alert of the Russian strategic forces. The statement of the NATO Secretary General Stoltenberg about NATO's intention to withdraw tactical nuclear weapons from Germany and redeploy them in Poland had a negative impact on Russia. Many in Russia think that it was one of the motives for Russia's special operation, although other doubt this assumption and say that it was just a pretext. But if political ground is prepared, then the pretext becomes a real motive.

Will the nuclear taboo be broken for the first time in 77 years, or will the balance of nuclear deterrence be maintained? The real risk involves the tactical weapons, and although the likelihood of use is low, there are fears that the Putin's calculation of profits and losses will lead him to escalate the campaign.

2. The second argument of nationalist revisionists against arms control is that nuclear proliferation is not guided by the lack of disarmament but rather by other incentives. They argue that the future of NPT lays not only in the responsibility of the nuclear weapons states and that nuclear disarmament of the NWS, will not lead a determined proliferation candidate to stop its nuclear programs. Iran's or North Korea's intentions are guided not by the lack of disarmament but by their regional strategic considerations or considerations of prestige or those of regime survival.

Strategic realists underline that reliance on nuclear weapons is the soft spot in non-proliferation approach of any NWS and it is used as a pretext by proliferation candidates to get nuclear weapons. They insist that a more thorough analysis shows that the link between nuclear disarmament and non proliferation did exist and does exist.

First, nuclear disarmament creates a favorable international context for non-proliferation. One cannot ignore the fact that around 40 new countries, joined NPT (including two of the declared nuclear powers, France and China) at the same time as intensive nuclear disarmament talks and real reductions in stockpiles of nuclear weapons were taking place from 1987 to 1998. (During this period, the INF Treaty, START I, START II, the START III framework agreement, and the CTBT were signed, and the United States and the Soviet Union/Russia took parallel, unilateral initiatives to reduce tactical nuclear weapons. There was also significant progress in non-nuclear but related areas, including the conclusions of the Treaty on Conventional Armed Forces in Europe and the Chemical Weapons Convention. The NPT was indefinitely extended in 1995, and the IAEA (International Atomic Energy Agency) Additional Protocol was drafted in 1997. Brazil, Argentina, South Africa and Iraq

abandoned their nuclear weapons programs. Ukraine, Belarus and Kazakhstan that had nuclear weapons on their territories as a result of the USSR break-up joined NPT as non-nuclear states.)[1]

Second, the deadlock in nuclear disarmament talks only serves to fuel mutual mistrust which directly affects NWS cooperation on non-proliferation, in particular sanctions against proliferation candidates.

Third, the link between nuclear disarmament and non-proliferation in some areas is even more direct and obvious. If the US had not withdrawn from ABM Treaty and not blocked CTBT (Comprehensive Test Ban Treaty) and FMCT (Fissile Materials Cut-Off Treaty), North Korea and potentially Iran would have had not just one barrier to overcome but three—NPT, CTBT and FMCT in trying to go nuclear.

So the link between nuclear disarmament and non-proliferation exists though it is not automatic. Fulfilling disarmament obligations along with the Article VI of NPT is not in itself a guarantee against nuclear proliferation which would require other measures. However non-fulfillment of obligations contained in Article VI practically guarantees nuclear proliferation.

3. The third argument of the revisionists' school is that after the new START, the so called Prague treaty, further reductions of the Russia nuclear arsenal will have a destabilizing impact. They will increase Russia's conventional inferiority, undermine its military reform, reinforce the BMD importance and encourage small nuclear states to expand their nuclear arsenals.

Strategic realists argue that the aggregated destructive potential of the world nuclear arsenals after the planned reductions will be about 2000 MT (80% of which is related to Russia and the US arsenals), which 60 000 times as large as the destructive power of the Hiroshima and Nagasaki bombs. So, even after the planned reductions there will be a long way to the rational minimal ceilings of the existing nuclear arsenals. Certainly, it is unrealistic to reach these rational ceilings without other measures: resolving the problem of BMD, joint management of the problem of the US long-range conventional precision-guided systems, tactical nuclear weapons, inclusion of third nuclear weapons states in the process of nuclear disarmament, the reinstatement of CFE regime and other measures.

4. The fourth argument of the Russian revisionists stems from their previous assumptions and boils down to the conclusion that it is impossible to stop nuclear proliferation. Therefore, we should accept nuclear proliferation as a reality, and therefore Russia and the US should learn how to live with other nuclear states and coordinate their policies. Of all arguments against nuclear disarmament this statement is the most dangerous and irresponsible. In the time of bipolarity it took USSR and US two decades of balancing on the edge of nuclear disaster and surviving several serious crises to achieve the stable mutual nuclear deterrence on the solid legal basis. It would be naïve to think that the future nuclear proliferation will be developing along the same pattern. With all criticism, in many senses the USSR and USA were much more reliable and responsible than the majority of states that are striving now

[1] At the Nuclear Threshold, ed., by Alexei Arbatov, Carnegie Moscow Center, Moscow 2007, pp.98–99.

for nuclear weapons. Their nuclear forces will be more primitive and vulnerable than those of NWS which means that these counties will be much more prone to first use of nuclear forces. Aside from this most of the states that would like to go nuclear are unstable political regimes, prone to extremism and adventurism. This state of affairs increases the probability of nuclear terrorism that cannot be prevented by any BMD system.

The easygoing proposal of the opponents to nuclear disarmament that NWS should reconcile themselves with the idea that Iran will go nuclear anyway is a recipe for disaster. It sends wrong messages both to Iran and Israel. The latter, who lives for decades under the threat of being erased from the surface, will never accept a nuclear Iran, which means only thing—a new military conflict.

5. The last argument of the hard-nosed revisionists is based on the recognition that given Russia's geopolitical vulnerability, slow economic modernization, corruption, lack of soft power, it would be a national suicide to destroy or even to diminish further its nuclear potential.

Their opponents would say that the role of nuclear weapons as a guarantor of Russia's security and its great power status is strongly exaggerated by the critics of nuclear disarmament. One should not forget that the USSR collapsed although its nuclear arsenal was 7 times bigger than that of Russia. Moreover that was exactly the reason of the USSR collapse. In the situation of détente under Gorbachev leadership it was impossible to justify the huge waste of financial and other resources for the East–West military competition. And the USSR rapidly began to crumble, despite having an army of four million men and a military arsenal that included more than 30,000 nuclear warheads, more than 2,000 strategic missiles, 60,000 tanks and almost 200 nuclear submarines (more than the rest of the world put together). Russia should not repeat this mistake and it is painful to think that nuclear weapons are the only possibility for Russia to remain a great power on the international arena.

8.3 Concluding Remarks

Summing up, it is possible to conclude that hard-nosed "revisionists" are the most dangerous school of our political thinking. The perniciousness of their philosophy lies in the fact that political elites are inspired with the idea that the arms control crisis is natural and not so detrimental, and the international community can live without treaties. They reject difficult and exhausting negotiations involving acute conflicts of interests outside and within the country and call for a bold "renovation" of the archaic practice.

However, upon closer examination their ideological arguments collapse like a house of cards. Being masters of superficial knowledge, the "revisionists" do not understand that the ceilings of the START treaties being only upper limits never imposed on the parties arithmetic equality of nuclear forces, but for decades they served as a guarantee of strategic predictability and removed incentives for the first

strike and stable deterrence. This guarantee was confirmed by verification and transparency measures. Such strict regimes cannot be replaced by general and vague strategic discussions, which in recent years have been demonstrated in the framework of the "nuclear five", as well as between Russia and the United States and between the United States and China.

However attractive the idea of multilateral nuclear disarmament may look, it is most easily perceived by politicians who are not specialists in tghis field and the ty cannot intelligibly explain why, up to and including START-3, Russia and the United States could conduct a bilateral arms control process, but cannot continue it now. If we take into account all the nuclear weapons available to nine nuclear-weapon states, then Russia and the United States individually have several times more such weapons than the rest of the seven combined. Uncertainty exists only with respect to China, and the reference to Chinese medium-range missiles serves as one of two reasons for the United States to withdraw from the INF Treaty.

If China agrees to negotiations, it's easy to predict its appetite: for eliminating its superiority in medium-range ground-based missiles, China will most certainly raise the issue of equality with Russia and the US in sea-based cruise missiles, as well as in strategic weapons (i.e. about lowering the START-3 ceiling seven times to Chinese level).

It is clear that the existing treaties are far from ideal and not self-sufficient. The development of military equipment, as before, poses new challenges: the limitation of strategic non-nuclear weapons, cybernetic, space, hypersonic and autonomous systems, etc. Against the background of an uncontrolled arms race, new technologies will have a more destabilizing effect. However, within the framework of vague discussion these most complicated problems cannot be solved outside concrete negotiations in deeply thought-out formats. Otherwise, the chaos of the world order and military technologies will be aggravated by the chaos of the legal system of disarmament and disorder.

The last but not least. The dangerous nexus between science and politics. imposes a special responsibility on scientists. When a scientist says or writes that a nuclear explosion may be less detrimental to environment than Karakatau volcano eruption, he or she sends a clear message to political leadership.

Part II

Chapter 9
Weapons of Mass Destruction in the Middle East Within the Context of Regional Security

Wael Al Assad

I think it is important to look at WMDs in the ME, and the efforts to eliminate them, within the context of regional security.

The ME has been plagued with a multitude of conflicts, some of which has become chronic with huge humanitarian cost. Naturally, these conflicts have a spill-over effect into neighboring states and beyond, such as refugees, terrorism, and illicit trade in arms and weapons. We have all followed with varying degrees of concern conflicts and wars such as Iraq, Syria, Libya, the abandoned conflict in Yemen, and of course the decades long chronic Palestinian-Israeli conflict and the occupation of the Palestinian home-land. These conflicts and others in the ME resulted in millions of refugees and displaced civilians, anger that led to militancy and terrorism or freedom-fighting depending on where you stand from the parties to the conflict, in addition to wasting the countries' economic resources that would have been, otherwise, directed to social and economic development.

Let me first start by stating the sometimes neglected basic fact that conflict in the ME is not the natural order of relations or an outcome of the nature of the people there, but it due to the nature of the international order that is power-based and not rules-based as some would claim.

Secondly, there are a number of reasons for this conflict-prone environment, but they mostly stem from one fact, namely the absence of a regional security and arms-control structures in the ME.

In spite of a number of attempts at constructing a regional security structure, these efforts failed for two main reasons.

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The first, is that any security architecture is naturally based on cooperative security and confidence building, while most, if not all, governments in the region apply a zero-sum approach to their national security, therefore, long-term cooperation and trust cannot be maintained among these states.

In this environment, we have shifting and competing regional centers of power. Current cooperation and agreements are merely short-term alliances, usually directed against other states.

The second reason is the disruptive role of the external powers in managing and resolving these conflicts. Contrary to what these powers claim, they bring to these conflicts their own interests which mostly clash with the interests of the region. They would protect governments in the region that are involved in the conflicts and causing massive human suffering, as long as these governments continue to provide access to raw materials and are buying 100 s of billions worth arms and weapons from them. Obviously, regional cooperation and arms control structures are not in the best interests of these super powers.

The hundreds of billions that were spent on buy arms and weapons from the weapon exporting states did not provide security to the region but only exacerbated the arms race and eroded confidence among the regional players. The introduction of WMDs in this volatile mix is not only dangerous to the region but has serious ramifications for international peace and security.

The motivations and drivers for the acquisition of WMDs dates back to the sixties of the twentieth century, when the Arab States realized that Israel was developing a military nuclear program. This heightened the threat perception of the Arab States, and it was clear to them that they had to react.

The Arab states realized that they cannot accept or coexist with nuclear weapons in the hands of Israel, their main adversary at the time. Israel's monopoly of nuclear weapons would aggravate the security and military imbalances in the ME. They also realized that to develop their own nuclear weapons is politically and financially costly and dangerous, not to mention accelerating the regional arms race. There was no NPT at the time, so that option was theoretically available to them, but they decided against it. The reasonable course of action to them was to resort to the international community to draw attention to the inherent dangers, and to exert pressure on Israel in order to reach a regional agreement to rid the region of these menacing weapons. Therefore, when Egypt and Iran introduced, in 1974, the zone initiative to the General Assembly, the rest of the Arab states seized the opportunity and adopted the zone concept as a way out of the regional nuclear proliferation dilemma.

Israel's nuclear weapons became a driver and an incentive for the Arabs and Iran to seek to eliminate it through an arms control arrangement and a security structure, namely a "Nuclear Weapons Free Zone in the ME".

Over the following years and decades, the states of the region realized that their efforts at multilateral disarmament forums did not provide any serious progress if any at all. The Israeli nuclear weapons became a driver for proliferation to counter the power imbalance in the region. A new thinking evolved in certain camps that if nuclear weapons are a guarantor for Israel's security it should be also good for their security. Others also thought of developing other WMDs, particularly chemical

weapons, to counter the military imbalance. We have seen that in Iraq and Syria. When chemical weapons were used by Iraq against Iran and against its own people, the rest of the Arab States realized the urgent need to eliminate all WMDs and not only Nuclear weapons. Led by Egypt, the Arabs modified or expanded their initial initiative to be A Nuclear Weapons and other WMDs Free Zone in the Middle East.

With the launch of the peace process in 1991, the security and political environment changed, and for the first time a large number of Arabs and Israel sat together within the multilateral track of the peace process to discuss for the first time security cooperation and Confidence building measures. This was within the Arms Control and Regional Security Working Group (ACRS). Within the coming three years, the ACRS failed and stopped.

We have now different narratives explaining the reasons for failure, an Arab narrative, an Israeli narrative, and a supporting American narrative, and each narrative blames the other party. It is counterproductive to go into this blame game or repeat the accusations. Unfortunately, this obscured the fact that the ACRS managed to agree on a number of CBMs and CSBMS that should have been considered a breakthrough, and were discarded and forgotten overtime.

The 1995 NPT Review and Extension Conference, adopted the initiative of a "Zone Free of Nuclear Weapons and other Weapons of Mass Destruction in the ME", and the zone became a permanent item on its agenda. Yet Israel refused to move forward on the issue. The 2010 Review Conference adopted a final document that requested the UNSG to hold a conference in 2012 to start a process that would lead to the creation of the zone, but the process again was sabotaged and Israel insisted with the support of the US and UK, that the objective of the 2012 conference should be changed to deal with all regional security issues. That was not the mandate given by the Review Conference, and the process once again failed.

This situation exploded in the 2015 Review Conference and led to its failure to reach an agreed upon final document, and accusations were exchanged over who caused this failure.

The Arab States, in their frustration, felt that they had to take matters into their hands, and in December 2018, the General Assembly adopted a new decision, based on an Arab Group draft resolution, to entrust the UN secretary-general to convene an annual conference, beginning in 2019, "until the conference concludes the elaboration of a legally binding treaty establishing a Middle East zone free of nuclear weapons and other weapons of mass destruction".

The first conference was held in 2019, and the second conference in 2021 with the participation of 22 Arab States and Iran, while Israel and the US rejected the Decision of the General Assembly, and boycotted the conference.

It is important to sum up the situation and take a step back and evaluate where the region is.

Over the last 15 years the Iranian nuclear file took center stage, with ups and downs, causing condemnations and provoking sanctions on Iran and on secondary parties. Finally, the negotiations between Iran and the P5+1 reached what I would call a win–win situation and the JCPOA was signed. But Iran also in those years became a regional player in conflicts and causing anger among many Arabs. Iran

used sectarian affiliations to support groups in Iraq, Syria, Lebanon and Yemen. It accumulated and developed missiles that caused alarm in many quarters. A lot of efforts are being exerted to limit Iran's missile capabilities, while totally ignoring the missiles arsenals in 9 regional actors. The biggest and most sophisticated of them is in Israel.

The concept of the WMDFZ in the ME survived 5 decades of inaction. The main reason behind that is that this proposed zone provides a comprehensive regional approach to the issue of WMDs proliferation, and avoids the selective and biased approach of dealing with states separately from the regional architecture.

Chapter 10
Conflict Areas—An Israeli Perspective

Ambassador David Danieli

The unfolding war and human tragedy in Ukraine cause many among us to reflect on human nature and the nature of war, and why is it that the community of nations is unable to resolve its conflicts in accordance with the principles enshrined in the United Nations Charter that laid the promise and hope of peaceful coexistence among nations, against the backdrop of terrible past experiences.

Looking back in modern history, global political culture has gone a profound change since 1945. Nuclear weapons have turned war among the big powers unthinkable and necessitated major efforts in search of less violent ways and mechanisms to limit not only direct conflicts among nuclear weapon states, but also conflicts of others.

Some argue that such efforts have been relatively successful and certainly prevented the use of nuclear weapons. Others assert that it mostly tolerated armed conflicts beneath the nuclear threshold, entailing the risk of a slippery-slop.

The world of 2022 is very different from the world of 1914 or 1939.The notion of a "successful war", previously shared by the elite and fueled by popular enthusiasm with a view to galvanize the nation and a promise of new territories, wealth and international status, is not possible any more. Untold human suffering, sheer destruction and humiliated defeats in the battlefield have proven kings, emperors, and dictators wrong and condemned their nations for long agony or misery.

Knowledge- based economy, education and technology replaced figures of armed forces and defense outlays as critical measures of national success and wellbeing. Not a single shot was fired by either Japan or Germany since 1945. Yet, both have become most advanced nations in many respects.

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Citizens of most states feel nowadays no fear of foreign invasion or an imminent threat posed by much stronger neighbor. For them, peaceful relations with their neighboring countries and in the region, have become a constant feature. Not a dream. Peace time ceased to be just short intervals between wars, as it was for centuries, mostly in Europe.

Russia indefensible, premeditated war on Ukraine, has installed therefore so much fear at the hearts of many and shook their conviction and beliefs that perilous war rhetoric and politics, are but the legacy of dark days in the history of Europe. The Russian Federation should have realized that by no account its war against the independent, sovereign state of Ukraine could be titled a "successful war".

Russia war on Ukraine is significantly affecting many parts of the world. The multifaceted negative implications of the war, too close to be fully assessed, will be far-reaching and long lasting.

The Middle East region, the territories that extend from Egypt to Iran and from Turkey to Yemen, Bab al-Mandab Strait and the Strait of Hormuz, occupies roughly 6.5 million square km. Saudi Arabia is the biggest with over 2 million square km. In this vast region, Israel's territory is 22,000 square km, about the size of the State of New Jersey, USA.

The Middle East presents its unique characteristics, threats, and risks. At this time, the region finds itself coping also with new challenges as a result of Russia war on Ukraine. Be it the global energy turmoil, shortages and higher prices of staple food, or other negative repercussions of the war, felt all over.

In general, the region is fraught with wars and unresolved conflicts; long standing religious and sectarian rivalries; Hotbed of terrorism and widespread civil unrest, fueled by great social and economic inequalities; Brutal dictators and autocrat rulers still prevail, even after the "Arab Spring", and the term 'democracy' is often despised as alien.

The Middle East is so far the only region where chemical weapons were put to use, on several occasions, in defiance of universal ban and more recently by the Syrian regime, a party to the Chemical Weapons Convention (CWC), against its own citizens. A harsh warning of retribution by the international community remained on paper. Many may have regrated today for then no action. Can any small state places its confidence in the U.N Security Council to enforce no-use of chemical weapons?

It is also the only region where the history of the nuclear non- proliferation is one of failures, deceit and unfulfilled Treaty commitments and obligations by four member states, parties to the NPT: Iraq under Saddam Hussein; Libya under Muamar Kaddafi; Syria under Bashar Assad, and the Islamic Republic of Iran.

The Middle East has recently felt the impact of the U.S withdrawal from Afghanistan and the scaling down of the American presence in the region. Leaders in the region clearly understood that regrouping, mutual cooperation and deviating from old political traditions, are required in order to better deal with external and internal challenges.

The recent full-fledged normalization of relations with the State of Israel on the part of Bahrain, U.A.E and Morocco mark a tectonic geo-political shift in the region. In addition, closer cooperation with Egypt and Jordan, expanding Saudi-Israeli range

of contacts, and even beginning of warming-up relations with Sudan, previously unthinkable, all serve for the same.

The map of the Middle East of 2022 is dotted by numerous subversive Iranian activities, direct or indirect acts of terror against the State of Israel across its borders or at sea, performed either by members of the Revolutionary Guards or by Iran's multiple regional proxies.

In this context it is important to remind ourselves that historically there has never been a conflict between the two states and nations, Iran and Israel, that rest 2000 km apart and shared many communalities and mutual respect throughout millennia.

Iran is making every effort to undermine and weaken local Sunni governments, using temptation, intimidation, brute force and diplomacy. Prime targets are American allies in the region.

The Hezbollah terror organization, financed, equipped, trained and coordinated by Iran, is practically dominating Lebanon and has established its military presence also on the Golan Heights, enjoying the hospitality of the Syrian regime.

The Houthi rebels in torn Yemen that is faced with a humanitarian disaster, and the Shia militias in Iraq, provide Iran a measure of deniability when missiles and Unmanned Aerial Vehicles (UAV's) made in Iran, are targeting Dubai, Riad, Jedda, Saudi oil fields or American installations in Iraq. Only last week U.S Secretary of State said, as he announced new sanctions against pertaining Iranian entities: "Iran's ballistic missile-related activities continue to destabilize the Middle East region".

Similar methods and means are applied by Iran vis-à-vis the tween terror organizations in Gaza, the Hamas and the Islamic Jihad, to sustain their mission of terror against Israel.

Other regional flash points are by no mean negligible. To mention few: ISIS, much weakened but still deadly across the Middle East; Syria, devastated by a decade-long civil war with over half a million dead and 10 million uprooted or refugees, where the Russian military presence secures Bashar Assad rule; Iraq, still recovering and catching its breath in an effort to establish its desired national and regional equilibrium; The Kurdish various factions, fighting to maintain some sort of autonomy against the interests of all their neighbors; and in the outer perimeter of the region, Libya, Sudan, or Ethiopia whose citizens undergo repeated internal armed conflicts.

Israel's strategic landscape has dramatically changed since it emerged victorious in its 1948 war of Independence, repelling six invading Arab regular armies.

Repeated failures of Israel's Arab neighbors to reverse 1948 outcome in the battlefield, ended practically in October 1973 war. Thereafter, a gradual change of attitude and new political thinking, have produced the first landmark peace accord with the Arab Republic of Egypt in March 1979. A second peace agreement, with The Hashemite Kingdom of Jordan followed in October 1994. By then, with almost no regular army deployed along its borders and no fear of a sudden invasion, for the first time since 1948, (Syria, much weakened, was conscious to maintain no-war situation on the Golan Heights since 1974), the center of gravity of Israel's strategic outlook shifted markedly.

First, since Israel's immediate neighbors ceased to pose an existential threat and since Israel took control over the territories and millions of Palestinian inhabitants

in the West Bank and Gaza, the conflict with the Palestinians, namely the historical rivalry and competing claims on the land, established itself again at the center. The bilateral agreements with the Palestinian Authority launched in Oslo in 1993 and thereafter, largely failed, culminating in a wave terror in the years 2001–2005 that cost the lives of over 1000 Israelis. The rise of the Hamas to power in the Gaza strip on the heels of Israel's unilateral disengagement in 2005, has made matters worse. Much more is required these days from Israeli and Palestinian leaders to break the deadlock of unsustainable status quo.

Second, it became clear, in early years, that persistent clandestine efforts by several regional parties to acquire nuclear weapons, not only cast a heavy shadow on the region but pose an extreme threat to Israel.

To date, Iran's pursuit of the bomb, in defiance of resolutions of the International Atomic Energy Agency (IAEA) and the United Nations Security Council, remains very ominous. Suffice to recall recent warning of the IAEA Director General, Rafael Grossi, that Iran is enriching uranium to concentrations that only countries making bombs are reaching.

A large portion of Iran's Nuclear Archive removed by Israel from Tehran on early 2018 and shared with foreign governments and the IAEA has shown, inter aliya, that Iran had made considerable progress on nearly every aspect of developing and manufacturing nuclear weapons, including implosion testing, weapon design, neutron generators, casting and machining …and integration of warheads and reentry vehicles. In short, Iran is unambiguously aiming at producing nuclear weapons; It possesses a large number of ballistic missiles- the delivery system for a nuclear weapon- in violation of Security Council Resolution 2231; It has covered up undeclared nuclear materials, sites, and activities, demolished suspected facilities and provided false declarations, all in violation of Iran's Safeguards Agreement with the IAEA and in order to undermine the Agency's verification system.

Iran's reaffirmation—embodied in the Joint Comprehensive Plan of Action (JCPOA)—that "under no circumstances will Iran ever seek, develop or acquire any nuclear weapons" has never been backed by Iran's deeds. The JCPOA has not blocked Iran's path to a nuclear bomb. Iran has viewed it merely a tactical pause during which Iran exploits priceless concessions. In the meantime, as the IAEA reports, Iran is rapidly advancing its nuclear activities while it has diminished the inspectors' ability to monitor, verify or to detect diversion of materials and other assets to undeclared facilities. At this point, where there is no agreement, there are practically no limitations on Iran's nuclear program. Iran continues its troubling progress in complete disregard to its legal commitments under its NPT Safeguards Agreement with the IAEA.

The State of Israel must seriously address the threat posed by Iran's pursuit of nuclear weapon. Iran is committed, ideologically, officially and practically to the destruction of the Stare of Israel. Iran leaders have declared, time and again, that it is the mission of the Islamic Republic of Iran to erase Israel from the map of the region. Israel is the only sovereign state whose very existence is openly denied by another member state of the United Nations. One wonders what drives such an "holy mission" to destroy another sovereign state, and how is it that others remain silent.

Historically, the existential threats faced by Israel in its region, either large standing armies deployed along its borders, or weapons of mass destruction (WMD) at the hands of sworn enemies, fueled Israel's perceived need to maintain strategic deterrence.

The State of Israel has repeatedly declared that it will not be the first to introduce nuclear weapons to the Middle East. This is Israel's long- standing policy since the 1960's, supported by all Israeli governments. Accordingly, Israel conducts a responsible policy in the nuclear domain and is fully committed to non- proliferation of nuclear weapons, and efforts to prevent their spread. Israel thus recognizes the value of the Treaty on the Non-Proliferation of Nuclear Weapons, (NPT) and supported its adoption in 1968 in the United Nations General Assembly (UNGA). However, Israel has realized in early years, that in the absence of peaceful relations and mutual recognition among all the parties in the region, a global regime like the NPT could not and would not remove the nuclear threat from the Middle East, as demonstrated by Iraq, Libya, Syria and Iran, all parties to the Treaty, in their pursuit of nuclear weapon.

During fifty years of the history of the NPT, no other region has demonstrated a similar culture of non-compliance and deceit as displayed by Middle East member states, parties to the Treaty.

As NPT membership is not a goal in itself but rather as potential means for enhancing security of all states concerned, Israel has made it sovereign decision to remain outside the Treaty.

Remaining outside the NPT has earned Israel annual condemnations at the United Nations and NPT fora. No other state, besides Israel, has ever been called out in a specific resolution to join the NPT "without delay".

The same can be said about frantic annual resolutions, at the United Nations and other international organizations, on Nuclear-Weapon-Free- Zone (NWFZ) in the Middle East.

One fails to register similar United Nations resolutions regarding the urgent need to create NWFZ in other regions that present serious and potentially volatile situations, notably the Korean Peninsula and South Asia. The unique treatment of the state of Israel and the Middle East region in this regard, suggests that the prime goal of the group of states that are behind the motion, is to pressure Israel regarding its national security interests through majoritarian resolutions.

Experience of other regions have shown that establishing a NWFZ depends entirely on the collective political desire of all parties to reassure each other that peaceful means will be used to resolve their conflicts. No vote at the United Nations General Assembly, can substitute for what emanates collectively from the region. Middle East realities, for sure denials and non-recognition, are a far cry from what is required for durable security arrangements, let alone NWFZ.

What is the prospect to sustain a regional security dialogue in the Middle East, where the Arab states focus on WMD, while the State of Israel is focused on inter-state relations as the source of threats and the security deficit, that works to Israel's detriment?

Modest efforts have failed so far to make headway. The events unfolding in the region took priority and the parties could not agree either on the framework or the contents of a viable regional security dialogue.

The first well noted effort was the multilateral working group on Arms Control and Regional Security (ACRS) of early 1990's, strongly supported by the USA and the Russian Federation, immediately after the Madrid Conference. (October 1991).

Two decades later, in the years 2013–2014, Ambassador Jaakko Laajava of Finland, chaired five rounds of meetings with participants of 15 countries from the Middle East, where key issues related to a Middle East Weapons of Mass Destruction Free Zone (WMDFZ) were formally discussed. Guiding principles of the discussions, first and foremost the principle of decisions making by consensus, were agreed upon. The process was stopped on the eve of the NPT Review Conference.

The famous scholar and philosopher Hans Morgenthau, often quoted by U.S President Ronald Reagan in the context of then USA – USSR bilateral relations concluded; "nations do not distrust each other because they are armed. They are armed because they distrust each other". Regrettably, this observation is equally relevant today to characterize Russia-NATO hostile and strained relations, as much as inter-regional relations in the Middle East. While it takes decades to overcome animosities and to build trust among the regional parties, a single unexpected major eruption could break trust and mutual confidence to pieces, almost overnight.

As we gather here in Rome, the city that is so much at the heart of modern Europe, as it was the Capitol of the ancient Roman Empire that ruled across the Mediterranean, the regions of Europe and the Middle East alike, are at cross road. Each region for its unique reasons, some of which are overlapping or reciprocally influencing each other.

In the current circumstances, the Middle East region with its multiple actors: states, non- states and external powers, remains volatile. Some developments are promising, but require broad support and encouragement. The Middle East pendulum keeps moving back-and-forth. As a minimum, it is incumbent upon all state parties to exercise utmost responsibility and to cooperate with each other to avoid a major turn for the worse. The alternative and warning, written in blood on the wall in these very days, could be terribly wasteful and costly.

Thank you.

Chapter 11
Tensions in the Middle East

Hussain Al-Shahristani

I would like to thank the Accademia Nazionale dei Lincei and the National Academy of Sciences for inviting us to this Conference in beautiful Rome and for their generous hospitability. This is my first participation in Amalfi Conferences, and it is a privilege to be among such distinguished academic colleagues.

The Middle East is one of the most volatile regions of the world. The stability of the ME can contribute to peace and security throughout the world, and its conflicts and wars would be a source of tension and threat to other regions.

The costs of civil wars, social unrest and violence in Iraq, Syria, Libya, Yemen, Palestine, and other ME countries have been horrendous. Counting the dead, wounded, internally displaced, refugees and the destruction of infrastructure and economy, one can see that the region has suffered the worst human disaster after the world wars. How did we get here and where are we heading to?!

The modern Middle East, as we know it, was shaped from the remnants of the Ottoman Empire by the victorious powers of the First World War. The colonial powers not only created boundaries that served their interests, but they also handed power to tribal chieftains and ex-Ottoman officers that had collaborated with them. Although these countries gained nominal independence some years later, they failed to make transition to political systems of representative governance.

All the Arab states, except Lebanon, were ruled by either military dictatorships or autocratic monarchies. It is true that significant advances were made in these countries: economically, socially, and educationally, but these were not accompanied by reforms of the political systems or observance of basic human rights for their citizens. Furthermore, the economic development was characterized by rampant

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corruption where ruling families helped themselves to the national wealth with little consideration for the needs of their people.

By 2010, millions of Arabs would no longer tolerate the incompetence and corruption characterizing their governments and state institutions. The Arab spring that followed saw masses rise against oppression refusing to live in submission to corrupt leaders or accept dictatorships; neither they were content with a global political discourse that allows democracies in the West to support oppressive regimes at home. Some of these regimes may seem to have a firm grip on power today, but I do not believe they will be immune from changes to come in one way or another.

Another cause of instability and tension in the region is the inter-regional rivalries and mingling in the affairs of neighbouring countries. Rather than focusing on solutions to their own internal problems, some governments find it convenient to distract their people with engagements outside their territories, and others endeavour to assume a greater role for themselves by supporting warring factions in other countries.

This is how we got here; so where are we heading to? Can peace and social tranquillity be restored, or will the region continue to be a source of instability and human suffering that threatens world peace and security? What reforms are needed internally and cooperation externally to help the countries of the region to be part of a peaceful collaborative world order rather than a source of tension, terrorism, and refugees?

No effort to restore tranquillity in the Middle East will succeed in my opinion if the states in the region will not reform. Without such reform, social unrest, turmoil, riots, and even civil wars such as those that we experienced since 2011 will continue to pop up with varying degrees of violence.

The first of these necessary reforms is political liberalisation and respect for human rights. Political liberalization to improve governance accountability should not be considered as potentially destabilizing; quite to the contrary in the long-term, it is the only guarantee for stability, progress, and social justice.

The West often saw authoritarian regimes as guarantors of stability. It allowed itself in the name of security and the fight against terrorism to support such regimes and turn a blind eye to human rights abuses. They conveniently chose to ignore that extremist ideologies were born and nourished by some of these countries and most of the funding that the terrorist organisations received came from there.

Democratisation of political systems and allowing the population to freely participate in electing their representatives is much overdue in many countries in the region, and without participatory democracy, the political system would lack legitimacy in the eyes of its citizens.

It is true that different regions of the world with diverse cultures may have different concepts of representative democracy and may follow different routes to achieve it. But there are basic principles such as free speech, freedom of peaceful assembly, freedom of religion, equality between men and women, equality under the law, respect and protection of minorities, and the right to choose your leaders are common to all societies.

We all share responsibility to uphold the same standards of universal human rights and to stand by those who strife for them wherever they are. The worse betrayal, in my opinion, is when we apply double standards and support a popular uprising in one country in the name of freedom and human rights and turn a blind eye and deaf ears when another regime violates those human rights not only among its own population but also commits war crimes against other countries and people in the name of security. There is a deep feeling among Arab masses that the West and especially the U.S. cannot be counted upon as a reliable supporter of democracy unless it serves their political and economic interests.

Another cause of instability in the region is the unconditional support that Israel receives from the West, particularly the United States, in pursuing its oppressive policies against the Palestinian people. The utter disregard for the Palestinian national aspirations and their unquestionable rights in their homeland would only pour fuel on an already inflammable situation. Without international cooperation and commitment to peace and justice, it would not be possible to reach a peaceful resolution of the Palestinian question.

This puts the United Nations and particularly the EU to face their responsibility in maintaining peace and order by salvaging the peace process by implementing the UN resolutions on the right of the Palestinian people to establish their own state and live in peace and dignity in their homeland with an internationally recognised boundary. Palestine would remain the central issue for the Arab people despite what some of their rulers may say or do; and without a just settlement, the region would not enjoy peace and security.

Another conflict that has caused unimaginable suffering is the Yemen war. According to the UN Special Envoy for Yemen, Hans Grundberg, to the Security Council on 14 December 2021 "Yemen has been facing a protracted political, humanitarian, and developmental crisis since uprisings broke out in 2011. With 80 per cent of the population, or 24.1 million people, in need of humanitarian aid and protection, it is now the largest humanitarian crisis in the world."

Indeed, it is the worst humanitarian disaster after the Second World War. It has left almost a quarter of a million people dead, and 2.3 million children are expected to suffer from acute malnutrition in 2022. Four hundred thousand children under the age of five are "in their last weeks and months of life" according to the UN's humanitarian report. Civilians were targeted by airstrikes and shelling in their homes, schools, mosques, hospitals, markets, and other places where civilians should be protected. Yemen has become a protracted crisis, with an entire generation of children growing up having known nothing but war.

In preparing this paper, I pondered that a viable way to put an end to this war is for the UN to work out a road map that includes the following points:

- Nationwide ceasefire including cessation of airstrikes by the Arab coalition,
- Lifting of restrictions on goods entering the largest Yemeni port, Hodeida, which is the humanitarian lifeline to the majority of the people of Yemen; and resuming commercial flights to the capital Sanaa's airport, which has been prevented for four years,

– Holding a national reconciliation conference where all belligerent and non-combatant parties in Yemen take part to form a government of national unity that can draft a new constitution and hold elections that would lead to a democratically elected government.

It is a very welcome development that the UN Special envoy to Yemen succeeded to get the warring parties to accept halting all air, ground, and naval military operations inside Yemen and across its borders beginning with the start of the Holy month of Ramadan a few days ago. They also agreed for fuel ships to enter Hodeida port and commercial flights to operate in and out of Sana'a airport. These are the first of the two points of the roadmap I just mentioned. Hopefully, the ceasefire will extend beyond the two months that has been agreed upon and the national reconciliation conference will follow soon.

I would like now to turn to the situation in Syria and Iraq. The Syrian civil war started in Feb 2011 as part of the Arab Spring uprising where people demanded freedom, social justice, and political reforms. But the initial peaceful demonstration quickly turned into violent clashes between government security units that used excessive force and the demonstrators. Shortly after the eruption of the conflict, extremist Jihadi groups from outside Syria poured into the country to support the demonstrators.

One of these extremist groups declared itself 'The Islamic State of Iraq and Syria (ISIS)' better known in the region as 'Daesh'. The group soon became the dominant fighting force among the opposition. Having established their terrorist state in central Syria, they overrun north-western Iraq in June 2014 capturing one-third of the country and ruling over 40% of the population including Iraq's second-largest city, Mosul. Horrendous atrocities were committed against civilians under their control, particularly the Shias, Christians, and Yazidis.

Despite internal turmoil, Iraqis quickly responded to the call of their religious leader Ayatollah Sistani and organised themselves in Popular Mobilisation Units to defend their country against Daesh. Mosul and other towns and areas were liberated, and the country was cleared of Daesh terrorists by end of 2017 at terrible costs. The number of civilian casualties in this war was more than 34,000, and the Iraqi armed forces lost about 15,000 soldiers. In contrast, 29,000 Daesh terrorists were eliminated, about half of them Iraqis and the other half of different nationalities, mostly Syrians, Saudis, and North Africans. Terrorists also joined them from other parts of the world, particularly from Western Europe and Central Asia.

In Syria, various opposition groups controlled most towns and rural areas outside Damascus at the peak of the civil war in 2015 including Syria's largest city of Aleppo. The civil war in Syria drew in several outside actors supporting the warring sides. Russia, Iran, and Hezbollah actively supported government forces while Turkey, Saudi Arabia, Qatar, the US, and some EU countries funded or armed various opposition factions.

Presently, the opposition controls the north-western province of Idlib, the SDF (a Kurdish rebel group sympathetic to PKK in Turkey) controls the north-eastern province of Hasaka, and the rest of the country is under government control. The

opposition in the Idlib province is overtly supported militarily and financially by Turkey and some Gulf countries even though the largest armed group in that pocket is the Al Qaeda-affiliated Al Nusra group. It is no surprise that Daesh leader Abu Bakr Al-Baghdadi and his successor Abu Omar were both located there and eliminated by US air operations.

It is estimated that between 500 to 600 thousand Syrians have lost their lives in this civil war, in addition to 6.7 million internally displaced people and 6.6 million refugees. That is in total about half of the population.

The Syrian civil war had a rippling impact on the Middle East and in a way spilt over into Europe. It caused the largest humanitarian crisis since World War II (only to be surpassed in 2018 by the Yemen war). Millions of refugees poured into neighbouring countries as well as into Europe.

The Syrian war like all other wars will have to come to an end one day. The sooner we get there, the less human suffering and destruction. What can be done to help end this war?

Sanctions have not diminished the will of the warring parties to fight, but only impacted the livelihood of millions of Syrians. International humanitarian relief efforts have had a limited effect in alleviating the suffering of the Syrian people. For such humanitarian efforts to be effective, they should not be politically manipulated. They should be delivered cross-line to all Syrians affected by the war in line with UNSC Resolution 2585 (2021).

There is no alternative to advancing a settlement process. This process should be led by the Syrians and supported by the United Nations. No resolution of the crisis is expected without an immediate ceasefire, release of detainees, safe and dignified return of refugees and inclusive political reform. Of course, preserving Syria's territorial integrity and unity is essential to a sustainable solution.

It is a welcome development that the seventh session of the Constitutional Committee which comprises the Syrian government and opposition representatives in addition to civil society groups was convened in Geneva last month under the UN auspices. All concerned parties including the UN, EU, and Arab League countries in addition to Russia, Iran and Turkey should exert all efforts to encourage the Syrians to agree on a peaceful transition to a constitutional process that allows them to live together in peace and build their future together.

Lastly, I would like to review the latest developments in the Libyan civil war. The civil unrest in this oil-rich country during the 2011 Arab uprising brought down the dictatorial regime of Moammar Al Qaddafi. But instead of setting up a transitional government to hold elections for a National Assembly that represent all the Libyan political spectra to draft a new constitution, the country was split between warring factions in the east and the west.

The conflict quickly turned into a proxy war fuelled by rival foreign powers. The main warring factions are the Tripoli-based Government of National Accord (GNA) and the Libyans National Army (LNA), a force of some twenty-five thousand fighters led by renegade General Khalifa Haftar based in Benghazi.

The GNA receives financial and military aid from Turkey, Italy, and Qatar. Turkey has sent a couple of thousands of Syrian militants from Idlib to fight with GNA forces.

On the opposite side, the LNA's backers include Egypt, the United Arab Emirates (UAE), Russia and France. Egypt and the UAE provide military and financial support to the LNA, while Russia has sent Wagner Group mercenaries to fight with them.

The UN asked all nations to refrain from sending arms to the warring factions in Libya and called for an embargo on arms shipment, and the EU launched operations in the Mediterranean Sea to monitor the arms embargo. However, this action does little to halt arms across land borders. The UN Sanctions Committee report from March last year found that all Libyan parties as well as Egypt, the United Arab Emirates, Russia, and Turkey had violated the arms embargo.

After exhaustive efforts by the UN, a ceasefire agreement between GNA and LNA was agreed upon in October 2020 that stipulated the departure of all foreign fighters from the country. Also, political talks involving 75 Libyan stakeholders were organised by the UN that culminated in the nomination of a Government of National Unity (GNU) to replace the GNA and the Interim Government in eastern Libya. Presidential and parliamentary elections were to be held in Dec 2021 and Feb 2022, respectively.

The transfer of power to a new interim Government of National Unity raised hopes for peace and the reunification of the country and its institutions. However, a new power struggle has erupted threatening further instability, including the return of parallel administrations and the risk of an armed confrontation.

Rosemary DiCarlo, the UN Under-Secretary-General for Political and Peace-building Affairs warned "Libya is now facing a new phase of political polarization, which risks dividing its institutions once again and reversing the gains achieved over the past two years." As a result of these unfortunate developments, the elections were once again postponed.

Libya is facing economic collapse, political instability, and ongoing conflict between warring factions, and it remains Africa's main departure point for migrants seeking safety and opportunity in Europe.

The country is at a critical point on its path to peaceful resolution of its internal strife. A stable unified Libya can only come via ballot not bullet. Regional intruders who have supported and armed various waring groups should cease indulging in Libyan affairs and leave the Libyans to resolve their political differences and decide their future. The UN should intensify its efforts to implement the 2021 Agreement between the warring parties and proceed with the presidential and parliamentary elections as soon as possible to form an inclusive government of national unity.

This has been an expose' to my uptake of the roots of conflicts in the Middle East and possible road maps to find an outlet from the quagmire that many nations in the region find themselves caught in.

Thank you.

Chapter 12
Dangers of Inadvertent Escalation in South Asia

Naeem Salik

Abstract Barry Posen has, in his study on Inadvertent Escalation, raised a very pertinent question asking, 'Can Nuclear Powers fight conventional wars with each other and avoid the use of nuclear weapons?' This question should always be kept in mind by all nuclear powers especially those with mutually hostile relationships. It is evident that the phenomenon of 'Inadvertent Escalation' cannot be understood without an understanding of the process of Escalation. South Asia despite the nuclearization of the region in 1998, has been facing one crisis after another each more belligerent than the preceding one and with the potential to wittingly or unwittingly embroil the antagonists into an irreversible escalation cycle with potentially catastrophic consequences. This paper is aimed at sensitising the decision makers in both countries to the dangers inherent in recurring crises especially in the absence of any overarching restraint regime and to make them understand that they might have escaped devastating results in the previous crises merely due to sheer good luck and not any prudence on their part. Case studies of February 2019 crisis between India and Pakistan and the March 2022 Stray Missile crisis have been employed to bring home the point.

12.1 Preamble

India and Pakistan have a history of chequered relations with several wars and border skirmishes and decades old unresolved dispute over the former princely state of Jammu and Kashmir. It was hoped that after the nuclearization of the two countries in May 1998, an era of relative peace and stability will usher in South Asia. However, this hope was not to be realized and the two South Asian antagonists have been moving from one crisis to the other over the past two decades or so. Many of these crises were quite serious and carried the potential of serious escalation leading to major conventional conflict and then on to a potentially disastrous nuclear

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conflict. While there may be little doubt that both countries are responsible international players, have established their respective command and control and safety and security mechanisms. They have also agreed upon some nuclear Confidence Building Measures (CBMs) but have failed to establish an overarching and institutionalized risk reduction and restraint regime which makes the strategic balance in the region tenuous at best. Currently the bilateral dialogue between the two countries is non-existent, tensions run high and the possibility of occurrence of a serious crisis is always lurking in the background. In this kind of an environment the danger of escalation as a result of unintended consequences of certain actions cannot be ruled out especially due to totally unexpected incidents such as the case of a stray Indian missile landing on Pakistani soil after traversing over 100 kms of distance inside the Pakistani airspace.

This brief paper will attempt to highlight the dangers of 'Inadvertent Escalation' between India and Pakistan by presenting two case studies of the two most recent crises between India and Pakistan which ended without causing catastrophic consequences but had a serious potential to quickly escalate into a devastating conflict between two nuclear armed states. The first case study is about the February 2019 Pulwama-Balakot crisis while the second study focuses on the most recent crisis in March 2022, involving a 'run-away' Indian missile.

12.2 The Pulwama–Balakot Crisis—A Case Study

This is one of the more recent crises between India and Pakistan that gripped the region in February 2019. It was precipitated when a young local Kashmiri dissident carried out a suicide attack, on 14th of February near the town of Pulwama in the Indian controlled part of Jammu and Kashmir, on a convoy carrying Indian Central Reserve Police Force (CRPF) personnel, killing at least 40 officers and men.[1] Given the fact that this attack happened in the midst of election campaign for national level parliamentary elections in India, Prime Minister Modi's government decided to take full political advantage of it to bolster its campaign for re-election. Consequently, the Indian government authorised the Indian Air Force (IAF) to launch another so called 'surgical strike' against a religious seminary belonging to 'Jaish-e-Muhammad,' the militant group that was purportedly behind this attack. Pakistani Prime Minister Imran Khan denied his country was involved and offered to help investigate the attack if any credible evidence was provided.[2]

The Indian reprisal strike carried out at 3 am on 26th of February, however, was unprecedented since it involved IAF for the first time since 1971 and the target itself was not in the Pakistani administered Kashmir but in the Khyber Pakhtunkhwa

[1] Mansoor Ahmed and Maimuna Ashraf, 'The Pulwama-Balakot Crisis: A Strategic Assessment,' CISS Insight, Summer 2019, Vol VII, No. 1, p. 2.

[2] https://www.cnbc.com/2019/02/26/pakistan-says-indian-aircraft-crossed-line-of-control-loc-frontier.html.

province of Pakistan some 80 kms from the Line of Control (LOC), which made the provocation far more serious.[3] The Indian officials claimed to have killed 300–350 "budding militants" in the strike using Israeli made air to ground stand-off missiles. An Indian TV Channel, NDTV reported that, "The government has said that at least 300 Pakistani terrorists have been eliminated." While another channel News 18 went a step further claiming that, "their sources indicated casualties as high as 400."[4] India's Foreign Secretary, Vijay Gokhale, claimed that the strike killed "a very large number of Jaish-e-Mohammad terrorists, trainers, senior commanders, and groups of jihadis who were being trained for Fidayeen action." Another senior Indian government official told reporters that about 300 militants had been killed. A graphic report based on satellite images by a credible international news agency laid bare the false Indian claims. According to the report, Pakistan disputed India's death toll estimates, terming the operation a failure adding that, Indian jets merely bombed a hillside without hurting anyone. Local villagers mocked the Indian claims. One local van driver Abdur Rasheed, said that, "It shook everything," denying the Indian claims about any human casualties, he added, "No one died. Only some pine trees died, they were cut down. A crow also died."[5]

The Indians were unable to provide any evidence in the form of aerial photographs or satellite imagery, to corroborate their claims. In reality, the missiles missed their target by some margin as graphically displayed by the Reuter report and landed in the nearby forest causing no casualties whatsoever except damaging some trees. Pakistan, lived up to its publicly declared intent to forcefully respond to any military action by India at a place and time of its own choosing by launching a retaliatory air strike on 27th of February in broad daylight in the Nowshera-Rajauri area in the Indian occupied Kashmir in an operation aptly code named 'Swift Retort.' However, since the Indian strike had not caused any casualties on the Pakistani side, Pakistani strikes were also modulated in a manner that the aircraft directed their ordnance to hit uninhabited spaces in the vicinity of important Indian military targets. As some IAF jets scrambled to intercept the Pakistani aircraft at least one Indian MIG-21 was shot down on the Pakistani side and its pilot captured alive and another Indian aircraft was reportedly hit but fell on the Indian side and therefore its shooting down could not be confirmed. The pilot who parachuted on the Pakistani side was later handed over to India by Pakistan as a 'goodwill gesture.' This Pakistani act of goodwill helped defuse the crisis. However, before the crisis subsided there were other twists and turns, wherein as per media reports India had conveyed threats to launch missile strikes against six Pakistani targets[6] and Pakistan had responded by

[3] Mansoor, p. 4.

[4] https://www.newslaundry.com/2019/03/12/over-300-casualties-in-balakot-airstrikes-but-whos-the-source.

[5] https://graphics.reuters.com/INDIA-KASHMIR/010090XM162/index.html.

[6] Sanjeev Miglani and Drazen Jorgic, 'India, Pakistan Threatened to Unleash Missiles at Each Other: Sources,' Reuters, March 17, 2019. The account says 'there was no suggestion that the missiles involved were anything more than conventional weapons.' A subsequent story reports that the Indian intelligence chief, Anil Dhasmana, told Munir [Lt Gen Asim Munir, DG ISI] that India would escalate the conflict if the Indian MIG pilot was harmed. Also see, Shishir Gupta, Rezaul H.

pronouncing that it would retaliate with three times the number of missiles fired by India. However, these threats did not materialise, otherwise the crisis would have then crossed many qualitative thresholds and might well have gone all the way up the escalation ladder. Knowledgeable Pakistani and Indian analysts have highlighted the dangers inherent in missile duels between two nuclear armed states. A prominent security analyst, Ejaz Haider has argued that, "an exchange of missiles would have remarkable escalation potential." Adding that, "Missilery between nuclear powers is a big no." Well known Indian journalist Shekhar Gupta concurs, saying that, "Both sides know the implications of even one ballistic missile… that is why all ballistic missiles, in both countries, have been taken away from conventional forces and put under the charge of their respective strategic force commands."[7]

It is evident that India was encouraged to undertake this highly provocative and risky venture emboldened by the partisan statements by senior US officials that denounced Pakistan, but neither counselled restraint to the two parties nor did they emphasise the need for a negotiated solution to the crisis. For instance, the US National Security Advisor John Bolton seemed to openly encourage some military action by India by supporting India's right to self-defence in the face of what he termed as 'cross-border terrorism.'[8] The two Prime Ministers had also boxed themselves into commitment traps from which it was difficult to back off. Prime Minister Narendra Modi on his part, had publicly "threatened, 'a fitting response' for the Pulwama attack, stating 'this is an India of new convention and policy,' a posture which Indian analysts subsequently branded as the 'new normal'…"[9] Modi had also committed himself to "punish the perpetrators of terror and the Pakistani prime minister Imran Khan had vowed that Pakistan will retaliate to any Indian strike."[10] Modi kept the rhetoric alive long after the crisis had subsided by continuing to make inflammatory statements during election rallies.

The genesis of this crisis can be found in September 2016, when India had claimed to have carried out a ground surgical strike across the Line of Control in Kashmir against the alleged terrorist launch pads in retaliation to an attack allegedly by Kashmiri freedom fighters against an Indian military cantonment at Uri in the disputed territory. Many Indian military analysts such as Praveen Sawhney have described

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Laskar and Yashwant Raj, 'India, Pakistan Came Close to Firing Missiles at Each Other on February 27,' *Hindustan Times,* March 23, 2019; quoted in Hagerty, p. viii.

[7] Toby Dalton, 'Signalling and Catalysis in Future Nuclear Crises in South Asia: Two Questions after the Balakot Episode,' *Nuclear Crisis Group,* June 25, 2019.

[8] 'Readout of Telephonic Conversation between National Security Advisor Ajit Doval and US NSA Amb. John Bolton,' Ministry of External Affairs, Government of India, New Delhi, February 16, 2019 (https://www.mea.gov.in/press-release.htm?dtd/31058/Readout-of-Telephonic-Conversation-between-National-Security-Advisor-Ajit-Doval-and-US-NSA-Amb-John-Bolton), quoted in Devin T. Hagerty, 'Nuclear Weapons and Deterrence Stability in South Asia, 2020, Palgrave Macmillan, p. viii.

[9] Toby Dalton, 'Signaling and Catalysis in Future Nuclear Crises in South Asia: Two Questions after the Balakot Episode,' Nuclear Crisis Group, June 25, 2019.

[10] 'Terrorists Will Pay for Pulwama Attack, Says PM; Delivers Warning to Pakistan,' Hindustan Times, February 15, 2019; "Pulwama Attack: Pakistan Warns India Against Military Action," BBC, February 19, 2019, http://www.bbc.com/news/world-asia-india-47290107, quoted in Hagerty, p. vii.

this so-called surgical strike as a routine happening astride the LOC where fire raids against each other's posts are interspersed with physical raids against the same. Pakistan on its part refused to accept that any such action had actually taken place which was variously interpreted in India as well as the West as a Pakistani ploy to avoid embarrassment, as in their opinion the Pakistani military was either unable or unwilling to respond to this Indian action. The West instead of cautioning India not to go down this dangerous path appeared to be appreciating the Indian action and patting India on its back for it. This author firmly believes that irrespective of whether this surgical strike actually happened or not Pakistan should have taken the Indian claims on the face value and retaliated accordingly to discourage such adventurism in future. This might well have prevented the hostile Indian action in February 2019 by imposing caution on them. As in the 'game of chicken' if one of the players appears to have shown weak resolve in the previous encounter the opponent is encouraged to take greater risks the next time around since it believes that the other side will back off again, thereby setting a dangerous precedent.

Having given a broad overview of the way the crisis actually unfolded, one can now proceed to hypothesise the alternative possibilities, scenarios and unintended consequences whose basic ingredients were inbuilt in the crisis. Let us consider some of the alternative outcomes had the crisis unfolded differently at different stages one by one as under:

- *What if, the Indian claim of having killed hundreds of seminary students whom they had arbitrarily labelled as potential terrorists had turned out to be true.* It would have resulted in large numbers of body bags going to Pakistani villages and towns under the media glare in an era where every individual carrying a smart phone is a virtual live reporter, there would have been a tremendous public outrage in Pakistan putting pressure on the government to take revenge. In that eventuality, Pakistani air strikes would not have been calibrated to avoid casualties, but instead, would have been aimed at causing large number of casualties on the Indian side to settle the score. There were other serious possibilities associated with it, as according to some media reports senior Indian military commanders including the Army Commander and the Corps Commander were present at Rajauri cantonment at the time of Pakistani reprisal attack and could well have been hit with serious repercussions that were bound to lead to immediate escalation.
- *What if the Indian pilot had died while bailing out or been killed by local civilians after he parachuted into Pakistani controlled territory.* Any of these outcomes would have resulted in raising of temperatures, inflaming the emotions and would have surely led to further escalation. It would also have taken away the chance for a goodwill gesture on part of Pakistan that became a catalyst for de-escalation of the crisis.
- *What if Indian stand-off weapons accidentally hit a sensitive target on Pakistani side.* In such an eventuality it would have been difficult for Pakistan to determine whether this was unintended or a deliberate act and given the sensitivity of the target Pakistan would have acted accordingly by hitting a target with similar value on the Indian side and thus an irreversible cycle of escalation would have ensued.

- What if India had neither lost an aircraft nor a pilot into Pakistani captivity. Would it have emboldened India to greater vertical or horizontal escalation?
- What if Pakistani 'Swift Retort' had not achieved the desired results. Would it have been possible for Pakistan to de-escalate so easily? Without any results to show that a befitting answer has been given to the Indian provocation it would have been difficult for Pakistan to satisfy its public sentiment and it would have been forced to carry-out a follow up attack to visibly achieve the desired results. This again would have led to inevitable escalation of the conflict.
- What if Pakistan Navy had sunk the intruding Indian submarine rather than warning it and letting it go. It would have been impossible for India to swallow its pride and not take any retaliatory action against Pakistani navy again leading to serious escalation.
- What if India was not bluffing but made good on its threatened missile strikes against Pakistani cities or other critical targets and Pakistan lived up to its resolve to retaliate three times over. This was the surest recipe for disaster and would have jumped many rungs of the escalation ladder in one go and would have made any de-escalation highly unlikely.
- What if either side had mistaken a conventional armed missile strike as a nuclear strike and accordingly reacted in 'launch on warning' or 'launch under attack mode.' It is hard to believe that there would have still been a chance left to apply the brakes and prevent further escalation of the crisis.

12.3 The Renegade Indian Missile—March 2022—Another Case in Point

A curious and unprecedented incident happened in the evening of 9th of March 2022, when an apparently out of control Indian Brahmos cruise missile entered Pakistani airspace and after flying over a hundred kilometres inside Pakistan landed near the town of Mian Channun in Southern Punjab. Providentially, the missile fell in a sparsely populated area, damaging the wall of a nearby house but causing no human casualties. However, there was no public reaction from either side for the next 24 hours and it was only in the evening of 10th March 22 that Pakistan's Director General Inter Services Public Relations held a Press Conference and gave the details of the incident. This was followed by the summoning of the Indian Charge D' Affaires to the Pakistani Ministry of Foreign Affairs. A subsequent statement issued by the Ministry stated that the Indian diplomat was "conveyed Pakistan's strong protest over the unprovoked violation of its airspace by an Indian origin 'super-sonic flying object' which entered into Pakistan from Suratgarh India at 1843 hours (PST) on 9 March 22 and fell to ground near Mian Channun city in Pakistan at around 1850 hours the same day causing damage to civilian property." The statement further elaborated that the 'imprudent' launch of the flying object had not only put at risk human lives on

ground it had also endangered several domestic and international flights which could have caused a serious aviation accident resulting in large scale civilian casualties.[11]

It was only on 11th of March 22 that the Indian Government broke its silence, 48 hours after the occurrence of the incident and 24 hours after Pakistani official statement. The Press Information Bureau (Defence Wing) Government of India issued a brief statement acknowledging that, 'On 9 March 2022, in the course of a routine maintenance, a technical malfunction led to the accidental firing of a missile. The Government of India has taken a serious view and ordered a high-level Court of Enquiry.' The statement termed the incident deeply regrettable and expressed relief over the fact that no lives were lost due to the accident.[12]

The Indian statement raised more questions than it answered and prompted the summoning of the Indian Charge D' Affaires to Pakistani Ministry of Foreign Affairs for the second time in two days. Islamabad rightly asked as to why India had failed to immediately share information of the 'accident' with Pakistan and pointed out that India had accepted its slip-up only after Pakistan had gone public with it. The statement added that, 'the grave nature of the incident raises fundamental questions regarding security protocols and technical safeguards against accidental or unauthorised launch of missiles in a nuclearized environment,' The statement also listed the following pertinent questions which it demanded must be answered by India:

- Explanation of the measures and procedures in place to prevent accidental missile launches and the particular circumstances of this incident.
- Explanation of the type and specifications of the missile that fell in the Pakistani territory.
- Elaboration of the flight path/trajectory of the accidentally launched missile and how it ultimately turned and entered Pakistan.
- Was the missile equipped with a self-destruct mechanism? Why did it fail to actualise?
- Were Indian missiles kept primed for launch even under routine maintenance?
- Why did India fail to immediately inform Pakistan about the accidental launch of the missile and waited to acknowledge it till after Pakistan announced the incident and sought explanations?
- Explanation if the missile was indeed handled by its armed forces or some rogue elements given the profound 'level of incompetence.'[13]

Pakistan also expressed its dissatisfaction on the Indian decision to hold an internal court of inquiry and demanded a joint probe since the missile had landed in Pakistan. The incident took place at a time of relative quiet and lower tensions between India and Pakistan. Had it happened during a crisis or in a period of heightened tensions

[11] https://mofa.gov.pk/pakistan-registers-strong-protest-over-unprovoked-violation-of-its-air space-by-A-super-sonic-flying-object-of-indian-origin-2/.

[12] Press Information Bureau (Defence Wing) Government of India, New Delhi, Phalguna 20, 1943, Friday March 11, 2022.

[13] Naveed Siddiqi, 'Why did India fail to immediately inform about accidental missile launch? Asks Pakistan,' Dawn, March 12, 2022. Also see, https://mofa.gov.pk/indian-official-acceptance-of-accidental-firing-of-missile-2/.

between the two countries the outcome of this serious incident could have been very different. Many Indian analysts have also voiced serious concerns about the safety of Indian strategic systems, have appreciated Pakistan's mature response and recognised the potential for serious escalation between two nuclear armed countries as a result of such lapses.[14] They have also urged the two countries to use this incident as an opportunity to discuss safety related issues and to develop requisite mechanisms to forestall such incidents in future. However, some Indians displaying the typically arrogant Indian mindset have instead of feeling embarrassed for their own inefficiency have raised questions about the inability of Pakistan's air defences to shoot down the missile. Such an attitude is highly irresponsible.[15] The Indian government on its part has tried to play down the incident and feigned ignorance as is evident from the official Indian government statement wherein it said, 'It was learnt that the missile landed in Pakistani territory,'[16] This statement clearly shows that either the Indians did not bother to track the flight trajectory of the errant missile or they were incapable of doing so. On 11th March 2022, Pakistan's National Security Advisor, Moeed Yusuf, also questioned Delhi's ability to handle sensitive technology and urged the world to consider whether India was able to ensure the safety and security of its weapon systems.[17]

The most worrying aspect of the episode is that the available hotlines between the two countries were not used to instantly share information about the accident. The DGMOs' hotline is normally used for exchange of information about any incident along the Line of Control or the International borders while the Foreign Secretaries' hotline was established in 2005[18] for the specific purpose of sharing information in case of a nuclear related incident to avoid any misunderstandings. There are several bilateral agreements between the two countries to prevent misunderstandings, such as the ballistic missile flight test pre-notification agreement[19] and the agreement to prevent accidental or unauthorised use of nuclear weapons.[20] However, none of these agreements has any provisions to cover such an eventuality and there is definitely a need to either modify the existing agreements or to negotiate a new one to take care of accidental launch of missiles including the cruise missiles.

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[14] Debak Das, 'Not much happened after India's accidental cruise missile launch into Pakistan—this time. *The Bulletin of Atomic Scientists,* March 25, 2022 available at https://thebulletin.org/2022/03/not-much-happened-after-indias-accidental-cruise-missile-launch-into-pakistan-this-time/.

[15] Tara Kartha, 'Why near—disaster BrahMos accident is an opportunity for India and Pakistan to discuss safety', India's missile misfired, Pakistan didn't intercept—now both must talk to ensure 'stability in conflict', The Print, New Delhi, 14 March 2022.

[16] Press Information Bureau (Defence Wing) Government of India, New Delhi, Phalguna 20, 1943, Friday March 11, 2022.

[17] Dawn, March 12, 2022.

[18] Hotline activated, August 09, 2005; https://mea.gov.in/articles-in-indian-media.htm?dtl/15127/activated.

[19] https://www.armscontrol.org/act/2005-11/india-pakistan-sign-missile-notification-pact.

[20] Agreement on Reducing The Risk From Accidents Relating to Nuclear Weapons, https://www.stimson.org/2007/agreement-on-reducing-the-risk-from-accidents-relating-to-nuclear-weap/.

The incident typifies the scenarios that can cause inadvertent escalation between two nuclear armed nations with catastrophic consequences. A combination of good luck, and cool-headed Pakistani response and a relatively calm environment prevailing between the two countries at the time prevented an Armageddon but it could have ended up very differently. Just consider the following possible eventualities:

- *What if the missile had landed in a thickly populated area or hit a sensitive target?* In both cases public sentiment would have enraged demanding a reprisal by Pakistani government and in case of a sensitive target in addition to the public outrage need would have been felt by the Pakistani military leadership to payback for the damages caused by the missile.
- *What if it had hit a passenger airliner and caused large scale civilian casualties?* Depending on whether it was international flight operated by some foreign country or a domestic flight, and whether it involved a small airliner or a large aircraft with large number of passengers on board the severity of the incident would have varied but in all eventualities the connotations would have been very severe and long lasting.
- *What if Pakistan had immediately responded in kind?* If Pakistan had acted on the basis of worst-case scenario suspecting the missile to be carrying a lethal payload and in accordance with its declared policy of 'quid-pro-quo' plus India would have found itself in a bind; whether to accept its earlier mistake and Pakistan's legitimate right to act in self defence and refrain from further action or react to Pakistani response and pave the way for rapid escalation.
- *What if the missile was armed with a conventional, worse still a nuclear warhead?* Had the incoming Indian missile been armed with a conventional warhead it would have caused much greater damage on ground compared with what it actually did and if it was armed with a nuclear warhead, it would have undoubtedly caused a nuclear war between two nuclear armed states.

12.4 Conclusions

The two case studies clearly highlight the need for in-depth and serious studies of the two incidents to recognise the inherent potential for inadvertently causing Armageddon. However, even this brief narrative allows us to draw some useful conclusions from the theoretical aspects of the concept of 'Inadvertent Escalation'

as well as some pertinent lessons from the case study of the February 2019 crisis between India and Pakistan and the March 2022 stray missile incident as under:

(1) The February 2019 crisis has for all practical purposes turned the conception of 'Third Party Brokering'[21] in Indo-Pakistani crises as a thing of the past. This is mainly due to the fact that there is no 'honest' or 'impartial' broker left to mediate in future South Asian crises. The United States has adopted a clearly partisan policy in favour of India which was clearly discernible from the conduct of US National Security Advisor, Secretary of State and other officials. China is viewed as hostile to India and sympathetic to Pakistan in general and by the Indians in particular. The middle eastern and Persian Gulf states that once had close fraternal ties with Pakistan now seem to be tilting towards India and in any case their politico-diplomatic clout though substantial cannot be compared with America's diplomatic weight. Russia has long-standing strategic relationship with India and of late has been trying to revamp its relations with Pakistan but as of now it doesn't have the political capital to influence the outcome of any India-Pakistan crisis beyond goodwill gestures and counselling restraint. The EU traditionally follows the US lead and rarely takes independent positions/initiatives in such situations.

(2) The February 2019 crisis has re-established the efficacy of Pakistan's conventional deterrence capability and has removed the myths that in any conventional confrontation with India Pakistan's conventional responses will not be adequate and it will be forced to lean on its nuclear capability sooner than later. Pakistan has also been able to demonstrate its political will and resolve to forcefully deal with any infringement of its security and has thus bolstered its deterrence message.[22]

(3) The crisis has also raised serious questions as to India's choices for escalation in a future crisis with Pakistan. India has now tried the ground 'surgical' strikes as well as the aerial ones and made a botched attempt to bring the maritime dimension also into play. What can be expected of India in the next crisis? Will it follow the same old playbook maybe at an increased scale and accept greater risks of escalation? The problem is that a large-scale aerial operation has greater risk of 'entanglement' thereby causing 'inadvertent escalation' and it cannot be pursued without taking defensive measures on ground which means creating greater tensions and risks of escalation. Will it use some other instruments such as the armed drones cutting the costs of failure because in case these are shot down the loss will be substantially less than an aircraft and there is no risk of losing a pilot in adversary's hands. However, these cannot find targets close to the LOC or international border for spectacular results and their ability to strike

[21] The concept of 'Third Party Brokering was developed by Moeed Yusuf through an analysis of India-Pakistan Crises but apparently it has fallen by the wayside after the Pulwama-Balakot-Rajauri Crisis of February 2019. See, Moeed Yusuf, 'Brokering Peace in Nuclear Environments: US Crisis Management in South Asia,' 2018, Stanford University Press.

[22] Mansoor, p. 5–6.

at deep targets in an active air defence environment is suspect at best. Yet, it is likely to be an option for future 'reprisal' strikes.

(4) It is also obvious that, the more limited the scale of an operation the more advantageous it would be for Pakistan, which can counter the threat with comparable or even greater force, while India would be frittering away its numerical advantage by employing its forces in a piecemeal manner. It is apparent that India has almost run out of options for sub-conventional responses and employment of anything more than very limited scale of force runs the risk of inevitable escalation. This problem would be further compounded by India's compulsion for permanent force deployments in Ladakh as well as North East frontier with China, resulting from last year's military stand-off between the two, the most serious since 1962; whereas in the past more of a lip service was paid in response to the Chinese threat than deployment of any meaningful military force on the Himalayan borders.[23]

(5) India's option to foment terrorism in Pakistan in response to alleged Pakistan sponsored 'cross-border terrorism,' as articulated by India's National Security Advisor Ajit Doval as well as by former Defence Minister Manohar Parrikar,[24] has also been severely curtailed with the loss of operational/intelligence facilities in Afghanistan.

(6) The often-repeated claims by the Indians and by some in Pakistan after the so-called surgical strikes that, Pakistan's nuclear bluff has been called were also proven to be baseless since Pakistan effectively demonstrated its conventional deterrence capability and the credibility of its nuclear deterrence was proven by India's inability to further escalate the military confrontation. The crisis has proven beyond doubt that Pakistan can deal with such minor infringements with its conventional forces and any expectation that Pakistan would start contemplating the use of nuclear weapons at least the Low yield short range NASR weapon systems is a fallacy. It should be very clear that the minimum provocation to evoke a serious consideration of a possible use of NASR would be 'Cold Start' type attack by Integrated Battle Groups (IBGs) at several axes. Short of this Pakistan is more than capable of returning the Indian favour maybe with some bonus in the conventional realm.

(7) The February 2019 crisis also witnessed irresponsible statements and nuclear sabre rattling by politicians on both sides of the border not unlike the past crises. However, in the past on the Pakistani side such statements came from ministers who are remotely concerned with security policy and particularly nuclear policy but the most disturbing development was that on the Indian side such inflammatory statements came from Prime Minister Modi himself who is the ultimate nuclear use authority in India, who continued to echo these

[23] For an analysis of the strategic costs to India of the Ladakh Crisis see, Arzan Tarapore, 'India-China Strategic Competition and the Costs of the Ladakh Crisis,' South Asian Voices, May 21, 2021.

[24] Former Indian Defence Minister Manohar Parrikar suggested in 2018 that, 'India should remove a thorn with a thorn', widely interpreted as a threat to sponsor terrorism in Pakistan…, quoted in Dalton, Signalling and Catalysis.

threatening pronouncements even months later simply to gain some political advantage in the soon to be held parliamentary elections.

(8) One can safely conclude that rhetoric aside India and Pakistan are sane enough to understand that unbridled military actions in a nuclearized security environment are fraught with dangers of escalation. Even if the care is taken to avoid deliberate escalation, the danger of inadvertent escalation cannot be eliminated altogether.

(9) In the context of the 'Indian missile that lost its way,' the question arises would it be possible for Pakistan not to react to such an incident in future. The answer to this question is certainly in the negative and Pakistan would be bound to react to maintain the credibility of its deterrence. The incident has also raised several pertinent questions which India must answer. For instance, why India failed to use the available hotlines to immediately inform Pakistan after the so called 'accidental launch.' Moreover, there has been no explanation from India as to why it waited for 48 hours before issuing an official statement. One thing is however, certain that this incident will lead to higher alert and readiness levels for at least a part of the strategic assets to swiftly respond to any such incident in future with inherent dangers of its own.

Chapter 13
South Asia A Three-Body Problem

R. Rajaraman

13.1 Kill that Hyphen

An important feature of the strategic dynamics in my part of the world, not sufficiently appreciated elsewhere, is that it is no longer just a binary India–Pakistan problem. The notion of a hyphenated Indo-Pak duality came into being during the Cold war days. Both countries had just gained their independence from British rule in 1947.The US establishment of the time, led by its Secretary of State John Foster Dulles, despised India for its sanctimonious sermons in the UN, for its unwillingness to join US led alliances and generating, instead, the Non-Aligned Movement. So the US chose to support Pakistan financially and strategically. In return, the USSR supported India on the diplomatic front and by supplying arms and industrial infrastructure. In that sense the US-USSR binary appeared to have spawned a miniature replica in the form of India–Pakistan in S Asia.

This a somewhat crude, un-nuanced description of the evolution of the India–Pakistan binary in the immediate aftermath of the cold war. It may make professional diplomats and historians cringe. We beg their forbearance. But, as a quick summary for fellow non-experts we hope it broadly conveys how the western binary view of the Indian subcontinent came to be.[1]

In reality, however, there never was much symmetry between the two countries, except as seen from far away, through the inverted binoculars of the Cold Warriors. On the one hand, India was much larger than Pakistan, in physical size, in population and in its S&T infrastructure. On the other hand, in terms of poverty, I don't think

[1] For a scholarly account of the Indo-US relations at that time see "*Communications across borders—The US, The Non-aligned and the New Information Order*" by K. P. Vijaya Lakshmi, Radiant Publishers, New Delhi 110019, India (1993).

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P. Cotta-Ramusino et al. (eds.), *Nuclear Risks and Arms Control - Problems and Progresses in the Time of Pandemics and War*, Springer Proceedings in Physics 291,
https://doi.org/10.1007/978-3-031-29708-3_13

Pakistan (i.e. the western part of the old undivided Pakistan) was ever as much of a basket case as India was, in the aftermath of their independence. Apart from all these and other characteristics distinguishing them, the two nations have also differed in their political history, with Pakistan's civilian governments interspersed with periods of military rule.

Nevertheless, since they

(i) fought 3 wars with each other,
(ii) officially became nuclear weapon nations within a few weeks of each other and
(iii) are, till today, embroiled in an unending conflict over the state of Kashmir,

it is understandable if the world views, in strategic terms, our subcontinent primarily as the scene of India and Pakistan rivalry. In deference to this viewpoint, I will give, a little later in this talk a comparative summary of the nuclear forces possessed by India and Pakistan and the extent of mutual deterrence they provide.

I will also argue that S Asia is NOT the "most dangerous place on earth" as has sometimes alleged. Such a judgement was first articulated in public by US President Bill Clinton during a visit to India.[2] It was very quickly refuted by the then Indian President K. R. Narayanan, but that has not stopped people in the academia and the media from repeating that catchy phrase. The fact is that despite several conflicts between them, the two countries have been quite responsible in staying away from any nuclear red-line.[3]

But before dwelling more on the Indo-Pak strategic behaviour, let me first introduce the new element in this narrative, which is the crucial role of the third player in the subcontinent's affairs, namely, China.

13.2 Entry of China into S Asian Affairs

India and China, both ancient civilizations, had no military conflicts between them for over two millennia. A part of the reason was that they had no common border, with the mighty Himalaya mountains and the Tibetan nation separating them. They only had amicable, if sparse trade and cultural relations, with Buddhism spreading from India to China and E. Asia

Coming to more recent times, both emerged, around the same period, as independent modern nations freed from centuries of fragmentation and foreign rule. India became independent of the British in 1947, although in the process it was broken into India and Pakistan. The People's Republic of China PRC was established by the Chinese Communist Party in 1949.

India's first Prime Minister Jawaharlal Nehru, was an enlightened statesman with a vision for his country as a liberal democratic republic. He also envisaged an important

[2] Jonathan Marcus, *Analysis: The world's most dangerous place?*, BBC News online: World-South Asia. http://news.bbc.co.uk/2/hi/south_asia/687021.stm.

[3] Ramamurti Rajaraman, "*South Asia is not the most dangerous place on Earth*", The Bulletin of Atomic Scientists, April 26, 2017.

collective role in the affairs of the world for the many recently independent and developing countries and pioneered the Non Aligned Movement (NAM)

In particular Nehru was a strong supporter of China. When PRC wanted to be recognized in the United Nations as the sole representation of China, (as distinct from the ROC government in Taiwan), India strongly supported the move. The PRC became a member of the Security council with veto powers, which, ironically, have been subsequently used by China oppose Indian interests. In addition, India renounced its own special rights in Tibet in 1954 and recognised it as the "Tibet Region of China".

In 1954 Jawaharlal Nehru and Premier Zhou En Lai signed the Panchsheel Agreement—a treaty to bring peace to the post-colonial South Asia.[4] I remember that during the 'Fifties we children in New Delhi schools were raised on the slogan of "Hindi-Chini Bhai-Bhai" (Indians and Chinese are brothers).

But, alas, Mr. Nehru's rose-tinted, benevolent view of geopolitics, including warm friendship with China, turned out to be illusory.

Earlier, China did not have a common border with India, since Tibet was a buffer in between them. But with the annexation of Tibet by China (ironically, facilitated by India), India's Tibetan border became now a border with China and a contentious one, as China felt that some of the territory on the Indian side belonged to the old Tibet and hence to China now.

Instead of negotiating the normalisation of this border issue China attempted to move into that disputed territory leading, in 1962, to a full-fledged war between China and India, which India, quite unprepared for such a war, lost.

The Chinese managed to enter Indian territory and declared a ceasefire only after occupying some part of the territory which they had claimed.

Even after that, China continues to claim, till today, about 90,000 sq. km of India's territory in the northeast, including the entire Indian state of Arunachal Pradesh, which is as integral a part of India as Kerala or Rajasthan. It is governed as per India's constitution like any other state, under the overall authority of the nationally elected central government in Delhi. Yet, the Chinese lodge protests whenever any major Indian functionary, including our President, visits that state. It is like Mexico claiming Texas as part of its territory, and objecting every time the US president visited that state.

Meanwhile there have been repeated clashes with China at various places on their border. The most recent of border skirmishes took place in 2020 where there was physical man-to man combat in which a score of soldiers from both sides lost their lives.

In addition to its own direct border clashes with India, China has also provided vital economic and strategic support to Pakistan on various fronts. These include:

(i) Providing loans and helping construct Civilian infrastructure

[4] For a comprehensive discussion of India-China relations from ancient times till now, see Shyam Saran, "*How China Sees India and The World*", Juggernaut, New Delhi, (2018) ISBN-10: 9386228858.

(ii) Constructing the Gwadar Port on the Arabian Sea, and getting management control of that Port, and
(iii) Building the China Pakistan Economic Corridor (CPEC) which is a pathway being constructed from the S. Eastern corner of China all the way to the Gwadar port.

China is also building the Karot power station, a Karachi Circular Railway, the Karakoram Highway, a subway in Lahore, the civilian reactors in Karachi. The CPRC corridor and the related infrastructural projects funded by the Chinese in Pakistan are shown in Fig. 13.1 below. In return, Gwadar and the CPEC will give China easy access to the Gulf region, without having to go around S.E Asia through the Malaccan Straights on which, as of now, China has little strategic control.

All this should provide jobs and prosperity to Pakistan, which is good for them and good for India, which would prefer a stable and prosperous Pakistan.

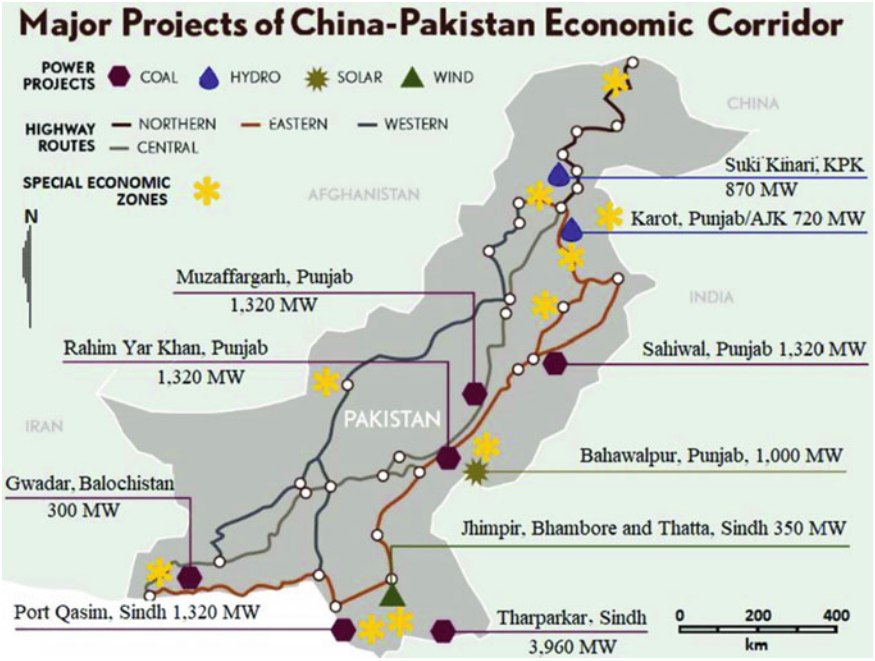

Fig. 13.1 Map of Pakistan showing the China–Pakistan economic corridor and related projects (Map taken from "*China–Pakistan Economic Corridor; Prospects and Challenges for Balochistan, Pakistan*". Farooqui, Muhammad and Aftab, Syed Mobasher, IOP Conference Series: Materials Science and Engineering, 414, 13th September 2018; https://doi.org/10.1088/1757-899X/414/1/012046)

But there are other areas where China's help has clear adverse implications for India on the strategic and diplomatic front.

(i) On the strategic front, China provided clandestine help for Mr A.Q. Khan's centrifuges in the old days, and later in enabling its 1998 its nuclear weapon tests, and in building the military Plutonium production reactors at Khushab. Portions of CPEC roads are built on territory under dispute with India. This did not happen by accident or oversight. It attempts to give some legitimacy to Pakistan's occupation of those areas.

(ii) China has given diplomatic support to Pakistan vis a vis India, such as blocking India's entry into NSG, blocking UN strictures against the Islamist militant Hafeez Sayed and so on.

Indeed, China is now Pakistan's biggest supporter in the world. So, India has to contend with two nuclear weapon states on its western and its northern borders respectively, both of whom are India's adversaries but support each other (Fig. 13.2).

Fig. 13.2 A map of the upper half of India, showing China on its northern border and Pakistan on its western border, with disputed areas on both sides. (Map Taken from the article "Fantasy frontiers", in The Economist, Feb 8th 2012 (Updated Oct 7th 2021); https://www.economist.com/graphic-detail/2012/02/08/fantasy-frontiers?utm_source=pinterest&utm_medium=social)

13.3 India's Nuclear Equations with Its Adversaries

China reportedly has a battery of nuclear armed missiles located in Tibet capable of reaching New Delhi and other cities of India. India too has developed nuclear weapons and as George Fernandez, an honest no-nonsense person and our Defence minister at the time of our nuclear tests said, India's nuclear weapons were intended more to deter China than Pakistan.

But, to start with, India did not have the delivery vehicles to carry its warheads to China. Its Prithvi, Agni I and Agni II missiles were only of intermediate range. It was not clear whether bomber planes sent deep into to China would have enough fuel to return or could be refuelled *en route.* Since then it has been developing and testing missiles of 5000 km range (Agni V) that can reach major Chinese cities. India also has a deployed nuclear powered Submarine and a couple more in the making which could potentially wander into the Pacific.

However, the India–China conflicts now are nowhere close to a nuclear threshold. Both nations have other priorities, on the economic and technological front. Notwithstanding their border disputes, they have considerable economic trade with each other and warily cooperate wherever they can—in alignments like BRICS. The India–China dialogue is less belligerent in tone, less visceral and more nuanced than the India–Pakistan exchanges. Therefore, despite all this nuclear armoury on both sides, there is very little possibility of a nuclear exchange between India and China.

Next, let us look at India–Pakistan nuclear dynamics. With both sides reportedly possessing over 100 warheads each, and sufficiently reliable platforms for delivering them, there is fairly credible second strike capability on each side to cause "unacceptable damage" to the other. I have shown this in quantitative terms in op-eds and articles.[5] Such retaliatory capability provides substantial mutual deterrence against deliberate, rational nuclear attacks on one another.

But some sources of strategic instability need to be considered in the South Asian context.

A. **Crisis instability**

One can ask if deterrence through credible retaliatory capability will be sufficient to stave off a nuclear exchange, if it is forced by other provocative factors—terrorism, domestic political crises and, the civilian-military equation, border conflicts, mini-wars etc. On this, much of the international community of analysts shows little confidence in S Asians. As mentioned already, the subcontinent has repeatedly been called the "most dangerous place on earth".

We totally disagree with this view, which is condescending about the leadership of the two countries. The truth is that despite many provocations both India and Pakistan have stayed very far from nuclear thresholds, albeit accompanied by some verbal saber rattling. The response of the Indian leadership to major terrorist attacks

[5] R. Rajaraman, "*Nuclear posture*", **The Hindu**, Editorial page, February 7, 2003; R. Rajaraman, "*Cap the Nuclear Arsenal Now*", **The Hindu**, Edit Page, 25th Jan 2005, and R. Rajaraman, "India–U.S. Deal and the Nuclear Ceiling" **The Hindu**, Edit page, September 10, 2005.

including the attack on Mumbai in 2008, and one on the Indian Parliament in 2001 was extremely restrained and statesmanlike. For an analogy, imagine the Houses of Parliament in London being attacked, while they were in session, by terrorists identifiably trained by, say, Iran or N Korea. Would the UK have been as restrained as we were?

In their own way, and for whatever reason, the Pakistani leadership has also been restrained. Let me give some examples. At no stage during the Kargil war in 1999, was there any serious thought by either side of escalation to a nuclear war. Let us not forget that that was just one year after both countries had turned nuclear, with fairly new Command and Control structures put in. One might have worried that the chance of a nuclear launch, by accident or because of misreading signals, were higher at that time. But good sense prevailed on both nations in not getting carried away by their new found nuclear arsenals.

In 2016, India finally launched a set of surgical strikes across the Line of Control in Kashmir, in retaliation against repeated attacks by Pakistan supported insurgents. The humiliation resulting from these successful strikes could have generated domestic pressure in Pakistan to retaliate against India with even bigger strikes. But Pakistan quickly dampened that by simply denying that the Indian strikes had even taken place! Whether this was due to statesmanship or wisdom or some other domestic compulsions, the fact remains that it helped de-escalate the crisis.

Likewise, once it became clear after the Mumbai terrorist attack in 2008 that in the event of another such attack, India would have to escalate their response, Pakistan has generally refrained from launching ***mainland*** terrorism on India. One can give more such examples. In short, we don't have serious Crisis Instability in S. Asia in the nuclear realm.

B. **Instabilities induced by technological developments**

(i) The Nasr: The introduction by Pakistan of the short range battlefield nuclear capable missile Nasr a few years back has affected the operational equation between the two countries, but it did not lead any serious strategic instability. The Nasr is intended to be used by the Pakistanis on their own soil against a possible conventional incursion by Indians into their territory. They feel it strengthens their deterrence against such an invasion. Of course India has no plans to attempt any such invasion. But they may well be forced to do it in response to continuing terrorist acts emanating from Pakistani soil.

From the Indian side the Nasr did not really call for any major changes in their nuclear arsenal or deployment. It only generated some mainly academic discussion about whether India would respond to a Nasr attack on our forces with massive nuclear retaliation, as the current language in its Nuclear Doctrine would imply. But even this debate has not led to any proposal to modify our nuclear doctrine. In fact, like the missile itself, the Nasr was just a "tactical" development doctrinally as well.

(ii) BMD: India has been developing a Ballistic Missile Defence program for some years. It has met with some success in its early stages but the program is still in its infancy. That is good because there is still time to shepherd the BMD program

in the right directions so that it doesn't destabilise strategic equations. BMD could have two different types of goals. It could be designed to protect certain specific sites which house the apex leadership and key strategic assets. That is an important and comparatively realistic goal. Although that information is classified, the major nuclear powers undoubtedly have such protection for key sites. Alternatively, BMD could be designed to protect all or some of the major cities. This is a far more ambitious goal. No country is even remotely close to achieving that. Furthermore, it would be an unwise goal from the strategic viewpoint for the following reasons.

Recall that the deterrence strategies of both countries rely on counter-value attacks on population centers. Only that can provide damage sufficiently "unacceptable" to act as a reliable deterrent. As long as neither side had the capability to significantly intercept missiles attacking their cities, they may be persuaded to stay with the *relatively* small arsenals they currently possess, which are sufficient for creating unacceptable damage through attacks on population centers.

Once each of the sides obtains enough ABM capability to protect their population it will significantly reduce their deterrence capability of the other side. That in turn will generate an arms race, as each side will feel that its existing offensive capability is inadequate in the face of it being shot down. As consequence, there is already some talk in S Asia of developing MIRVs (Multiple Independently Targetable Re-entry Vehicles) to overcome the enemy's BMD systems. It would be disastrous both financially and strategically if either country in the subcontinent started a program to build MIRVs. Therefore, any development of BMD on either side has to be tempered by some understanding of what that will do to the deterrence posture of the adversary.

13.4 Conclusion

We are not for a minute saying that it isn't terribly dangerous to possess nuclear weapons, especially in a region with 3 nuclear neighbors (India–Pakistan–China) two pairs of whom are in a state of conflict. Yes, S. Asia IS a dangerous place and there is no doubt about that. Those of us who live there, and have let our governments foist this deadly danger upon us bear a special responsibility to fight against it.

But it is no more dangerous than, say, the N Korea–S Korea–US triad or the S China sea, or Syria, let alone the Ukraine–Russian border. Or, for that matter, the world as a whole, what with the two superpowers still possessing thousands of nuclear weapons, many of which are deployed on trigger alert!!

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Chapter 14
The Case of the Korean Peninsula

Anton Khlopkov

The Korean Peninsula remains a hotspot in terms of the nuclear nonproliferation regime. Despite diplomatic efforts and increasingly severe sanctions on Pyongyang by the UN Security Council, initially imposed following DPRK's first nuclear test in 2006, as well as years of unilateral sanctions by the United States and several other countries, the DPRK managed to acquire the technological capability to produce nuclear weapons, including their delivery systems.[1] According to assessments in the report cited in footnote 1, by September 2022 the DPRK may have sufficient nuclear material—HEU and weapons-grade plutonium—to produce nearly 60 nuclear warheads. Analysts estimate that Pyongyang's existing short- and medium-range missiles are capable of reaching targets in the Republic of Korea, Japan, and Guam, an unincorporated territory of the United States. The Hwasong-14 missile has enough range to strike targets in Alaska, while the Hwasong-15, once deployed, is capable of reaching the rest of the United States.

Meanwhile, the Republic of Korea has been exploring the nuclear option in one form or another for many decades. The country has reportedly initiated nuclear-related activities, which could have military applications, at least three times in the history. Support for acquiring the country's own nuclear capability continues to grow among South Korean politicians, scientists, and military officials who fear the United States could refuse to defend its ally. In this context, Seoul's attempts to

[1] Anton Khlopkov's contribution to the XXII Edoardo Amaldi Conference is based on the report '*DPRK Strategic Capabilities and Security on the Korean Peninsula: Looking Ahead*', prepared jointly by the Center for Energy and Security Studies (CENESS) and the International Institute for Strategic Studies (IISS) (http://ceness-russia.org/data/doc/Joint_IISS-CENESS_report_on_Korean_Peninsula_English_Very%20Final.pdf). That said, the paper does not necessarily reflect the views held by everyone involved in the research project resulted in above-mentioned publication or the organizations engaged in this work.

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further develop its nuclear fuel cycle, including uranium enrichment and spent fuel reprocessing technologies, are likely to expand in the coming years.

After a round of intense diplomatic efforts in 2018–2019 that brought limited but important results (suffice it to mention the DPRK's unilateral moratorium on long-range missile launches and nuclear tests, as well as Pyongyang's announcement of the closure of the Punggye-ri nuclear test site) the international community is entering another phase of escalating tensions in the region, with a likely prolonged pause in dialogue between the main antagonists—Washington and Pyongyang, Pyongyang and Seoul. In his contribution to the XXII Edoardo Amaldi Conference, the author examines the history of the nuclear factor on the Korean Peninsula, considers possible approaches to reducing nuclear risks in the region, and proposes his views on progress toward denuclearization of the peninsula in the long term.

14.1 Why is The Region Being 'Nuclearized'?

It is believed that the DPRK's interest in pursuing a military nuclear program has historically been driven by four main factors.

First, the division of Korea in 1945 and the ensuing confrontation between the North and the South that escalated into the Korean War, during which the United States stated it could use nuclear weapons. In November 1950 the U.S. President Harry Truman publicly declared his readiness to use nuclear weapons if necessary in order to win the Korean War. According to archival documents, in April 1951 he ordered 9 nuclear bombs to be transferred to the U.S. Air Force and transported to the Okinawa base.

Pyongyang's fear of a nuclear threat increased after American tactical nuclear weapons were deployed in South Korea in the late 1950s. At one point there were as many as 950 nuclear warheads for 8 types of US tactical nuclear weapons in the Republic of Korea. Their complete withdrawal was announced 1991. There have been no corresponding verification measures, although most analysts tend to believe that there are no U.S. nuclear weapons left on South Korean territory.

Secondly, confronted with the United States and its allies, the DPRK was interested in obtaining a kind of 'insurance' in case relations with Moscow and/or Beijing, with which it then had allied treaties, began to deteriorate. Due to the prolonged crisis in Sino-Soviet relations and other political developments in the socialist camp, as well as the USSR–US detente and US–China rapprochement that began in 1971, Pyongyang no longer had full confidence that Beijing and Moscow would unreservedly support it in the event of another military crisis.

Third, in the 1970s Pyongyang became aware of Seoul's efforts to develop its own nuclear weapons. South Korean President Park Chung-hee ordered the start of a secret plutonium weapons program in 1970, with the goal of developing a domestic nuclear explosive device by the end of the 1970s.

Fourth, some experts believe that the DPRK may feel that nuclear weapons could help achieve the declared goal of unifying the Korean Peninsula by preventing the

United States from supporting the Republic of Korea in the event of renewed hostilities. The Constitution of the DPRK refers to the restoration of the country's unity as 'the nation's supreme objective'. At the same time, the Constitution of the Republic of Korea claims that its territory consists of the entire Korean Peninsula, and the South Korean National Security Act describes the DPRK as an 'anti-government organization'.

The Korean War of 1950–1953 ended with an armistice with no peace treaty signed to date. Thus, the continued mutual antagonism between the two Koreas creates additional nuclear risks on the peninsula. Moreover, currently Pyongyang's top priority is to strengthen its deterrence capability against the United States.

14.2 Potential Steps to Reduce Tension and Achieve Denuclearization

A rapid denuclearization of the Korean Peninsula is not a realistic possibility. Nevertheless, diplomatic developments and a number of summits in 2018–2019 demonstrated that progress towards denuclearization is possible. The key principle in working out a long-term agreement should be that of 'steps in the field of security on the one side in exchange for steps in the field of security on the other.' Economic projects and cooperation (and in this regard, the easing and lifting of sanctions) could make an important contribution to the creation of a sustainable peace and security system in the region, but they cannot be the foundation for it in the long term.

The parties should adopt a step-by-step and reciprocal approach. The step-by-step strategy is especially important in the early phase of dialogue as an element of confidence building. A long-term solution to the nuclear issue on the Korean Peninsula should be based on the principle of taking into account the security interests of all parties. At the same time, the expectations of all parties involved in the short and long term must be moderate and realistic. The primary goal here should be to prevent escalation in the region.

It is necessary to create conditions for the development of joint measures that provide proportionate benefits to all participants in the process in exchange for movement toward denuclearization. The lack of a 'proportionate response' from the United States and South Korea following unilateral steps by Pyongyang was one of the major bottlenecks in the dialogue process that took place in 2018–2019.

In the same vein, Washington and Seoul should recognize that the sanctions imposed on Pyongyang frequently not only do not contribute to solving the current crises in the region, but also complicate the achievement of this goal, drive the situation into an even greater deadlock and have a negative impact on the DPRK population, rather than the country's nuclear and missile capabilities. This is also valid for the UN Security Council sanctions, which, in accordance with their proclaimed objectives, were aimed primarily at abandoning by the DPRK its nuclear missile program. Visiting the DPRK (which the author had the opportunity to do several

times before the COVID-19 pandemic), one can easily find examples of the negative impact of the sanctions on various areas of life of ordinary North Koreans. These include an acute shortage of medications, medical equipment, and other essentials for the proper functioning of the healthcare system. An annual UN report on food security released in July 2022 found that the percentage of undernourished people in DPRK reached 41.6% in 2019–2021.[2]

A blatant example of Washington and Seoul failing or unwilling to make their way through the hurdle of sanctions was South Korea's inability to supply the DPRK with 200,000 doses of the antiviral Tamiflu in January 2019, at the height of diplomatic efforts in the region following South Korea's pledge at the highest level.

Although the 2018–2019 nuclear diplomacy did not achieve its goals, it did produce tangible results, helping to temporarily ease tensions and security concerns in the region. Pyongyang's unilateral moratorium on nuclear testing, which as of June 2022 continues to be in place, limits its ability to improve its nuclear warheads. The complete dismantling of all Yongbyon nuclear facilities (which the DPRK and the US discussed at the Hanoi summit in February 2019) would greatly reduce North Korea's capacity to produce weapons-usable nuclear materials (up to 80% according to some estimates) and effectively freeze the DPRK's thermonuclear program.

When it comes to the dialogue format needed to work out further steps to reduce tensions and make progress on denuclearization of the Korean Peninsula, one can draw on the experience of the negotiations to resolve the Iran's nuclear program crisis, which resulted in the adoption of the Joint Comprehensive Plan of Action (JCPOA) in July 2015. The multinational approach, which included both bilateral and multilateral formats and was applied during the negotiations on the Iranian nuclear program, seems to be the most promising and sustainable. Distrustful of the U.S., Pyongyang has been closely following the negotiation process over the Iranian nuclear program for years, and appears to be trying to understand (among other things) the added value of multilateralism. The Panmunjom Declaration, adopted following the April 2018 meeting of South Korea and DPRK leaders, stresses the importance of international support and cooperation to address the denuclearization of the Korean Peninsula.

In any future talks on the Korean Peninsula, the same basic principles that guided the negotiation of the JCPOA should apply: mutual respect, reciprocity, as well as recognition of state sovereignty and security interests of all parties involved.

The complete denuclearization of the Korean Peninsula and the development of a comprehensive peace and security system in Northeast Asia, however difficult and distant this goal may seem, should remain the long-term goal of the negotiation process. In this context, it would be useful to recall lessons from the Six-Party Talks, including the working group that was established to examine possible peace and security mechanisms in Northeast Asia. Each of the countries involved in the process should aim at reducing tensions, working out interim agreements in the short and medium term, and reaching complete denuclearization of the Korean Peninsula in the long term. In this regard, many analysts point out that Japan has been part of the

[2] Table A1.1. https://www.fao.org/3/cc0639en/cc0639en.pdf.

problem rather than part of the solution in recent years, putting forward unrealistic conditions for starting a dialogue, as well as regularly bringing up issues that have nothing to do with denuclearization and only complicate the pursuit of a sustainable dialogue in the region.

Chapter 15
The Struggle to Save the JCPOA: Negotiations to Nowhere?

Steven E. Miller

Abstract On May 8, 2018, President Donald Trump announced that he was withdrawing the United States from the Joint Comprehensive Plan of Action (JCPOA). However, he failed in his subsequent efforts to coerce Iran into capitulation on the nuclear issue or to accept what Washington regarded as a better deal. The Biden Administration thus inherited a situation in which neither the United States nor Iran was complying with the deal but the Administration was pledged to restore the JCPOA. Rather than simply reverse Trump's unilateral policy on the JCPOA, though, Biden launched a diplomatic effort aimed at restoring the agreement while possibly modifying some of its terms to address concerns about Tehran's nuclear progress that had arisen when Iran too began to ignore JCPOA constraints. The ensuing negotiations soon bogged down, impeded by a tangle of misaligned perceptions and irreconcilable positions. Washington hoped that the leverage provided by Trump's sanctions would give Iran incentives to rejoin the agreement, but this perspective failed to take into account that Tehran has its own complaints and reservations about the JCPOA as well as its own internal opposition to the agreement. As a result, more than two years into his Presidency, Biden has been unable to correct what he regarded as the "gigantic mistake" of withdrawing from the JCPOA.

15.1 Trump Abandons the Iran Nuclear Deal

On May 8, 2018, President Donald Trump announced that he was withdrawing the United States from the Joint Comprehensive Plan of Action (JCPOA), the painstakingly negotiated multilateral nuclear deal with Iran. Trump had long been a harsh critic of the deal, not least because of his intense antipathy to his predecessor, President Barack Obama; Trump seemed determined to undo major elements of Obama's legacy, including the JCPOA. In his determination to derail the agreement, Trump

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resisted the entreaties of other parties to the agreement, was indifferent to the preferences of allies who wished to preserve it and ignored the recommendations of even some of his own senior officials that the agreement was best left in place. Rather, Trump insisted that the JCPOA was a bad deal and justified his decision to withdraw by offering excoriating assessments of the agreement. "The Iran deal," he said in the official announcement of his decision, "was one of the worst and most one-sided transactions the United States has ever entered into."[1]

Abandoning the deal that, in its essence, had exchanged sanctions relief in return for substantial constraints on Iran's nuclear activities and high levels of transparency to monitor those activities, Trump instead launched a campaign of maximum pressure against Iran. He ordered an immediate reimposition of sanctions that had been lifted as part of the deal and threatened severe consequences for those who continued to do business with Iran. The maximum pressure policy was linked to a very ambitious set of objectives, spelled out in detail by Secretary of State Mike Pompeo.[2] Confident in the Trump Administration's ability to coerce Iran and declaring an intention to impose "the strongest sanctions in history," Pompeo outlined a sweeping agenda of a dozen explicit demands that called for a full surrender of elements of Iran's nuclear program, an end to Iran's ballistic missile program and an abandonment of most of Iran's foreign policy behavior in the region. Specific measures sought included a full confession of Iran's previous covert nuclear weapons development activities, an end to Iran's enrichment program, unlimited International Atomic Energy Agency (IAEA) access to Iranian territory to allow monitoring of nuclear activities, a reversal of Iranian policy in Palestine, Lebanon, Iraq, Yemen, Syria, and Afghanistan, a curtailment of the activities of the Iranian Revolutionary Guard, and an end of threatening behavior toward US friends and allies. This was not an agenda for negotiation; it was a policy of coercion. The explicit intent was to confront Iran with a choice between changing its behavior and being forced to its economic knees. But Trump and his team also suggested that this was the road to a better nuclear deal with Iran.

A year later, confounding the expectations of the Trump Administration, Iran was not succumbing to pressure and had not complied with the Pompeo demands. Rather than capitulate to American pressure, in May 2019 Iran itself began to violate JCPOA limits—ending a twelve-month period in which Iran had continued to comply with the agreement despite Trump's withdrawal. As has so often been the case in the long evolution of the Iran nuclear controversy, Washington concluded that the solution to the failure of pressure was more pressure. In the spring of 2019, Trump

[1] "President Donald J. Trump is Ending United States Participation in an Unacceptable Iran Deal," TrumpWhiteHouse.archive.gov/briefings, May 8, 2018. See also Mark Landler, "Trump Abandons Iran Nuclear Deal He Long Scorned," *New York Times*, May 8, 2018.

[2] Pompeo spelled out the Trump Administration's twelve demands in a speech at the Heritage Foundation shortly after Trump announced the US withdrawal from the JCPOA. His speech is available at "After the Deal: A New Iran Strategy," The Heritage Foundation, May 21, 2018, https://www.heritage.org/defense/event/after-the-deal-new-iran-strategy. The Trump Administration's policy on Iran is elaborated in Michael Pompeo, "Confronting Iran: The Trump Administration's Strategy," *Foreign Affairs*, November/December 2018.

and Pompeo announced another wave of sanctions, some aimed at Iran's oil sector, others (widely viewed as largely symbolic) aimed at Iranian individuals and entities.[3] Efforts to escalate the maximum pressure policy mounted thereafter, unleashing a frenzy of sanctions measures against Iran that continued to the final days of Trump's presidency. Trump put in place some 1500 additional sanctions in the final three years of his term, the last of which were announced on January 15, 2021, just five days before Trump left office.[4] As one analysis of this policy explained, "Trump's immediate goal appears to be to batter Iran's economy with sanctions to the point that the country's leaders will renegotiate the nuclear deal—and its military support for Hezbollah and other proxy groups—on terms that the administration deems more favorable to the United States."[5]

But more pressure did not produce better results; maximum pressure seems to have produced maximum resistance. There was no demonstrable improvement in Iran's regional behavior. On the contrary, as the International Crisis Group noted in a major report issued near the end of Trump's term, Iran's regional policies remained unchanged and indeed "its actions and those of its allies have if anything become more belligerent."[6] Trump and Pompeo seem to have shared this judgment, complaining repeatedly about Iranian misbehavior. In explaining the January 2020 assassination of the head of Iran's Revolutionary Guard, Qasem Soleimani, for example, Pompeo said that it had been necessary to stop Iran's "reign of terror" while Trump, in his public remarks, offered a litany of violent and aggressive Iranian acts that in his eyes justified the killing.[7] Clearly, ever rising levels of maximum pressure did not bring an end to assertive Iranian activity in the region.

Similarly, Iran did not modify its nuclear program in the ways demanded by the Trump Administration. Rather, in an incremental fashion Iran's behavior increasingly transgressed its obligations under the JCPOA, as Tehran came to judge that it could not justify complying with the agreement when the United States was engaged in extensive and flagrant rejection of it. One step at a time over the course of 2019, Iran disregarded important provisions of the JCPOA, growing steadily more noncompliant as the Trump Administration redoubled its sanctions policy.[8] Iran initially took the

[3] Edward Wong, "Trump Imposes New Sanctions on Iran, Adding to Tensions," *New York Times*, June 24, 2019.

[4] Karen DeYoung, "Negotiations Over the Iran Nuclear Deal are Close to the End and a Deal Appears Possible," *Washington Post*, February 23, 2022.

[5] Ronen Bergman and Mark Mazzetti, "The Secret History of the Push to Strike Iran," *New York Times Magazine*, September 4, 2019.

[6] International Crisis Group, *Iran: The US Brings Maximum Pressure to the UN*, Report No. 218, August 19, 2020. Michael McFaul and Abbas Milani, "The Minimal Value of Trump's Maximum Pressure on Iran," *New York Review of Books*, January 8, 2020, offers a similar description.

[7] Pompeo's remarks can be found in "Interview with Secretary of State Pompeo," January 5, 2020, available at https://il.usembassy.gov/interview-with-secretary-pompeo-january-5-2020/. For Trump's comments, see "Remarks by President Trump on Iran," January 8, 2020, available at https://trumpwhitehouse.archives.gov/briefings-statements/remarks-president-trump-iran/.

[8] A very useful summary of Iran's steps away from the JCPOA can be found in "The Joint Comprehensive Plan of Action (JCPOA) at a Glance," Arms Control Association, March 2022.

fairly limited and easily reversed steps of exceeding JCPOA limits on inventories of heavy water and enriched materials. But thereafter it went beyond permitted limits on levels of enrichment, began to install prohibited advanced centrifuges, and initiated enrichment activity at its Fordow facility, though that is forbidden by the JCPOA. Then on January 5, 2020—probably in part in reply to the drone attack that killed Soleimani two days earlier—Iran announced that it no longer regarded itself as constrained by any of the operational limitations in the JCPOA.[9] No better deal ever materialized—indeed, no negotiations were ever undertaken during the Trump years though the administration thought that Iran would be desperate for new talks—while the existing, unprecedented JCPOA limitations on Iran's nuclear program were lost. Having championed a policy that liberated Iran from an extensive web of nuclear constraints, Secretary of State Pompeo complained shortly after leaving office that Iran had "unwound the nuclear deal in a matter of months."[10] That indeed is what followed from the Trump-Pompeo policy of rejecting the JCPOA—their approach left Iran unconstrained by agreement and much closer to a nuclear bomb than had been the case under the JCPOA.

Though proponents and supporters of maximum pressure believe that it was working (at least in the sense of causing impactful economic pain for Iran) or would have succeeded in achieving at least some of its objectives had Trump been re-elected, at the time of his departure from office, it was on its own terms a complete failure. Not one of the twelve articulated objectives had been achieved—literally zero out of twelve. Trump came then to the end of his presidency with Iran as belligerent as ever, its nuclear program unleashed and accelerating, with the JCPOA undone, diplomacy absent from the picture, and the promised "better deal" nowhere in sight.[11] As Senator Chris Murphy later commented, during the years of Trump's Iran policy "Everything got worse."[12] Trump's maximum pressure campaign was strikingly unsuccessful in altering Iranian behavior or producing a better nuclear deal but it did have one significant consequence that was pleasing to its supporters: it derailed the JCPOA and put in place both a damaged diplomatic setting and an elaborate web of sanctions that would make it difficult for any successor to restore the agreement.

[9] On this development and its implications, see Robert Einhorn, "Averting a New Iranian Nuclear Crisis," Brookings Institution, January 2020.

[10] Yonah Jeremy Bob, "Pompeo to Post: Iran Unwound Nuclear Deal in Matter of Months," *Jerusalem Post*, June 24, 2021.

[11] As one assessment put it, "Maximum pressure, minimum gain." See Colum Lynch, "Iran: Maximum Pressure, Minimum Gain," *Foreign Policy*, December 23, 2020.

[12] Comment on social media, August 29, 2022: https://twitter.com/ChrisMurphyCT/status/1564084810427015169.

15.2 What to Do About a Wrecked Deal?

This was the situation that President Biden inherited when he assumed office in January 2021. During the 2020 American presidential campaign, Biden had been an outspoken supporter of the JCPOA and was a harsh critic of Trump's decision to withdraw from the agreement. Trump's move, Biden argued during the campaign, was "reckless," a "self-inflicted disaster," a "dangerous failure" that left the United States worse off. Biden was critical of the incoherence of Trump's policy, withdrawing from and thereby undermining the agreement but then insisting that Iran abide by it and protesting loudly when, in response to large breaches of the agreement by Washington, Iran too began to violate it.[13] President Trump, Biden would state, walked away from an agreement that was blocking Iran's path to nuclear weapons. As he continued to say even after taking up the presidency, he regarded Trump's JCPOA decision to be "a gigantic mistake."[14]

Accordingly, Biden was explicit and unambiguous during the campaign that if he became President he would seek to restore the JCPOA. It will be a "priority" of the Biden administration, he wrote in an op-ed in September 2020, "to set Iran policy right." In his eyes, this meant a return to the JCPOA on the basis of "compliance for compliance." If Iran were prepared to come back into compliance with the agreement, Biden would "rejoin" the JCPOA.[15] In short, if he won the election, Biden intended to correct Trump's "gigantic mistake" so long as Iran was also interested in the restoration of the agreement.

Once Biden assumed office on January 20, 2021, the question became how this might happen. One approach available to Biden was simply to reverse Trump's policy. Trump's decision to withdraw from the JCPOA was a unilateral act. It was not negotiated with Iran, nor coordinated with allies, nor discussed in the UN. It does not normally require an international negotiation for the United States to take (or reverse) a unilateral foreign policy decision. On the day of his inauguration, for example, President Biden signed an executive order that overturned Trump's withdrawal from the Paris Climate Agreement; less than a month later, the United States had formally rejoined the treaty.[16] Biden might have taken a similar step with the JCPOA, establishing in an executive order on day one of his presidency the intention to immediately bring the United States back into the JCPOA. During the campaign, he had repeatedly stated that this would be done only on a "compliance for compliance" basis, so such a move would have been conditional on Iran also moving back into compliance on some reasonable time frame. The JCPOA is a long, detailed, painstakingly negotiated document in which Iran's obligations are explicitly

[13] For a compendium of Biden's remarks on Iran during the election and after he became president, see "Joe Biden on Iran," *The Iran Primer*, July 11, 2022.

[14] Kate Sullivan, Allie Malloy, and Sam Fossum, "Biden Says Trump Made Gigantic Mistake Withdrawing the US from Iran Nuclear Deal, *CNN*, July 13, 2022.

[15] Joe Biden, "There's a Smarter Way to be Tough on Iran," *CNN*, September 13, 2020.

[16] See, for example, Oliver Milman, "Biden Returns US to Paris Climate Accord Hours after Becoming President," *The Guardian*, January 20, 2021.

spelled out so it would have been clear what Iran needed to do to reestablish its compliance and the JCPOA's intrusive verification provisions would have provided clear indication of the pace at which Iran was altering its behavior to conform to JCPOA requirements. Presumably, if withdrawing from the JCPOA was a "self-inflicted disaster," as Biden believed, then getting the United States back into the agreement quickly was very much in the US interest so this was a plausible path that would leave the decision about America's connection to the JCPOA entirely in his hands.

Employing what might be called the Paris Climate Change model for the JCPOA would have had several advantages. First, Trump's withdrawal had positioned the United States as the agreement-wrecker—the party whose actions had derailed an agreement that many other parties regarded as both desirable and effective. If Biden had immediately rejoined the agreement on the condition that Iran do likewise, the onus would then have been on Tehran to bring its behavior back into compliance with the agreement or take responsibility for the demise of the agreement. Among other things, this could have served as a test of Iran's real intentions. Second, this would have brought the matter to a head while Iranian President Rouhani and Foreign Minister Zarif—who negotiated the JCPOA and were important advocates of it in the Iranian context—were still in office, ahead of the Iranian presidential election of June 2021. Because of term limits, Rouhani was ineligible to run for reelection, so it was certain that there would be a new government in Tehran and there was every expectation that the new leadership would be less hospitable to, if not hostile towards, the JCPOA. It might have been advantageous to have Iran's initial response to an American return to the JCPOA be set in the Rouhani-Zarif era. Third, an immediate American acceptance of the JCPOA, if reciprocated by Tehran, would minimize the amount to time that Iran was acting outside the constraints of the agreement, limiting the advancement and modernization of its nuclear program. Especially given concerns about the expiration of JCPOA provisions and worries about the short period of time remaining before some key limits began to lapse, it would make sense to maximize the amount of time in which Iran was constrained by the agreement. On the other hand, if Iran failed to conform to JCPOA requirements, this would offer more clarity about Iran's intentions and would facilitate and justify coordinated international efforts to press Iran for nuclear restraint.

After the 2020 election, there was some expectation that Biden would rapidly, if not immediately, reverse Trump's policy by bringing the United States back into the JCPOA. Once in office, however, Biden did not make a quick unilateral move to alter US policy, opting instead for a diplomatic path that involved discussions in the P5 + 1 context and indirect engagement with Iran. The intent was to find a negotiated arrangement that would synchronize US and Iranian returns to compliance, allow discussions that might address concerns and perceived shortcomings of the JCPOA, and hopefully lay the groundwork for follow-on negotiations leading to a "longer and stronger" deal.

Why did Biden surrender his unilateral discretion over US policy and instead put an important American interest into a complicated diplomatic process? A number of factors seem likely to have influenced this outcome. The decision reflected, in part,

the desire for a longer and stronger agreement, which would require an ongoing negotiation. There was also a feeling that Iran's nuclear advances once it had breached JCPOA limits should be dealt with; Iran's progress meant that circumstances had changed since the JCPOA was negotiated. Moreover, while Iran's nuclear program was improving, the nonproliferation benefits of the JCPOA were shortening as time passed and expiration dates grew nearer. There was also a sense among some of the Democratic experts that Trump's maximum pressure campaign, though misguided and unsuccessful, had in fact put considerable pressure on Iran that could be an asset for the Biden Administration as it sought to tackle some of these issues; the pressure might work if linked to reasonable goals rather than to Trump's demands for surrender. There was a line of analysis, in short, that suggested that just returning to the JCPOA in its original form, was insufficient. As one influential analysis argued, "Simply returning the United States to the Joint Comprehensive Plan of Action (JCPOA) is not a long-term solution….The United States needs to pursue a renewed nuclear bargain with Iran, building on the solid foundation of the original and addressing its shortcomings."[17]

Biden's calculations were undoubtedly also influenced by the international and domestic pressures and constraints he would face when trying to deal with Iran. Important friends and allies—Israel and Saudi Arabia notable among them—were hostile to the Iran deal and opposed to or unenthusiastic about a resumption of the JCPOA. More immediately, at home Biden faced a domestic setting marked by widespread opposition to the JCPOA. His Republican opponents were and are unanimously and (in many cases) vehemently and outspokenly disparaging about the agreement; Trump's scathing characterization of the deal as a terrible giveaway reflected the views of his party. But some in Biden's own party were almost equally zealous in their criticisms of the agreement. One of the loudest detractors, for example, is Senator Bob Menendez (D-New Jersey), who voted against the JCPOA in 2015 and has remained steadfastly hostile to the agreement in the intervening years, causing some to describe him as a "JCPOA saboteur."[18] If Biden acted unilaterally without addressing alleged weaknesses of the deal and without confronting nuclear progress Iran made while operating outside the deal, criticism was sure to be intense and the domestic political price would be high. Further, Biden's ability to deliver sanctions relief or other concessions under these circumstances was very much in doubt—indeed, any step that required Senate action or support seemed politically infeasible. Hence, while it was clear that the Biden Administration wished to rejoin

[17] Robert Einhorn and Richard Nephew, *Constraining Iran's Future Nuclear Capabilities*, (Washington DC: Brookings, March 2019), p. 1.

[18] See, for example, Ryan Costello, "Iran Nuclear Deal: Senator Menendez is on the Iran Warpath Again," *Responsible Statecraft*, February 3, 2022. Menendez argues that any deal that fails to completely dismantle Iran's nuclear program is unacceptable. For a good statement of his views, see his statement to the Senate Foreign Relations Committee, "We Cannot Allow Iran to Threaten us into a Bad Deal or an Interim Agreement that Allows it to Continue Building its Nuclear Capacity," February 1, 2022, available at https://www.foreign.senate.gov/press/chair/release/chairman-menendez-we-cannot-allow-iran-to-threaten-us-into-a-bad-deal-or-an-interim-agreement-that-allows-it-to-continue-building-its-nuclear-capacity.

the agreement and hoped that the JCPOA could regain its status as a functioning arrangement complied with by all, the President's freedom of maneuver has been limited by a substantial set of constraints that make some plausible paths forward painfully difficult and arguably too politically costly to pursue.[19]

Biden's decision to follow a diplomatic track rather than to modify US policy and then join his JCPOA partners in calling for Tehran's timely return to compliance thus may be understandable and even defensible but it has so far turned out to be fateful. The ultimate outcome for the JCPOA is as yet unknown but more than thirty months into President Biden's term, the negotiations have been fruitless, the process is stymied, and at this moment it seems that there is a good chance that it will prove impossible to save the agreement. Negotiations were slow to get started and were soon bogged down. Proceeding down the diplomacy track to resurrect the JCPOA had as an inevitable consequence that Iran's reactions and behavior would have a decisive impact on the pace, direction, and outcome of the negotiating process.

15.3 Tehran's Doubts and Grievances

The choice to reverse Trump's Iran policy by diplomacy rather than by unilateral decision and action brought the Biden administration up against a tangle of complicating Iranian perceptions and calculations.[20] First, Tehran's belief is that the difficulties for the JCPOA have been caused by the United States and hence it is incumbent on Washington to take steps to remedy the situation. In this view, it was not Iran that undercut the agreement and it is not Iran's responsibility to repair the situation. In Tehran's eyes the matter was very simple: resolution of the issue will occur when the United States corrects its policy. As then-Foreign Minister Zarif explained early in the Biden Administration, what was required was that "US unconditionally and effectively lift all sanctions imposed, re-imposed, or re-labelled by Trump. We will then immediately reverse all remedial activities."[21] The Iranian position collided, however, with the Biden Administration view that Iran should come back into compliance with the

[19] For thoughtful discussions of the constraints on Biden's Iran policy, see George Perkovich and Megan Dubois, "Can Biden Revive the Iran Nuclear Deal?," Carnegie Endowment for International Peace, April 27, 2021; and Michael Singh, "Biden's Iran Dilemma," The Washington Institute for Near East Policy, February 2021. Singh lays out the obstacles that would face any president in making Iran policy: "an Iranian leadership that cannot give up its hostility to the United States and that has proven resistant to both disincentives and incentives to change its policies, regional partners who are wary of any US-Iran engagement, and a thus-far insufficient domestic consensus to sustain a diplomatic accord with Tehran".

[20] My understanding of Iranian positions and perceptions has benefitted enormously from participation in the long-running Iran dialogue program run by the Strategic Technology and Arm Control program of the International Institute for Strategic Studies. My thanks to the leadership of that program: William Alberque, Dana Allin, Mike Elleman, Mark Fitzpatrick, and Mahsa Rouhi. The discussion that follows draws on that exercise.

[21] Zarif is quoted in "Timeline: Biden Diplomacy on Iran," *The Iran Primer*, US Institute of Peace, April 2, 2022.

JCPOA before the United States abandoned Trump's policy. Neither side wanted to make the first move, which was a serious bottleneck as the negotiations unfolded.

Furthermore, the Biden Administration has left in place the entire enormous set of Trump sanctions, in effect perpetuating Trump's policy while seeking to restore the JCPOA. When it comes to sanctions, nothing has changed under Biden. During the course of the negotiations with Iran, it became evident that while Biden is willing to provide significant sanctions relief, he is unwilling to reverse all of Trump's sanctions, believing some of them to be justified on grounds unrelated to the nuclear deal. Not surprisingly, Tehran feels itself still subjected to maximum pressure and is reluctant to succumb to what it sees as coercion—indeed, there is a view in Tehran that it is a vital interest to avoid allowing itself to be bullied by the United States because capitulating will be an open invitation for future bullying. Iran seeks the complete elimination of Trump's sanctions, which it regards as unfair and unjustified, but it seems unlikely to obtain this objective.

In short, Iran believed that the complete abandonment of Trump's policy and a return to full compliance by the United. States was the path back to the JCPOA, steps it regards as both necessary and warranted. Washington, on the other hand, was unwilling to alter course until Iran had taken steps to bring its nuclear program back into conformity with the JCPOA. These misaligned expectations were not conducive to swift and smooth negotiations.

Second, for Iran, the benefits of the agreement have been very disappointing, even during the Obama administration and even more so, obviously, under Trump. It may be that Iranian expectations were unrealistic, but the economic gains from the limited and uneven sanctions relief provided by the JCPOA have been, as Iran sees it, lamentably meager. Nor is this merely a misguided perception on Tehran's part. As Middle East expert Juan Cole has pointed out, the United States and its allies largely failed to deliver on the economic promises made to Iran: "The Republicans in Congress refused to allow Obama to lift US sanctions, which threaten third parties. European companies, fearing the US Treasury Department, refused to invest in Iran. So the country never really got the sanctions relief it was promised."[22] The presumption of both Trump's maximum pressure campaign and Biden's diplomatic initiative has been that economic pressures would make Tehran eager to get the JCPOA back in place in order to regain the economic advantages provided by the deal. It is far from clear that this presumption is correct. Some economic gain for Iran will ensue if the JCPOA is revived and no doubt this remains an incentive for Tehran to retain interest in salvaging the deal. But the lure of sanctions relief will be limited if the benefits are expected to be modest, and there is nothing in Iran's experience since 2015 to suggest that a macroeconomic bonanza awaits it if only it will agree with the Biden Administration on a path back to the JCPOA. Quite the contrary, many in Iran seem to have concluded that the United States is incapable of providing genuine and substantial sanctions relief, while the Europeans are incapable of standing up to Washington's ongoing recalcitrance. Hence, Iran's incentive to save the agreement

[22] Juan Cole, "Why Right Wingers in Israel and the US Really Oppose Iran Nuclear Deal: They Want Regime Change Instead," *Informed Comment*, August 25, 2022.

may be much weaker than anticipated in Washington. Why would Iran make what it sees as major concessions for minor, inadequate benefits?

Third, the American miscalculation about Iran's incentives to rejoin the agreement may be traced to highly divergent perceptions of Iran's ability to withstand sanctions. US policy has long been rooted in the judgment that American pressure could compel Iran to take desired steps. Trump's maximum pressure campaign, in particular, seemed to reflect high confidence that Tehran simply could not withstand a fully mobilized and unrestrained economic assault and that the resulting desperation would drive Iran to accept Trump's maximalist demands. Iran, on the other hand, has been coping with American sanctions continuously since the revolution in 1979 and takes pride in its so-called "resistance economy." Where Washington sees Iran as isolated and penalized, Tehran draws comfort and gains from that fact that much of the world does not share the American obsession with sanctioning Iran. Trump's determined escalation of the sanctions campaign has had painful effects on the Iranian economy, no doubt, but Iran withstood the blow and survived while denying Trump and Pompeo all of the ambitious objectives they sought. To Tehran, this may look like a win. Certainly, there is little in the four years of Trump's bluster and sanctions escalation to suggest that Iran is going to capitulate in response to American pressure.

Fourth, as Tehran sees it, an explanation for the unsatisfactory economic results is that the Western parties to the JCPOA failed to fulfill their obligations under the agreement. Even the Rouhani-Zarif team, though associated with and supportive of the JCPOA, complained bitterly about what they saw as persistent non-compliance and unrelenting pressure by the United States and its European friends. As Zarif put it in his revealing collection of interpretations and documents from the JCPOA saga:

> "The JCPOA participants have underlined that 'the lifting of sanctions, including the economic dividends arising from it, constitutes an essential part of the JCPOA.' However, the United States—aided and abetted by its European accomplices—never implemented these and many other provisions of Resolution 2231 and the JCPOA in good faith. The western JCPOA participants continued to use economic pressure to achieve those illegitimate political objectives that they had failed to achieve in the course of the long and tedious JCPOA negotiations…. The US and E3 have been transparent about their transgressions and have repeatedly stated their ill-intention to compel Iran to renegotiate those provisions through economic pressure and blackmail.[23]

This picture of the malfeasance of the United States and its European friends stands in stark contrast to Iran's self-image as stalwart defender of the JCPOA. Again, Zarif's words emphatically illustrate the point. He wrote in July 2021:

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[23] M. Javad Zarif, *Letter to the UN Secretary General: Documenting Six Years of Western Non-Implementation of the Iran Nuclear Deal*, (Tehran: Institute for Political and International Studies, 2021), pp. 8–9. This 200 page book, available in English, is a compilation of Iranian documents and messages pertaining to the JCPOA, mostly involving communications with the IAEA. It is introduced by a long letter from Zarif to UN Secretary General Guterres in which Zarif, not long before leaving office, offers his explanation of the evolution of the issue over the previous half dozen years.

> Throughout the past six years the Islamic Republic of Iran has proven its commitment to the Joint Comprehensive Plan of Action in deeds and not just words. My Government and the people of Iran have made enormous sacrifices—almost single-handedly—to preserve the JCPOA in spite of U.S. contempt for it and EU/E3 complacency in the face of that contempt.[24]

This is, of course, not how Washington and other outsiders see it, but Tehran's calculations will be rooted in its own perceptions however much disagreement its views may prompt. And it is reasonable to ask why Iran would pay a significant price for or attach a high value to an agreement if it has good reason to believe that the United States and its friends will not deliver on their end of the bargain.

Fifth, Iran must also factor into its policy on the JCPOA the prospect that a revived agreement could be very short-lived. Trump has established the precedent of American withdrawal, which of course demonstrates that Washington can be an unreliable negotiating partner. Republicans in Congress have been loud and unambiguous about their intention to do whatever they can to block a return to the JCPOA if Biden and the P5 + 1 manage to reach a deal with Iran. In March of 2022, for example, 49 Republican Senators announced that they oppose the JCPOA and stated that if Biden agrees to rejoin it "Republicans will do everything in our power to reverse it."[25] When the negotiations showed signs of progress in the late summer of 2022, Republicans in the House Armed Services Committee took to social media to proclaim: "Even if Iran accepts President Biden's full capitulation and agrees to reenter the Iran nuclear deal, Congress will never vote to remove sanctions. In fact, Republicans in Congress will work to strengthen sanctions against Iran."[26] Possible Congressional action to block the restoration of the JCPOA is not an idle threat. Under the Iran Nuclear Agreement Review Act (INARA) of 2015, passed by Congress to give it the right to oversee the JCPOA, Congress can pass a Joint Resolution of Disapproval that would deny Biden or any successor the ability to lift sanctions, thus "nullifying" the deal.[27]

Further, even if, in the short run, a renewed deal survives Congressional scrutiny, Iran must still take into account the 2024 US Presidential election—a point which Iran's experience with Trump will have made blindingly clear. And there is ample and very open evidence that a resurrected JCPOA will not survive beyond Biden's term in office if a Republican wins the next presidential election. As one example among many, Trump's former Ambassador to the United Nations and declared Republican presidential candidate Nikki Haley said in a public speech, "If this president signs any sort of [Iran nuclear] deal, I'll make you a promise: The next president will shred it on

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[24] Zarif, *Letter to the UN Secretary General*, p. 16.

[25] US Senate Foreign Relations Committee, "49 Senate Republicans Tell President Biden: An Iran Agreement Without Broad Congressional Support Will Not Survive," March 14, 2022.

[26] Available at Armed Services GOP, @HASCRepublicans, August 17, 2022.

[27] See Jonathan Lord, "The Greatest Obstacle to Returning to the Iran Deal Isn't Iran – It's Congress," *The Hill*, August 21, 2022. Lord explains, "Were Congress to pass a Joint Resolution of Disapproval (JRD), it would nullify the president's ability to lift any sanctions on Iran associated with the deal. INARA essentially gave Congress veto power over the JCPOA, or any new or amended deal with Iran.

her first day in office."[28] Another possible Republican presidential contender, Texas Senator Ted Cruz, has stated that "I intend to systematically fight the implementation of this catastrophic deal, and will work with my colleagues to ensure that it is blocked and eventually reversed in January 2025" —another promise to wreck the JCPOA immediately if a Republican Administration takes office after the next Presidential election in 2024.[29] In a subsequent public comment Senator Cruz clarified his point: "The next Republican president will rip up whatever ridiculous Biden-Iran deal is struck."[30] In view of this extensive, unambiguous, and unmissable evidence of Republican intentions, Iran's leaders can be forgiven if they conclude that the JCPOA could turn out to be a very short-term deal—too short to allow major economic benefits to occur. Even if Biden is reelected in 2024, the opposition is so widespread, so intense, and so unwavering that Biden himself will face fierce opposition if he agrees to a deal that returns the United States to the agreement and his ability to deliver on sanctions relief is questionable.[31]

For all these reasons there are grounds for questioning how much value Iran attaches to the JCPOA, particularly after the Iranian elections replaced the Rouhani government with one much more skeptical about the agreement. Iran sees the United States as implacably hostile and believes that its nuclear leverage is necessary if Washington is to have any incentive to negotiate reasonably with it. Giving up that leverage in return for benefits that are meager, disappointing, unreliable, and quite possibly very short-term will hardly look like an enticing bargain, especially to Iran's opponents of the deal. Hence, while American critics of the JCPOA wail about the "Biden giveaway" and insist that Biden's alleged desperation to reach a deal is producing an outcome overwhelmingly favorable to Iran, there is scant evidence that Tehran sees the deal as highly attractive or even acceptable. Quite the contrary. The negotiations have produced a draft agreement that the Biden Administration and other parties to the agreement believe is good and acceptable. The problem is that Iran has yet to accept it—to the puzzlement, frustration, and irritation of American and western negotiators who clearly believe that a good deal has been put on the table and it remains only for Iran to seize this opportunity and accept it. The protracted Iranian hesitation and resistance leads to the suspicion—if not the conclusion—that Iran simply is not interested in a revived JCPOA deal. Symptomatic is the comment by the head of British Intelligence, Richard Moore: "I think the deal is absolutely on the table. And the European powers and the (U.S.) administration here are very clear

[28] Haley is quoted in Michael Starr, "Nikki Haley Hints at 2024 Presidential Run, Promises No Iran Deal at Christian Zionist Rally," *Jerusalem Post*, July 19, 2022.

[29] "Senator Cruz Issues Statement on Iran Nuclear Deal Developments," Press Release, August 23, 2022, available at https://www.cruz.senate.gov.

[30] Cruz comment of August 30, 2022 available at https://twitter.com/tedcruz/status/1564615673212416018.

[31] Biden's numerous and noisy critics hold that no deal is better than a bad deal, and any deal done by the "desperate" Biden is by definition a bad deal. In effect, opponents of the deal prefer that Iran's nuclear program remain unconstrained in order to leave room for a policy of unlimited pressure on Iran. See, for example, Luke Coffey, "No Deal With Iran is Better than a Bad Deal," *Arab News*, August 326, 2022.

on that. And I don't think that the Chinese and Russians, on this issue, would block it. But I don't think the Iranians want it."[32] If this is true, it is not hard to understand why. The deal that Tehran was prepared to accept in 2015 in anticipation of economic and diplomatic gains may now seem, in light of the experience of the past five years, no longer worthwhile from an Iranian perspective. American critics will no doubt draw from Iran's reluctance to move forward with a deal the conclusion that Tehran is simply preserving its option to pursue nuclear weapons—a possibility that cannot be dismissed but that would be more clear-cut and convincing if Iran actually had in front of it a deal that it found attractive and in which it could trust.[33] It may be, however, that Iran has its own tribe of critics and policymakers who believe that no deal is better than a bad deal.

Choosing the diplomatic track for changing American policy not only exposed the Biden Administration to Iran's doubts and ambivalences about the deal, but also created an opportunity for Tehran to air its grievances and to seek remedies for the deficiencies it sees in the JCPOA. Washington is not the only town with an abundance of critics of the deal. Indeed, the domestic politics of the JCPOA seem as harsh and intense in Tehran as in Washington and Iranian opponents of the deal echo the negativism of Biden's critics. Iran's leaders must heed their own political and policy imperatives, no matter how much disappointment and exasperation this produces for their American counterparts. The reality is that progress has been complicated and slowed by the fact that Iran, like the United States, has sought to use this process to address the concerns and deficiencies it sees with the JCPOA—though in truth at least one of Iran's demands is unsatisfiable, impossible for the United States to address and hence a potentially intractable roadblock.

For understandable reasons, Iran has sought guarantees on two particularly difficult issues. First, it has desired assurance that the United States will remain in the deal—a solution to the risk that any agreement with Biden will be very short-term in nature. This is a natural reaction to the Trump derailment of the JCPOA, but it is simply not possible for the United State to provide any such guarantee. Biden has no way of binding his successors. Even if the restored JCPOA were to take the form of a legally binding treaty—utterly unattainable given the current makeup of the US Senate—there is nothing the prevent a future president from withdrawing, as Trump did from the INF Treaty, the Open Skies Agreement, and the Paris Climate accord. The problem is that Iran has good reasons for wanting such an assurance and Washington is correct in explaining that nothing of the sort can be provided. This is the sort of stalemate that bogs down a negotiation.

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[32] Moore as quoted in Phil Stewart, "Iran Doesn't Appear to Want a Deal, British Spy Chief Says," *Reuters*, July 21, 2022.

[33] To American critics of the JCPOA, Iran's appetite for nuclear weapons is taken as an unquestionable given and serves as the only plausible explanation for Iran's nuclear activity and negotiating behavior. See for example, the tendentious analysis in "Seven Myths About the Iran Nuclear Deal," Hudson Institute Policy Memo, September 2022. This is another instance of the bizarre logic that those who believe Iran is fervently committed to obtaining nuclear weapons prefer that Tehran's nuclear capabilities remain unconstrained and subjected to less scrutiny.

A second vexation has influenced Iran in the negotiations: Disturbed by what it sees as persistent and even flagrant noncompliance by the United States and its friends, Tehran has sought serious monitoring and verification of the sanctions relief that is meant to be the main Iranian benefit from the deal. Iran's own compliance under the JCPOA is intensely monitored by unprecedentedly extensive and intrusive verification arrangements, but equivalent measures were not put in place to confirm that Washington and its friends were fulfilling their obligations under the agreement. In view of its disappointment with the benefits provided it by the JCPOA, Tehran has a strong incentive to insist on assurances that there will be meaningful scrutiny of the behavior of the United States and other parties in fulfillment of their JCPOA obligations and accountability if noncompliance is detected. It should hardly be a shock that Iran seeks to protect its own interests.

Iran has also demanded an end to IAEA investigation of its past nuclear behavior—a problem that has arisen because unexplained nuclear particles were discovered at undeclared sites in Iran. This is an issue that falls outside the JCPOA and involves Iran's obligations under its safeguards agreement. The IAEA has the right and the obligation to follow up on all situations involving the presence and handling of fissile material and, with support from Washington and other JCPOA parties, it is rightly pursuing the matter until it concludes that a satisfactory account has been provided. Iran's unwillingness to be forthcoming has reinforced suspicions that it is covering up illicit, possibly weapons related activity. Iran, for its part, claims to see this issue as the latest in a never-ending series of allegations that haven't stopped no matter how much Iran has cooperated with the IAEA. The current negotiations have provided an opportunity for Iran to force this issue into the JCPOA discussion and use it, perhaps as a bargaining chip, perhaps as a deal-blocker, and perhaps in the hopes of gaining some concession that would end or abate what Tehran clearly views as an ongoing irritant. There appears to be no inclination to give Iran relief on this issue, so this has become another complication in the Biden Administration's so far futile quest to restore the JCPOA.[34]

These illustrations (and others) demonstrate that Iran brought to the negotiations on restoring the JCPOA its own agenda, its own sense of needed improvements, its own list of deficiencies to be corrected. The Biden team may have believed that they were in a position, with Trump's maximum pressure in place and Biden's more reasonable goals in hand, to negotiate modifications that address American concerns about the JCPOA given the situation that existed when Biden came into office. However, Iran believed that the expansion and momentum of its nuclear program gave it leverage and when Biden opted for the diplomatic track, Tehran too sought gains and corrections that would improve the agreement as they see it.

[34] As of this writing, the IAEA has been unable to resolve this issue and Iran's failure to satisfy the IAEA's concerns leaves the matter stuck on the agenda and a potential sticking point in moving the negotiations forward. The status of this issue is described in "IAEA Cannot Assure Peaceful Nature of Iran Nuclear Programme," *Al Jazeera*, September 7, 2022.

15.4 Troubled Negotiations, Glacial Progress, and Risks of Failure

These various perceptions, positions, and dynamics have made the negotiated return to the JCPOA a slow, frustrating, and volatile exercise, with phases of apparent progress and optimism alternating with periods of setback and pessimism. There have been months of haggling over who would take the first step, the sequencing of steps, the timing of sanctions relief in relation to Iran's return to compliance, the extent of sanctions relief, the verification of sanctions relief, the permanence of the American commitment to the deal, the prospects for follow-on negotiation aimed at a longer and stronger deal, and the resolution of Iran's dispute with the IAEA (which is of concern to both sides but from opposite perspectives).[35] Time has been lost, reciprocal frustrations have accumulated, Iran's program has continued to advance in an unconstrained fashion, Trump's maximum pressure scheme remains in place (still upsetting Tehran and still failing to achieve its objectives), while the JCPOA lingers in an odd limbo, not completely dead but not implemented by either the United States or Iran. Somewhat remarkably, more than half-way through Biden's term, Washington and Tehran have been unable to rejoin an agreement that was finalized and accepted by both sides in 2015. The negotiations continue, however, and could still produce an agreement. Occasional moments of apparent progress make it seem as if a positive outcome is still possible. But the protracted failure to bring the negotiations to a conclusion, the recurrent periods in which the negotiations are stalled or stalemated, the apparent inability of the two sides to surmount the remaining obstacles to agreement have led many to gloomy expectations about the likelihood of achieving an agreement that restores the deal. As one recent analysis observed, "Both sides point to the other as the problem. In fact, both are the problem. Washington and Tehran lack the political will to offer a viable compromise. And so, the talks drift."[36]

What is at risk are the constraints and transparency measures contained in the JCPOA. It is true that those who demand that a negotiated agreement contribute to regime change in Iran or who insist that Iran must be transformed by negotiations into a benign regional actor find these measures insufficient and regard the JCPOA as a failure. If the goal is to coerce Iran's surrender rather than to achieve a useful bargain, then the JCPOA comes up short—but Iran has been successfully resisting American pressure since the Iranian revolution in 1979 so it seems rather short-sighted to prefer a very unlikely coerced capitulation to an existing bargain that significantly constrains Iran's nuclear behavior.

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[35] For a full account of this saga, detailed and comprehensive, see the indispensable series of reports by the International Crisis Group. For example, International Crisis Group, *The Iran Nuclear Deal at Six: Now or Never*, January 2022.

[36] Emma Belcher and Tom Z. Collina, "Drifting Toward Disaster as Iran Nuke Talks Stall," *Defense One*, July 14, 2022.

It is also true that supporters of the JCPOA commonly adopt the habit of conceding imperfections in the agreement, perhaps as a shield against the relentless and often vehement assaults of the critics. What gets lost in the overheated rhetoric and the emphasis on faults and flaws of the agreement is its unprecedented nature. In the history of the nonproliferation regime, no other state has ever willingly accepted as many constraints or as much transparency as Iran did in the JCPOA. (This perhaps helps account for the Iranian view that they gave much and got little out of the JCPOA.) Iran accepted a limit on the level of enrichment at 3.67%, suitable for producing fuel for nuclear reactors but well below what is required to produce nuclear weapons. This is a clearcut and monitorable provision that allows no grey areas about compliance. Iran accepted limitations on its holdings of enriched material at a level of 300 kg—well below its existing inventory, which accordingly had to be reduced—and a level which inhibits rapid breakout in the direction of a weapon. Iran accepted limits on numbers of centrifuges at a level that required it to remove two-thirds of its installed centrifuges, and also agreed to restrictions on its ability to modernize centrifuges. In the realm of transparency, Iran agreed to challenge inspections; to daily access by inspectors to its uranium enrichment facility at Natanz; to monitoring of centrifuge production and of excess centrifuges that had been removed from service; to monitoring of uranium ore production. All of these measures are unprecedented. All of them are desirable. All of them are useful in restricting movement toward a weapons capability. Indeed, if properly understood and valued, they would be regarded as significant improvements to standard practice in the NPT regime, to be emulated when possible rather than criticized and rejected.[37] In addition, Iran pledged to sign and ratify the Additional Protocol to the IAEA's safeguards agreements, which would provide more information to and additional authority to the Agency. And in the JCPOA Iran accepted limits that persist over protracted periods of time. There has been much complaint about the so-called sunset clauses (which, it should be noted, are common and normal in arms control agreements); the JCPOA includes expiration dates, some of which are not so far off given the time that has elapsed since the agreement was reached in 2015. But what often gets left out of such discussion is that the JCPOA is a "variable speed" agreement: some measures expire after 15 years (in 2030), others in 2035 or 2040, and still others are permanent—including the prohibition on weapons-related activities.[38]

Overall, then, the JCPOA provides future years of implementation in which Iran's nuclear program is unprecedentedly constrained and unprecedentedly monitored. An array of unique and highly useful measures greatly constrict Iran's ability to pursue nuclear weapons even if it retains an appetite to do so. This should be regarded as an

[37] George Perkovich has highlighted this point in his important piece, "The Iran Deal's Building Blocks of a Better Nuclear Order," Carnegie Endowment for International Peace, June 9, 2016, available at http://carnegieendowment.org/2016/06/09/iran-deal-s-building-blocks-of-better-nuclear-order-pub-63780.

[38] In other arms control contexts the obvious solution to expiration dates is the negotiation of follow-on agreements, something the Biden Administration has expressed interest in doing from the beginning of its term with the objective of achieving a "longer and stronger" deal.

impressive accomplishment to be valued, not a failure to be rejected.[39] It is hard to see the case that a world worried about Iran's nuclear ambitions is better off without such measures in place—no matter how distasteful the regime is seen to be and no matter how objectionable its foreign policy is regarded. In a rational and reasonable debate it will be understood that perfect agreements are not possible, neither side will get everything it wants in a bargained outcome, and arms control will not be the full or permanent solution to all concerns regarding Iran. The question is whether the agreement is useful in addressing significant security problems. The JCPOA passes that test.

Whether it can survive the current diplomatic process remains in doubt, however. A failed negotiation will leave Iran's nuclear program outside of all the negotiated constraints, the much-condemned sunset clauses will be irrelevant because Iran will no longer be bound by any restrictions, the nuclear progress Iran has made during the Trump withdrawal phase of this melodrama will not in any way be rolled back (whereas the JCPOA would require reversal or reduction of many steps it has taken), and Iran's advancing nuclear efforts will be subjected to less scrutiny. This is the prospect that stalemated diplomacy has raised—all the more disturbing because the alternatives to diplomacy, perennially unsuccessful sanctions or risky uses of force, do not seem more likely to effectively provide durable solutions to the challenge posed by Iran's nuclear program. Perhaps if Biden had simply altered American policy unilaterally on the day of his inauguration, Iran would have refused to bring its behavior back into conformity with the JCPOA and we would have ended up in the same place—with a failed JCPOA. But the diplomatic track has proven no more fruitful and may turn out to have been a path to slow-motion failure.

This is, for the Biden Administration, a painful dilemma. If it was, as candidate Biden insisted in the 2020 campaign, a self-inflicted disaster and a gigantic mistake to withdraw from the JCPOA, then surely it is equally a disaster to fail to restore the agreement.

[39] As one leading expert, Professor Nicholas Miller of Dartmouth University has commented, "there is essentially no historical precedent for believing a significantly better deal was possible with an adversary like Iran with decades of mistrust of the US. See https://twitter.com/Nick_L_Miller/status/1415359053937717249. See also his article, "The Lessons of the Past Point to Rejoining the Iran Deal," *War on the Rocks*, January 20, 2021.

Chapter 16
The Fate of the Iranian Nuclear Deal (JCPOA)

Ali A. Salehi

16.1 In the Name of God the Compassionate, the Merciful

Before starting, I am honored to learn that I and Prof. Miller share the same alma matter. It is indeed a distinct pleasure to participate in this prestigious and relatively long established Amaldi Conference. Let me at the very outset, seize the opportunity to express my deep appreciation to the organizers of the conference for the kind invitation. The very title and the work program of the conference as well as the mosaic of the participants comprising international experts, decision makers and scholars, points to its relevance to a wide range of serious issues the regional, i.e., the Middle East and the international communities are grappling with.

Addressing a conference of this kind and caliber, puts me in a very challenging position. However, having been in charge of my country's Atomic Energy Organization for long, I have no choice but to focus on concrete and relevant issues and, which interestingly enough happens to be a matter of common concern to us all. Vital among the major issues and interests are first the fate of the Iranian Nuclear Deal the JCPOA; and second is the possible scientists' role in realizing Nuclear Weapons Free Zones in various parts of the world, specifically in the Middle East and finally the third issue being the future of nuclear power programs in West Asia with an specific outlook on the prospects of Arab-Iranian cooperation in the nuclear domain. Since the allotted time for the talk is predestined, I therefor, will touch upon each of the issues very succinctly.

As for the first issue, namely, the long standing stalemate with the West since 2000, despite all the ensued negative consequences, finally the case lead to a change of outlook within the American body politics especially during President Obama's

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second term. The obviously futile imposition of the so called "Zero Enrichment" dogma gave way to a more pragmatic, solution-oriented approach in Washington, which coincidentally was reciprocated by Iran. The quite interesting and equally exciting and challenging negotiations ultimately culminated in a promising win-win nuclear deal called the JCPOA. A deal that ensured Iran's inalienable statuary rights and privileges as stipulated in the NPT and the IAEA statute.

The hard-won agreement, in which I was personally engaged, especially at its scientific and technical level is simply too precious to be allowed to be hampered or weakened. In contrast to the previous US administration's negative perception, there is a modest positive impression and acceptance of the accord in my country. I believe that the vast majority of the international community also share a similar view.

The previous US administration's withdrawal from the JCPOA put the deal on the verge of collapse. Hadn't been for Iran's rational response and reasonable stance, the deal would have been terminated by now. However, just to bear in mind, Iran, under no situation will ever choose to relinquish its stipulated rights.

To conclude this part, I reiterate that my country never ever opted for the deal to be unraveled. However, the international community's interest were more at stake than the national interests of Iran- Where the US wishes to harm- if the deal were dissolved. Certainly, Iran's state politics would have changed course and the US political credibility and its international status would have further been undermined.

Should the JCPOA survive the current impasse; mutual confidence must be regenerated. If so, the way will be paved for the resolution of other chronic outstanding issues. Let's hope that under these circumstances, commonsense and discretion shall prevail.

Coming to the next issue, one should note that all during history, region's comprising West Asia and North Africa, namely, the Middle East and the Levant have always been the heartland of attention. Despite, some conciliatory efforts, the situation at present time is unfortunately very volatile and susceptible to confusion and unrest. One of the pivotal issues is the case of Palestine. This issue compounded with the arrogance of the Israeli regime in other domains such as the acquirement of Nuclear Weapons has further exacerbated the problem. Here, I believe the impartial role of committed scientists can to some extent mitigate the state of affairs. First and foremost, we need to advance the conviction of declaring a Nuclear Weapons Free Zone in the Middle East (First proposed by my country to the UN body in 1974).

Considering the colossal detrimental consequences of the use of nuclear weapons on human beings and the environment, scientists based on their social obligations should contribute to the realization of the noble goal of NWFZ, specifically one in the Middle East by preparing and exposing to the world public opinion unbiased scientific technical reports based on authentic data such as the following;

1. Scientific data of Hiroshima and Nakazaki Atomic bombardment. It is imperative upon the scientific community to sensitize the public opinion towards such horrendous acts.
2. Technical data of the fall-out of radioactive substances of hundreds of nuclear tests to show the gravity of the disaster of the use of nuclear weapons.

3. Technical/scientific reports on the past major nuclear accidents: TMI in the US, Chernobyl in Ukraine and Fukushima in Japan. Such reports will enlighten the public and encourage them to urge their political decision makers to take rational and cautionary measures regarding peaceful uses of nuclear energy.
4. Setting up a comprehensive data base of nuclear facilities which are outside international verification mechanisms, especially those to be believed to be for nuclear weapons production and use in the Middle East, particularly those in Israel.

As for the third issue, we note that today, the living conditions of people living in the Middle East and North Africa have reached a stage that the need for peace and sustainable development has become a necessity. Given the world's rapid growth in social awareness and various economic, scientific and technological fields, this real need is so obvious that no opportunity to strengthen it should be missed.

Acknowledging the fact that the current existing divisions, discords and conflicts among the nations in the region have their roots in the complex hidden angles, such as the intervention of outside powers, we should therefore, spare no effort but first and foremost to remedy those social ills, because they are the source of hindrance on the way to development and expansion of relations. It is, therefore, incumbent upon the elites of the countries in the region and their political leadership to pave the way for mutual trust building and expansive cooperation.

In the following, I shall mainly focus on an initiative based on nuclear science diplomacy to develop regional cooperation, especially between Iran and the Arab World.

It is commonly agreed that negotiation is the most important tool of diplomacy. In science diplomacy, negotiation is a key step in reaching an understanding. Reasoning and negotiations with scientific basis is the strength of science diplomacy. The language of science does not heed or rather depend on social, ideological, historical or political status, hence it is free from any such situation. The history of hostilities and disputes have no place in the language of science, rather, common sense and forbearance are its features. With the promotion of science diplomacy, the ground can gradually become ready for resolving chronic disputes. In short, scientific cooperation promotes peace and development.

On the other hand, science diplomacy is formed in interactions between scientists and diplomats. Inducing the "Perspective of Science" to diplomats and the "Perspective of Diplomacy" to scientists, facilitates dialogue for settling discords.

Based on interactions between scientists and diplomats, effective elements, essential for rapprochement and reconciliation can be perceived. In recent years, the issue of nuclear development of the countries in the region has prompted a challenge in their relations. Starting a dialogue on nuclear science diplomacy will help to strengthen trust, respect and mutual understanding. In order to pursue this goal, it is suggested that issues that have the potential of collaboration be considered from a purely scientific perspective in order to avoid misunderstandings and to build trust through sharing of knowledge and exchange of experience and expertise.

The Islamic Republic of Iran, based on its long-standing policy, calls for the use of regional cooperation mechanism in various fields, especially in nuclear technology in order to induce more trust and transparency among the countries of the region. Here are some suggestions that are recommended in relation to the expansion of cooperation of the countries in the region:

- Nuclear safety is one of Iran's priorities. Although the responsibility for nuclear safety lies entirely with each country, Iran strongly believes that this area should be strengthened through cooperation between the countries of the region. In this regard, Iran has proposed the establishment of an advanced *Nuclear Safety Center* (*NSC*) as a reliable safety hub for the region.
- It is suggested that in order to enjoy the benefits of nuclear energy, joint macro-projects on research and construction of small power plants be defined and implemented. In this case, each country can do a part of the plan based on its capabilities.
- As a developing country, Iran has an extensive industrial, research and academic infrastructure that can be provided to the countries of the region in the course of regional cooperation.
- Due to the high complexity of nuclear science and technology, the creation of a Middle East Atomic Energy Agency (MAEA) can also be considered as a long-term perspective.

By following the forgone suggestions, we will acquire through synergizing our efforts a high degree of scientific competence and we will be giving equal weights to both scientists and diplomats. These initiatives have the potential to advance scientific goals and good will beyond the political considerations of any country.

Proposing a meeting between the highest scientific and political officials of the countries in the region to discuss this initiative could be a good start. The Islamic Republic of Iran is proud to be ready to negotiate with any country to implement this initiative and to accept new proposals. I end the talk with the luminous words of our great prophet peace be upon him.

Problems with teamwork that you do not like are better than what you think is good in individual work, because in teamwork there is mercy and in individual work there is torment. In a nutshell, Teamwork makes the dream work. Thank you for your attention.

و ما نكرهون فى الجماعة خير مما تحبون فى الفرقة ني الجماعة رحمة و ني الفرقة عذاب

رسول اكزم)ص(

Part III

Chapter 17
Nuclear Weapons and the Militarization of AI

Guglielmo Tamburrini

Abstract This contribution provides an overview of nuclear risks emerging from the militarization of AI technologies and systems. These include AI enhancements of cyber threats to nuclear command, control and communication infrastructures, proposed uses of AI systems affected by inherent vulnerabilities in nuclear early warning, AI-powered unmanned vessels trailing submarines armed with nuclear ballistic missiles. Taken together, nuclear risks emerging from the militarization of AI add new significant motives for nuclear non-proliferation and disarmament.

17.1 Introduction

The major powers are busy incorporating Artificial Intelligence (AI) into existing and emerging military systems [3, 15, 24]. Summarizing the drive towards pervasive military uses of AI technologies and systems, the US National Security Commission on Artificial Intelligence (NSCAI from now on) stated that AI-enabled technologies are going to be integrated into "every facet of warfighting" ([23], p. 79). In a similar vein, China's "New Generation Artificial Intelligence Development Plan" underscored the need to "promote all kinds of AI technology to become quickly embedded in the field of national defense innovation" [11]. And Russian President Vladimir Putin confidently claimed that whoever becomes the leader in AI will rule the world [26].

Inspired by similar objectives and aspirations, recent actions towards the militarization of AI include both the launch of NATO's innovation fund—which prioritizes investments into artificial intelligence, big-data processing, autonomous systems, and other dual-use emerging technologies [22]—and the use that the British Army made for the first time in 2022 of an AI system to process terrain and other contextual

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information during a military exercise in Estonia (https://www.gov.uk/government/news/artificial-intelligence-used-on-army-operation-for-the-first-time).

Nuclear defense systems are not exempted from ongoing military plans and actions focusing on AI technologies and systems. The US NSCAI recommended that "AI should assist in some aspects of nuclear command and control: early warning, early launch detection, and multi-sensor fusion." ([23], p. 104). Moreover, the emerging use of AI in cyber operations may increase the quantity and quality of cyber threats to nuclear command, control, and communication (NC3) infrastructures, thereby impinging on nuclear defense systems and nuclear escalation risk in conflicts.

This contribution provides an overview of major nuclear risks emerging on account of the militarization of AI. Section 17.2 reviews cyber threats to the military nuclear infrastructure and their impending enhancement by means of AI-powered cyber attacks. Section 17.3 examines proposals to use AI technologies to modernize nuclear early warning systems, and related risks arising from AI inherent vulnerabilities, brittleness, and information processing opacity. Section 17.4 briefly overviews wider destabilizing implications of AI on nuclear deterrence policies, arising from AI-powered, autonomously navigating vessels trailing submarines armed with ballistic missiles, AI deepfakes eroding the credibility and consistency of political leaders of nuclear powers, and autonomous weapons systems having the potential to tilt conventional military equilibria and to provide adversaries with new incentives to threat the use of nuclear weapons to avoid defeat. Section 17.5 concludes.

17.2 AI-Powered Cyberthreats and Nuclear Escalation Risks

Cyber attacks are, roughly speaking, cyber operations targeting computers and computer information systems, networks, or infrastructures, with the aim of stealing, exposing, altering, disabling, and destroying data or disrupting their normal computational processing. Cyber attacks are carried out using a variety of tools and methods, including malware, phishing, and denial of service.

The question has often been raised whether one might respond to a cyberattack not in kind, but rather using conventional weapons deployed in other traditional warfare domains or even weapons of mass destruction. An instance of this general question is whether (and, if so, in which circumstances) one might consider employing nuclear weapons to respond to a cyber attack. The latter question is meaningfully related to a general claim made in the 2018 US Nuclear Posture Review, according to which one may consider the use of nuclear weapons "in extreme circumstances to defend the vital interests of the US, its allies, and partners." It is further specified there that extreme circumstances "could include significant non-nuclear strategic attacks."

([31], p. 21). And to exemplify, two broad scenarios are mentioned there which may qualify as significant non-nuclear strategic attacks:

(i) attacks on the US, allied, or partner civilian population or infrastructure;
(ii) attacks on US or allied nuclear forces, their command and control, or warning and attack assessment capabilities ([31], p. 21).

Both scenarios are described in terms of their objectives and effects, without introducing any restriction on the types of weapons employed to achieve those objectives and effects. This approach agrees with a US Air Force doctrine document stating that a strategic attack "is not defined by the use of a particular weapon or the focus on a specific target" ([2], p. 3). Its strategic character depends instead by the goal of achieving "war-winning effects by the most direct, effective, and efficient means possible. [A strategic attack] disrupts critical leadership functions, infrastructure, and strategy, achieving results by affecting the psychological, cognitive, and behavioral aspects of warfare." ([2], pp. 3–4).[1]

If no restrictions are placed on the kinds of weapons to achieve strategic effects, one may legitimately ask whether a cyberattack might count as a significant non-nuclear strategic attack. If a positive answer is given to this question, one may further ask—in the light of both the 2018 Nuclear Posture Review and similar positions expressed in the more recent 2022 Nuclear Posture Review—whether there are conceivable circumstances licensing the use of nuclear weapons as a response to a significant non-nuclear strategic cyberattacks.

Ch. Ford addressed these questions at a time when he was assistant secretary of state for international security and non-proliferation: "Lest there be any confusion about whether a cyber attack could potentially constitute a 'significant non-nuclear strategic attack', I can say with confidence that it most certainly could if it caused kinetic effects comparable to a significant attack through traditional means." [14]. Commenting on this claim, Herbert Lin remarked that "the proposal for possible first use of nuclear weapons in response to devastating cyber attack is likely less of a departure from previous policy than it might seem" ([21], p. 28).

To begin with, let us consider Ford's claim in the framework of scenario (i), that is, in connection with "attacks on the US, allied, or partner civilian population or infrastructure". Cyberattacks against civilian infrastructures are legion, their list is rapidly expanding, and their disruptive effects are increasing. Cyber attacks which made the headlines for their relatively significant effects were carried out against the Colonial Oil Pipeline in 2021 and against the Ukrainian power facility PrykarpattyaOblenergo in 2015. The malware attack against the Colonial Oil Pipeline—which supplied almost half of diesel, gas, and jet fuel needed in the US East Coast—resulted in the shutdown of this facility for a few days. The cyberattack to PrykarpattyaOblenergo disrupted power supply and affected more than 200,000 consumers for up to 6 h. Clearly, neither one of these events qualifies as a significant non-nuclear strategic attack on civilian population and infrastructure.

[1] See Air Force Doctrine Publication 3–70, *Strategic Attack,* 21 November 2021, pp. 3–4.

Can a cyber attack conceivably achieve the effects of a significant non-nuclear strategic attack on civilian population and infrastructure? Undoubtedly, the artisanal character of activities that human operators must perform through all stages of the cyber kill chain is a bottleneck hindering their speed, volume, and destructiveness. Time-consuming and labor intensive operations include identifying software and hardware vulnerabilities, developing suitable tools for attack delivery, exploring target environments, and taking on command and control of penetrated systems. But what about *future* developments of cyber warfare in the light of ongoing attempts to remove or mitigate this bottleneck? Are cyber attacks bound stay below the threshold of significant non-nuclear strategic attacks, if these labor intensive activities get automated?

Initiatives leveraging on AI systems based on machine learning methods are well under way to automate and increase the speed, volume, and destructiveness of cyber attacks. Even though there are presently "no publicly known reported cases of machine learning being used to directly attack a system or an application" (Abaimov Martellini, p. 122), the 2021 NSCAI final report warns that "machine learning has current and potential applications across all the phases of cyber attack campaigns and will change the nature of cyber warfare and cyber crime. The expanding application of existing AI cyber capabilities will make cyber attacks more precise and tailored, further accelerate and automate cyber warfare, enable stealthier and more persistent cyberweapons, and make cyber campaigns more effective on a larger scale." (NSCAI, pp. 50–51). Accordingly, current and prospective applications of machine learning methods to expand the cyber capabilities of AI systems must be continually reviewed to assess the potential destructiveness of cyber attacks and their impact on future warfare. Even though known cyber attacks to civilian infrastructures have not caused kinetic effects comparable to a significant strategic non-nuclear attack, one cannot exclude that this situation will radically change in the future.

Let us now turn to consider the evoked nuclear response to cyber attacks in the framework of scenario (ii), that is, "attacks on US or allied nuclear forces, their command and control, or warning and attack assessment capabilities". The computational infrastructure of the US nuclear defense complex offers an extended cyber attack surface, that is, software or hardware elements that one may explore and penetrate for malicious purposes. These elements are notably present in off-the-shelf hardware and software used by military contractors and available to hackers for examination, in computing modules embedded into nuclear weapons delivery systems, and in NC3 software supporting nuclear planning and situational awareness ([21], pp. 38–90). This extended cyber attack surface raises doubts about the reliability and integrity of nuclear weapons systems, especially concerning the ability to launch a weapon when authorized or to prevent its inadvertent launch, to maintain uninterrupted command and control over nuclear weapons, or to preserve the functionality of nuclear communications ([28], p. 3).

Moreover, the modernization of nuclear defense systems may further extend the cyber attack surface, due to the implementation of new and more advanced computational functionalities. In general, Lin emphasized the tension between modernization of the military nuclear complex and its cybersecurity needs, suggesting that a sensible

trade-off must be reached, moderating appetites for added computational functionalities in the light of attending cybersecurity risks ([21], pp. 123–4). The prospect of AI-powered cyberattacks can only exacerbate these concerns about the cybersecurity of a more extensively computerized military nuclear complex.

Let us take stock. Past cyber attacks to civilian infrastructures have not caused kinetic effects expected from a significant strategic non-nuclear attack. Accordingly, these events are not meaningfully related to scenario (i) envisaged in the 2018 Nuclear Posture Review. However, this situation must be continually reassessed, in the light of machine learning methods being used to expand the cyber capabilities of AI systems, to automate cyber warfare, and to increase the speed, volume, and destructiveness of cyber attacks. Additional concerns about scenario (ii) arise from modernization plans involving the extension of computing infrastructures for the military nuclear complex and AI-powered cyber attacks on this infrastructure compromising the reliability and integrity of nuclear weapons systems.

These cyber risks and their potential exacerbation flowing from AI applications in the cyber kill chain call for the establishment of permanent venues to discuss AI's impact on nuclear crises and stability. The AI research community has a central role to play in this context—to foster dialogue and exchange scientific information, to advance specific trust and confidence building measures, and to raise the awareness of political decision makers and public opinion on AI-related cyber risks affecting nuclear weapons systems and infrastructures.

17.3 Nuclear Early Warning and AI Misclassification Risks

The NSCAI final report emphasized that the decision to authorize the employment of nuclear weapons should firmly remain in human hands and should never be delegated to an AI-enabled system. It is further recommended there that that the US "should include a statement to this effect in the next Nuclear Posture Review and should seek an analogous commitment by Russia, China, and other nuclear powers." ([23], p. 98). At the same time, however, NSCAI recognized some role for AI to play in the modernization of NC3: "AI should assist in some aspects of the nuclear command and control apparatus: early warning, early launch detection, and multi-sensor fusion, to validate single sensor detections and potentially eliminate false detections" ([23], p. 104, n. 22). Let us critically examine this claim, pointing to risks distinctively arising from this suggested use of AI technologies *within* nuclear early warning systems.

Early warning systems play a central role in nuclear deterrence based on second strike retaliation capabilities. By increasing automation of early warning systems, one expects to reduce information processing time and to buy more extended temporal windows for human decision-making, thereby alleviating the enormous pressure involved in evaluating whether a nuclear attack is in progress and deciding what is to be done. As noted in Borrie ([8], p. 49), "[i]n the absence of declassified information about current nuclear early-warning and command-and-control systems, it is difficult

to assess the pros and cons of AI-enabling aspects of these systems." Nevertheless, independently of the availability of this detailed information, one may still identify a variety of potential risks depending on distinctive features of automation in general, and AI-powered automation in particular. Automation bias is one of these risks, which applies to AI-powered automation, but is not specific to it. Indeed, the tendency to trust machine decision-making more than contrasting human judgments has been observed across a variety of automation technologies, leading to accidents in both civilian and military application domains. Other risks are specific to the use of AI in nuclear early-warning and in other critical domains. In what follows, we focus on distinctive fragilities affecting deep neural networks (DNN), motivated by the fact that these AI systems have contributed most to determine the pervasive impact of AI over the last decade and across a variety of application domains.

To train a learning AI system formed by a DNN to perform early launch event detection, one usually relies on the availability of relevant "big data", that is, vast amounts of sensor data about launch and non-launch situations. Accordingly, the scarcity of nuclear launch event data may hamper the training process, negatively affecting downstream the accuracy of the trained AI system. Let us suppose, for the sake of argument, that this preliminary bottleneck can be overcome, that enough training data can be collected or synthetically generated, and that an AI system trained on these data is found to achieve "good" classification accuracy on early launch detection. One should carefully note that the estimated achievement of good classification accuracy does not exclude the occurrence of mistakes, for the possibility of an error is intrinsic in the statistical nature of AI decision-making. Clearly, a mistake occurring in nuclear early warning, no matter how infrequent, may have existential implications: an AI classifier detecting a false positive launch of intercontinental ballistic missiles (ICBMs) may trigger an unjustified use of nuclear weapons.

The high risk associated to an infrequently occurring early warning mistake demands that the responses of AI systems must be carefully verified by human decision-makers. However, the additional time required by this verification process may offset the expected reduction in processing time allegedly flowing from AI-powered automation, thereby defeating the goal of buying more extended temporal windows for human decision-making, which is one of the pros one may adduce for using AI in nuclear early warning.

Additional risks involved in AI-powered nuclear early warning emerge by reflecting—in connection with the need to countervail automation biases—on the difficulty of interpreting AI information processing and explaining its outcomes. Humans in command-and-control positions are expected to act on the basis of a proper understanding of machine behaviors, rather than blindly trusting its responses. Hence, they must be able to obtain enough humanly understandable information about machine information processing, mapping the latter into perceptual and cognitive domains that humans can make sense of. However, AI learning systems based on DNN raise major stumbling blocks towards the fulfilment of this "interpretability" requirement. Indeed, classification outcomes of AI learning systems depend on features of input data that may significantly differ from features that humans use to perform the same classification task. To illustrate, to decide whether there is a cat in

an image, humans usually focus on salient features of typical cats—such as whiskers, ears, nose, and tail—and their spatial arrangement. In contrast with this, AI image classification processes may rely on distributed sets of image parts and pixels that the human perceptual system does not meaningfully associate, as a rule, to distinctive features of cats.

The "semantic gap" between human and machine knowledge representation and processing ([18], p. 20) extends well beyond the identification of salient features in input data. AI learning systems process information *subsymbolically*, without operating on humanly understandable declarative statements and without applying stepwise logical or causal inference [25]. Because of these remarkable differences between machine and human information processing, AI systems are mostly opaque and hardly interpretable to human users and decision-makers.

Another risk arising from the use of AI systems in nuclear early warning flows from the unexpected and counterintuitive mistakes that AI systems make and that a human operator would unproblematically detect and avoid. These fragilities were discovered by means of adversarial machine learning [7] early on in the history of learning AI systems formed by DNNs. A variety of errors were identified that are most relevant to military uses of AI systems. Notably, visual perceptual systems based on DNN architectures were found to mistake images of school buses for ostriches [27] and 3-D renderings of turtles for rifles [6]. These mistakes were induced by small input perturbations crafted on the basis of adversarial machine learning methods. A human operator would not incur in such mistakes, for the small adversarial input perturbations inducing the machine to err are hardly noticeable by the human perceptual system. Clearly, these mistakes are potentially catastrophic in a wide variety of conventional warfare domains, for normal uses of school buses are protected by International Humanitarian Law, and someone carrying a harmless object in the hand may be mistakenly taken by an AI system to wield a weapon, thereby triggering an unjustified use of force [4]. By the same token, one cannot exclude that AI systems for nuclear early warning will make counterintuitive and potentially catastrophic errors of the same sort that adversarial machine learning has enabled one to highlight in other critical application domains.

To detect and correct machine errors that human operator would easily prevent, nuclear decision makers should be put in a position to understand the reasons *why* an AI-powered early warning system provided a certain classification of sensor data. To fulfil this "explainability" condition, AI systems should be endowed with the capability to provide elements of a good and humanly understandable explanation of their decisions and classification results. However, causal or logical forms of reasoning are often needed to provide these explanations. But logical and causal reasoning, as already noted above, is beyond the current capabilities of the more successful AI learning systems. Accordingly, the development of explanation-giving AI systems raises formidable research problems, which now characterize the goals of the eXplainable AI (or XAI in brief) research area (https://www.darpa.mil/program/explainable-artificial-intelligence). Pending significant breakthroughs in XAI, one cannot but acknowledge the difficulty of fulfilling interpretability and explainability

conditions that are necessary for nuclear decision makers supported by early warning AI systems to achieve the required situational awareness.

Adversarial machine learning demonstrates the possibility of *accidental* misclassifications leading to surprising and potentially disastrous mistakes. More recent developments in this research area have additionally showed that *deliberate* adversarial attacks can be maliciously exploited to induce an AI system to make classification mistakes. Indeed, adversarial AI attacks have been systematically carried out against AI systems operating in the real world. By altering the illumination of a stop signal on the street—in ways that are hardly perceptible to human eyes—an AI system was induced to classify it as a 30-mph speed limit sign [16]. To carry out this optical attack, AI scientists used inexpensive and readily available equipment only: a low-cost projector, a camera, and a computer. These developments pave the way to intentional adversarial attacks which manipulate input data, inducing AI-powered early warning systems to make perceptual mistakes. Similar hostile motivations may prompt intentional attacks of a different kind, carried out by "poisoning" AI learning systems. Poisoning attacks aim at corrupting datasets for learning, degrading the learning procedure or even the resulting AI system. There are no patches available to avoid either input manipulation or poisoning attacks, insofar as these are based on inherent weaknesses of the deep learning methods and systems that are prevalent today [12].

Let us take stock. Alleged advantages one may expect to flow from automated AI systems supporting nuclear early warning include a reduction of information processing time, buying more extended temporal windows for humans to assess whether a nuclear attack is in progress. However, specific AI fragilities discussed in this section, leading to accidental or intentionally induced counterintuitive misclassifications, erode confidence in the reliability of this technology in this high-risk application area. To avoid disastrous consequences of false positive or false negative early warning classifications, human decision makers should do their best to control the correctness of responses produced by AI classifiers. But this process is hindered by the lack of transparency and explainability of AI information processing and its outcomes, so that its enactment may offset reductions of processing time allegedly flowing from AI-powered automation. Therefore, the NSCAI recommendation that "AI should assist in some aspects of the nuclear command and control apparatus," including early warning and early launch detection ([23], p. 104, n. 22), cannot be taken at face value, but stands in need of a thorough critical assessment taking in due account fragilities, opacities, and unintended consequences of AI classification mistakes.

17.4 Wider Implications of AI for Nuclear Stability

Potential impacts of AI technologies and systems on nuclear defense and stability extend well beyond AI enhancements of cyber threats to NC3 and the envisaged use of AI-powered systems for nuclear early warning. Unmanned vessels, whose

autonomous navigation capabilities are powered by AI systems, are likely to have a significant impact on the prong of nuclear deterrence which is based on SLBMs (submarine launched ballistic missiles). Autonomous unmanned vessels are being developed as new elements of anti-submarine warfare, to identify submarines as they emerge from port or at maritime chokepoints and to trail them for extended periods of time henceforth. The surface vessel Sea Hunter is a significant case in point: originally prototyped in the framework of the DARPA anti-submarine warfare ACTUV (Autonomous Continuous Trail Unmanned Vessel) program, Sea Hunter is now undergoing further development by the US Office of Naval Research, to perform autonomous trailing missions lasting up to three months (https://www.darpa.mil/news-events/2018-01-30a). Another case in point is the autonomous extra-large unmanned undersea vehicle (XLUUV) Orca, manufactured by Boeing to meet a variety of undersea operations including anti-submarine trailing missions and warfare (https://www.naval-technology.com/projects/orca-xluuv/). According to a report of the National Security College of the Australian National University, "oceans are, in most circumstances, at least likely and, from some perspectives, very likely to become transparent by the 2050s." In particular, counterdetection technologies will be of little or no avail, so that submarines carrying ballistic missiles will be "detected in the world's oceans because of the evolution of science and technology." ([5], p. 1). A similar suggestion was advanced earlier on in a 2016 British Pugwash report in connection with SLBM-enabled Continuous At Sea Deterrence (CASD): "…adaptable long-endurance or rapidly-deployable unmanned underwater vehicles (UUV) and unmanned surface vehicles (USV), look likely to undermine the stealth of existing submarines." [10].

AI systems are used to generate synthetic data called *deepfakes*—a word blending the expression *deep learning* with the word *fakes*. Malicious uses of AI deepfake technology include the fabrication of videos imitating political leaders. These increasingly realistic and deceitful videos may induce misconceptions about the personality, behaviors, political positions, and actions of the represented political leaders. Deepfake videos of leaders of nuclear powers like Barack Obama, Donald Trump, and Vladimir Putin were widely circulated. Fueling doubts about their consistency and rationality, these videos may undermine the effectiveness of nuclear deterrence policies, which are crucially based on the credibility of second-strike threats to deter first uses of nuclear weapons.

The race to the militarization of AI was initially fueled by the rise of autonomous weapons systems (AWS). These are AI-enabled weapons systems that select and apply force to targets without human intervention [19, 30]. Instances include loitering munitions and autonomous drones. Loitering munitions overfly an assigned area in search of targets to dive-bomb and destroy without requiring any further human intervention after their activation. The loitering munition Kalashnikov ZALA Aero KUB-BLA was allegedly used by Russian forces in Ukraine [20]. And the Turkish unmanned aerial vehicle STM Kargu-2 was reportedly employed in autonomous attack mode during the Second Libyan Civil War against Haftar-affiliated forces. The repertoire of existing autonomous weapons is continually expanding, with an initial comprehensive survey provided in [9]. AWS raise serious concerns about the

respect of IHL in conventional conflicts [4, 19]. Moreover, AWS have the potential to give large conventional military advantages to adopters. It was claimed in this connection that if AWS happen to tilt the conventional military balance, a nuclear-armed adversary may feel incentivized to threat the use of nuclear weapons to avoid military defeat ([17], p. 31).

17.5 Concluding Remarks

The decision that Lieutenant Colonel Stanislav Petrov made on September 26th, 1983, is an enduring lesson about nuclear risks arising from technological efforts to automate nuclear early warning systems and reduce the role of human judgment. The Soviet early warning system OKO wrongly signaled an incoming nuclear attack as it mistook sensor readings of sunlight reflecting on clouds for signatures of ICBMs engines. However, Petrov correctly concluded that OKO had signaled a false positive. Commenting some years later on the mental processes that led him to the conclusion that saved humanity from a nuclear war, Petrov remarked that "when people start a war, they don't start it with only five missiles." (https://www.armscontrol.org/act/2019-12/focus/nuclear-false-warnings-risk-catastrophe). This is an instance of human commonsense reasoning at its best. In contrast with this, AI still lacks commonsense reasoning, unable to respond properly and often revealing its brittleness to changing contextual situations that fall outside the scope of narrow sets of assumptions and boundary conditions [13].

The brittleness to changing context and the inherent vulnerabilities of AI information processing clearly support the US National Security Commission on Artificial Intelligence recommendation to "clearly and publicly affirm existing U.S. policy that only human beings can authorize employment of nuclear weapons", and to include "such an affirmation in the DoD's next Nuclear Posture Review", seeking "similar commitments from Russia and China" ([23], p. 98). There are, however, additional risks arising from AI inherent vulnerabilities and information processing weaknesses, especially in connection with plans and proposals to use AI to modernize nuclear early warning, including NSCAI own proposals in this respect. AI Computer scientists can and should do better to highlight risks to nuclear stability induced by limitations affecting current AI technologies and systems, by AI-powered cyber attacks, and by AI-induced erosion of nuclear deterrence. Taken together, nuclear threats emerging from the militarization of AI reveal additional limitations of nuclear deterrence policies and provide new significant motives to support nuclear non-proliferation and disarmament.

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Chapter 18
The Roadmap to Fusion: Science and International Cooperation for Sustainable Energy

Piero Martin

Abstract The transition to non-fossil energy sources is gaining a rapidly increasing attention in the international agenda. The global disruptions caused by the pandemic and more recently by the Ukrainian crisis add to the growing concern about the consequences of climate changes. All situations that have highlighted how crucial energy is for sustainable development and for international relations, and the extreme vulnerability of a world still largely depending on fossil sources. In this framework research on nuclear fusion energy is attracting a growing interest. It is an extremely attractive potential source of electricity for a future CO_2-free energy basket. It uses widely available fuel, does not produce high-level radioactive waste and its plants are inherently safe. For its practical applicability, high-level research is still required. As the science progresses and the realization of fusion comes closer, it also necessitates a debate about non-technical issues, including diverse social and ethical implications. This requires a multi-disciplinary approach, which includes conversation outside the traditional technical borders of fusion research. Questions like the following need to be addressed: what are the ethical implications of sourcing electricity from fusion? What kinds of evaluations (financial, environmental, ethical) are at play here? How would the costs and benefits associated with fusion technology be distributed? What factors may affect availability of fusion energy? How to deal with public acceptance of an energy source that, despite being very different from fission, has a nuclear nature? And, ultimately, considered in a broader environmental, social, and geopolitical context—would this form of energy deliver a better energy future for all?

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18.1 Bridges in the Times of Walls

"No sensational reports were made at the conference, and to an outside observer it may have possibly appeared not outstanding". Even considering the typical understatement of scientific communication—at least that of those times—from this description it sounds like the Third International Conference on Plasma Physics and Controlled Nuclear Fusion Research, held in Novosibirsk from August 1st to August 7th, 1968, was not such a big excitement for the delegates who attended it. The sentence comes from a summary report about the meeting written by the famous soviet physicists B. B. Kadomstsev and published in the journal Soviet Physics Uspekhi [1].

But, reading the next lines in the paper, some hints that something interesting happened appear: "However, to the participants of the conference—some 700 delegates and guests from 20 countries—it was not only a propitious opportunity to form a general picture of the development of thermonuclear studies, but also a rather impressive demonstration of progress in all directions, and of the ever-growing advancement in the parameters of thermonuclear plasmas". And indeed, the progress that the soviet T-3 tokamak reported was such to impress the whole western fusion community. We should not forget that we were in the middle of Cold War, tension was very high between the two blocs and nuclear fusion was a very strategic area of research. The news that soviet scientists achieved in their tokamak plasma temperatures as high as 10 million degrees—with energy confinement times an order of magnitude larger than any other fusion device—shocked the rest of the world, suggesting that Soviet Union was taking the leadership in such an important research field. Numbers were hard to believe, and the international community asked for independent assessment.

Despite the political divisions, the scientific channels in fusion science had remained open.

So, when Lev Artsimovitch, head of fusion research in Moscow, suggested to his British colleague Bas Pease, Director of the Culham Fusion Research Center, to have an independent evaluation conducted by UK physicist, the proposal was accepted. British physicists were not only from the western bloc, but also had recently developed a very high precision plasma temperature measurement based on laser and Thomson scattering. If the collaboration was successful, this would have meant for the Soviets a confirmation of their measurements and for the British a spectacular testing ground and an international visibility for their applied physics team. After weeks of preparation, the measurements were successful and confirmed what their Soviet colleagues had reported the previous year, opening the way to the international success of the tokamak configuration. Just a few months later, the United States transformed their main experiment in the Princeton laboratory into a tokamak and quickly obtained similar results. In short, the tokamak configuration became the leading player in worldwide research on controlled thermonuclear fusion.

In a period when walls were erected, fusion demonstrated that scientific collaboration has no borders.

I find this anecdote particularly relevant to introduce my contribution, dedicated to fusion, to the XXII Edoardo Amaldi Conference, which has the title "Nuclear Risks and Arms Control. Problems and Progress in the Time of Pandemics and War". Despite being a process first used by humans for military applications—the hydrogen bomb—pacific research on controlled thermonuclear fusion has always been characterized by very open worldwide collaborations. For example, our present flagship experiment, ITER, will demonstrate the scientific feasibility of magnetic fusion and is under construction in France as the result of a partnership which involves European Union, People Republic of China, India, Japan, Republic of Korea, Russian Federation, and the United States. And the origin of the project dates to 1985, when at the November Summit in Geneva dedicated to arm control, Mikhail Gorbachev and Ronald Reagan spoke also about the peaceful use of nuclear energy. The official press release at the close of the summit noted that the "two leaders emphasized the potential importance of the work aimed at utilizing controlled thermonuclear fusion for peaceful purposes and, in this connection, advocated the widest practicable development of international cooperation in obtaining this source of energy, which is essentially inexhaustible, for the benefit of all mankind." This commitment was soon translated into the start of ITER [2]. One year later, an agreement was reached among the European Union, Japan, the Soviet Union, and the United States for the joint design of the program. The People's Republic of China and the Korean Republic signed on to the project in 2003, followed by India in 2005.

On the medium-term fusion must be a big player of the energy transition, which is an issue for all the world. International collaboration is therefore crucial to win such a big challenge and fusion is a neat example on how such cooperation may work despite political difficulties.

18.2 Fusion and Energy Transition

The transition to non-fossil energy sources has a rapidly increasing importance in the international agenda. The global disruptions caused by the pandemic and more recently by the Ukrainian crisis add to the growing concern about the consequences of climate change, now more and more evident. All situations that have highlighted how crucial energy is for sustainable development and for international relations, and the extreme vulnerability of a world still largely depending on fossil sources. We should also not forget the issue of energy poverty—undoubtedly less felt in rich economies—which reminds us of the responsibility of dealing with a world strongly divided between north and south also in terms of energy, with 770 million people who do not have access to electricity. A problem, the latter, with ethical implications, but also strategic and international relations (just think of the consequences on migratory flows).

It is therefore not surprising that research on energy issues is attracting increasing interest. One source that a large community has been working on for decades is fusion. For some a utopia, for others a short-term panacea for all energy problems, in

reality fusion is neither. It is an extremely attractive potential source of electricity, and I would say necessary, for a future CO_2-free energy basket. It uses widely available fuel, does not produce high-level radioactive waste and its plants are inherently safe. For its practical applicability still high-level scientific and technological research is required and its penetration in the electricity market is foreseen in the second half of this century. This is not a short time scale, but it is comparable to that necessary for the penetration of other energy sources. And, in any case, time scale will not diminish the need for a source such as fusion. In fact, if in the short term the energy transition cannot make use of fusion, in the medium to long term its role as a source of "baseload" will be unavoidable and necessary in a fully electric and hydrogen-based economy [3].

For fusion to become one of the key actors of the electricity market, research is needed. This research will increasingly benefit from interactions with other sectors of physics, given that plasma—the fully ionized gas that is the fuel for fusion—is widely present in the universe. It is this ubiquity that inevitably makes fusion physics interdisciplinary.

18.3 The International Fusion Research

The fusion reaction most studied for energy purposes is that between two isotopes of hydrogen, deuterium (D) and tritium (T), which gives rise to an alpha particle and a neutron:

$$\mathrm{D} + \mathrm{T} \rightarrow {}^{4}\mathrm{He} + \mathrm{n}(+17.6\,\mathrm{MeV})$$

17.6 meV of energy are released for each reaction, 3.5 meV are associated with the alpha particle and 14.1 meV with the neutron. To obtain enough fusion reactions in a reactor, and therefore in a space necessarily limited by practical reasons, two approaches are mainly used for fuel confinement: inertial and magnetic. In inertial confinement, the mixture of deuterium and tritium—in the form of small capsules—is compressed by electromagnetic radiation produced by very high-density lasers, up to a thousand times greater than that of matter in the liquid state [4]. With magnetic confinement, the reactants, initially in the form of gas, are heated in a discharge vessel up to temperatures of 10^8 K in a reactor. This vessel for the larger experiments has linear dimensions of the order of a few meters and a toroidal shape. Under these conditions the gas ionizes and becomes a plasma composed of positive ions and electrons. The plasma can be confined within the reaction chamber by a suitable magnetic field. At sufficiently high temperatures the reaction rate for D-T is maximum and therefore the optimal conditions for controlled thermonuclear fusion are achieved. This paper deals only with magnetic confinement fusion.

The fusion of light nuclei has been the subject of international research since the 1950s. If realized, controlled thermonuclear fusion would have the potential to provide nearly unlimited and widely available energy, free from CO_2 emissions.

Raw fuels will be water—from which deuterium is extracted—and lithium, that will turn into tritium by neutron bombardment directly inside the reactor. Unlike nuclear fission (what is today often referred to as 'nuclear energy'), it would not produce long-lasting radioactive waste, and it minimizes the risks of serious industrial accidents.

The most used magnetic configuration is tokamak [5]. It was invented in the 1950s in the Soviet Union [6, 7]. Numerous experiments currently in operation around the world belong to the tokamak configuration. The largest currently in operation is JET, located in Culham, UK and managed by the European Union. JET has recently reported ground-breaking results [8] with the production of a total of 59 Megajoules of heat energy from fusion over a five second period, corresponding to the duration of the fusion experiment. During this experiment, JET averaged a thermal fusion power of around 11 megawatts.

The ITER experiment is also a tokamak. It will be the largest tokamak ever made [9] and will aim to demonstrate the scientific feasibility of fusion as a source of energy. Alternative configurations to the tokamak and different from it for the spatial distribution of the confinement magnetic field are the stellarator [10] and the Reversed Field Pinch (RFP). The largest RFP device in the world is in operation in Padua [11].

At the scientific, political, strategic, and industrial level, in recent months a broad international attention has been concentrated on fusion research. The European Union is proceeding, through the EUROfusion consortium, in the implementation of the "Roadmap to the realization of fusion energy" [12], which identifies the main research priorities to be addressed to achieve the objective of producing electricity from fusion around the middle of this century. The European program has as its future pivotal elements ITER and the Italian DTT tokamak, now under construction at the ENEA laboratory in Frascati, which will be described later in this document. Both will be crucial for the design and construction of DEMO, the reactor prototype dedicated to the conversion of fusion energy into electricity. The W7-X stellarator at the Max-Planck Institut für Plasmaphysik in Greifswald [13], Germany will also provide information for the stellarator line, while the renewed RFX-mod2 device will advance the RFP concept. Interestingly, the RFP is also studied as a configuration suitable for a novel fusion-fission hybrid reactor (FFHR) [14], which could accelerate the penetration of fusion in the energy mix and contribute to the sustainability of fission. A FFHR has a fusion core, which supplies a steady flux of fast neutrons to a surrounding blanket of fissile materials. FFHR is a tool to transmute the long-lived minor actinides which constitute high level nuclear waste into shorter-lived waste more safely disposable, and to generate electricity and produce tritium fuel for fusion reactors.

All major world fusion communities are developing strategies for fusion exploitation. Just to give two notable examples, in March 2022, the White House launched a program to build "A Bold Decadal Vision for Commercial Fusion Energy" [15]. This is a notable bipartisan initiative promoted by the Biden administration to accelerate the exploitation of fusion for energy purposes. The People's Republic of China has instead developed a strategy that, in addition to ITER, provides for the realization of an intermediate national experiment between ITER and DEMO, called "Chinese

Fusion Engineering Testing Reactor" (CFETR, with a production of thermal energy from fusion of the order of 1 GW), again with the aim of finding solutions that speed up the construction of a series of fusion reactors [16].

An element that has recently aroused strong interest in the panorama of fusion research has been the growing synergy between public and private research. In fact, in recent years there has been a drastic growth in the commitment of private companies for the development of fusion, as well summarized in a recent article in the journal Nature [17]. This resulted in a significant injection of capital into research: according to the 2022 survey of the Fusion Industry Association [18] declared private funding surpasses $4.7 bn, plus an additional $117+ million in grants and other funding from governments. This is a 139% increase in funding since the 2021 version of their survey. The case of the Commonwealth Fusion System (CFS), a spin-off of MIT [19] (in which the Italian energy company ENI, also a partner of the Italian DTT experiment, participates) is striking: according to the Wall Street Journal in 2021 it raised 1.8 billion dollars from investors [20]. CFS and MIT are working together to develop SPARC, a compact, high-field, net fusion energy device. SPARC would be the size of existing mid-sized fusion devices, but with a much stronger magnetic field [21].

18.4 The Italian Program

Italy has always had a leading role in the scientific and technological program on fusion and in plasma physics in Europe and worldwide. Today the Italian fusion program has about six hundred researchers—physicists and engineers—and is the second largest in Europe, together with the French one and immediately after Germany. The main laboratories are those of ENEA of Frascati, of the RFX Consortium in Padua (of which ENEA, CNR, INFN, University of Padua and Acciaierie Venete s.p.a. are members), of the CREATE Consortium in Naples and of the Institute of Physics and Technology of Plasmas of the CNR. To these add research groups mainly in the Universities of Bologna, Cassino, Catania, Cosenza, Milan, Naples, Padua, Palermo, Pisa, Rome, Viterbo and in the Polytechnics of Milan and Turin. Recently the ENI company has started a growing research program in fusion, with the involvement in the SPARC project and, in Italy, in the construction of the DTT tokamak. The Italian plasma and fusion community is engaged on many fronts, both experimental and theoretical. In the following I list only the main ones, but there are many others of great scientific importance.

First, there is the DTT project, currently under construction in Frascati [17], home to one of the main ENEA research centers and formerly of the FTU tokamak [22], which was in operation until about a couple of years ago.

DTT is a large size, high magnetic field experiment, which answers to a crucial research need expressed by the EUROfusion roadmap [12]. DTT has major radius of the torus 2.20 m, minor radius 0.7 m and is capable of a maximum plasma current of 5.5 MA [23–25]. It will be equipped with plasma heating systems that will be

able to deliver a power to the plasma of up to 45 MW. The experiment is designed in such a way as to be able to tackle the problem of dissipating the intense energy loads due to heat, radiation, impact of particles and neutrons that the plasma releases and that will pour onto the components facing the plasma itself in a future reactor. These loads are currently beyond the capabilities of known materials. The fundamental processes that regulate them must therefore be understood and solutions studied both to control them and to develop suitable materials and components. This will be one of the main scientific missions of DTT which will be addressed with a broad scientific cooperation.

DTT was conceived by physicists and engineers of the Italian fusion community under the guidance of the ENEA laboratories in Frascati and is now under construction. A complete description of the project can be found in the Interim Design Report [17]. The scientific and financial approval process for the experiment was completed in 2019. Over 80% of the 500 million euros that will be used for its construction are financed by the Italian government, thanks also to a loan from the European Investment Bank under the Juncker Plan. 60 million have been allocated by the European consortium EUROfusion and the Chinese government is expected to collaborate through the Hefei laboratory of the Chinese Academy of Sciences. In 2019, the Consortium DTT s.c.a r.l. was established, which currently sees ENEA as the majority shareholder. ENI participates in the DTT s.c.a r.l. with a share of 25%. The other shareholders of DTT s.c.a r.l. they are the CNR National Research Council, the CREATE Consortium of Naples, the RFX Consortium of Padua, the INFN, the Polytechnic of Turin, the University of Milan Bicocca, the University of Rome Tor Vergata and that of Tuscia. Construction of the device is currently underway, and it is expected to be completed by 2028.

The other main Italian research center is Padua, by the RFX Consortium for Research, Innovation and Training. About 150 people work in its laboratories, which host the Reversed Field Pinch experiment called RFX-mod [11, 26]. It is now in the operational recovery phase after a significant improvement [27]. Also in Padua, in close collaboration with INFN, the Neutral Beam Test Facility (NBTF) [28] is being carried out, an experiment that consists in the 1: 1 scale prototype of a powerful linear accelerator of negative ions (acceleration voltage 1 MV and beam current 40 A). It will be used to heat the ITER plasma. Italian physicists and engineers are also involved in the operation of the JT-60SA tokamak [29], as part of a Euro-Japanese collaboration agreement that sees our country in a leading position. Italy also participates in numerous scientific activities aimed at the realization of ITER measuring instruments, the study of the physical processes that will characterize it and the design of the DEMO demonstration reactor. Italian physicists also occupy positions of undisputed international importance also in the theoretical and modeling sectors.

18.5 The Scientific and Technical Route to Fusion

The present and planned magnetic fusion experiments—and the associated theoretical work—aim at demonstrating the scientific feasibility of magnetic fusion by sustaining in nearly steady state conditions fusion thermal energy production. ITER, for example, will produce 500 MW of thermal fusion power for about an hour, with an amplification factor x10 with respect to the power needed to heat the plasma. This calls for addressing the main physics and technology open problems, which need to be solved to move towards practical exploitation of fusion energy. They can be summarized as follows[1]:

(a) Identification of the most efficient operational plasma regimes, where:
   - plasma confinement is optimized in high density conditions, with minimal energy and particle losses, i.e. with reduced transport driving turbulence);
   - magnetohydrodynamic plasma stability is under control—both with passive and active means—and strategies for the avoidance/mitigation of transient events due to instabilities are implemented;
   - additional heating to reach thermonuclear burning conditions is used in efficient manner.

(b) Understanding dynamics of thermonuclear burning plasmas, which will be characterized by significant population of super-thermal particles, like alpha's.
(c) Managing intense heat and particle loads at the plasma edge.
(d) Developing neutron tolerant materials.
(e) Designing efficient strategies for tritium self-sufficiency.

In parallel with the solution of these challenges the community works to design the next step device, which will need to demonstrate practical conversion of thermal energy into electric energy. These will be the DEMO-class experiments previously mentioned. Their detailed goals may vary from approach to approach, but the overarching mission is well summarized in [30]: "DEMO in Europe is considered to be the nearest-term reactor design to follow ITER and capable of producing electricity, operating with a closed fuel-cycle and to be a facilitating machine between ITER and a commercial reactor…. It is a device which lies between ITER and First-of-a-Kind (FoaK) Fusion Power Plant". Its main targets will be:

- Conversion of fusion heat into electricity (∼500 MWe).
- Achievement of tritium self-sufficiency (Tritium Breeding Ratio >1).
- Reasonable availability with several full power years.
- Minimize activation waste without long-term storage.
- To be component test facility and pathfinder to a First-of-a-Kind Fusion Power Plant.

[1] This list in inspired by the EUROfusion roadmap, where more details on the various topics may be found [https://www.euro-fusion.org/eurofusion/roadmap/].

While detailed roadmaps to fusion may vary in different countries and considering that sudden accelerations may occur—for example due to private efforts or grand political decisions driven by energy and environmental crisis—there is a consensus that at the present pace fusion will become a key component of the global energy mix in the second half of this century. This confidence is mirrored in growing investments in this form of energy from private capital markets, as we have seen before.

This is only apparently a long timescale. As the science progresses and the realization of fusion comes closer, it necessitates a debate about non-technical issues associated with this energy source, including diverse social and ethical implications. Now the—by far—largest fraction of efforts is devoted to scientific and technical problems. A few decades horizon for fusion commercialization calls instead for coping also with issues related to public acceptance, development of scenarios for fusion penetration as an energy source and, more generally, with energy ethics considerations.

How to balance energy demands with concerns for anthropogenic climate change and with strategic and geopolitical issues is one of the most profound and urgent challenges facing humanity today. As the global economies move towards a lower carbon energy future, great emphasis is placed on developing new energy technologies. But the challenge of transitioning to a more sustainable energy mix for the whole mankind is not just a technical one. It also requires us to collectively address questions about how to create a better energy future for us all.

Given the importance that fusion will have in a sustainable energy mix, questions like the following need to be addressed: what are the ethical implications of sourcing electricity from fusion? What kinds of evaluations (financial, environmental, ethical) are at play here? How would the costs and benefits associated with fusion technology be distributed? What factors may affect availability of fusion energy? How to deal with public acceptance of an energy source that, despite being very different from fission, has a nuclear nature? And, ultimately, considered in a broader environmental, social and geopolitical context—would this form of energy deliver a better energy future for all?

18.6 Social, Environmental, and Ethical Aspects of Fusion

The questions I closed the previous section with, need to be tackled starting now. This requires a multi-disciplinary approach, which includes conversation outside the traditional technical borders of fusion research. Fusion scientists will be required to talk more and more both with experts outside their communities—sociology, environmental science, psychology, economics, political sciences, communication science, journalism are just some examples of fields that need to be involved—and with the public. For many of us this requires a significant change of attitude that needs to be nurtured with appropriate education and supported by additional new resources. In the following I will mention some areas where work needs to be done, obviously without the ambition of being complete. I will briefly talk about energy

scenarios, safety and environmental risks, non-proliferation, which are all central to public acceptance of fusion.

18.6.1 Energy Scenarios

The energy system is characterized by a strong inertia and therefore policies need to be implemented and penetration scenarios must be analyzed well before the technology is expected to enter the energy market. Work on this topic has already started and will certainly grow soon. To give a significant example of this kind of activity, Bustreo, Zollino et al. are addressing the question on how fusion power can contribute to a fully decarbonized European power mix after 2050 [31]. The European energy mix will be likely decarbonized in the second half of this century, and this may happen thanks to two main driving forces: relying on renewable energy sources only or integrating renewables with fusion power plants (and with a new generation of fission nuclear power plants). If only renewables are used, a large storage capacity and/or dispatchable generation are required to compensate for the variable electricity generation. Since a carbon-free economy will heavily rely on electricity, there will be a higher electricity demand during cold seasons—for heating—and in the nighttime, to recharge electric vehicles. This request might be difficult to be matched with offer in countries with prevailing solar electricity, and therefore needs significant investments in long term storage. The size of the necessary storage systems and dispatchable power plants can be strongly reduced if a base-load carbon free power technology like fusion is available.

Bustreo et al. have performed cost analyses [31] to assess whether and to what extent fully decarbonized power mixes could take benefits from nuclear fusion power concluding that "fusion would reduce the cost of electricity, in comparison with 100%-RES scenarios. This is true as long as the overnight cost of a fusion power plant will be lower than 8500 Euro/kW in the North-Europe case and lower than 12,500 Euro/kW in the South-Europe case. …the convenience of a power mix with fusion would result even higher if a detailed electric grid model were considered. In addition to cost, warnings on soil consumption, linked with hundreds GW size deployment of PV and Wind power plants, is a further issue in favor of power generation scenarios with fusion".

A strong program on the simulation of the role—and the cost—of fusion in CO_2 free energy scenarios will be extremely important both for attracting public and private investments and for gaining political and popular support towards fusion.

18.6.2 Safety and Environmental Risks

Unlike nuclear fission (what is today often referred to as 'nuclear energy'), fusion would minimize the risks of serious industrial accidents and not produce long-lasting radioactive waste.

The fusion process is inherently safe since the physics requirements to start and maintain the nuclear fusion process make impossible—by nature and not by human technics—an accident like those which happened in Chernobyl and Fukushima, leading to nuclear meltdown due to chain reaction. In a fusion reactor, there will only be a limited amount of fuel (a few grams) at any given moment. Operation of fusion reactor relies on a continuous input of fuel and on maintaining the plasma parameters within a very narrow range. If there is any perturbation and plasma parameters deviate from the optimal conditions the reaction ceases immediately, making a runaway chain reaction impossible. In other words, fusion is a self-limiting process: either you keep the plasma in good shape, or physics itself switches the reactions off.

As for radioactive waste, exploitation of nuclear energy by fusion has the enormous advantage with respect to fission that no long-lasting radiotoxic elements like actinides and other fission products are generated, thus avoiding the need of geological storages. Nevertheless, nuclear fusion is not totally free from radioactive waste, albeit of a very different nature. As a result of the operation of a fusion reactor there will be an inventory of low level and intermediate level waste, for example from the activated bio-shield, activated reactor components and from tritiated material. Available predictions are that this will be a easily manageable issue without long term environmental or health consequences. As we are still in an early stage of fusion technology development, work is needed to fully characterize the radioactive products of fusion electricity generation and to design an efficient waste management strategy. Communicating in a transparent way the outcome of this work will be crucial for the social acceptance of fusion. While it is probably little known that coal-fired power plants also produce radioactive waste since coal combustion creates small amounts of naturally occurring radioactive material [32], due to the nuclear nature of fusion we should expect a very high level of public sensibility that needs to be considered and openly addressed. In this respect it is interesting to note that in the UK, where the government is investing in the ambitious STEP program [33], the Committee on Radioactive Waste Management has recently released a preliminary position paper on radioactive waste from fusion energy [34], that illustrates the state of the art and recommends several initiatives.

18.6.3 Nonproliferation

While in practical terms the vertical and horizontal proliferation risks for nuclear fusion reactors will be negligible because of economic reasons, difficulty to conceal clandestine production given the size of the plants and standard operation with zero

fissile material—in other words it is cheaper and simpler to produce weapon relevant materials with other means than fusion—it will be nonetheless important to openly address and communicate even the more remote ones to the public and the stakeholders.

Given the low priority of the subject very little literature is available (see for example [35] and [36]). Potential proliferation issues derive from the availability of neutrons and tritium. Pure fusion systems do not contain source or special fissionable material, but in principle neutrons could be misused for production of ^{239}Pu and ^{233}U. The nuclear cycle of interest which is planned to be used to breed tritium in a reactor is:

$$\mathrm{D} + \mathrm{T} \rightarrow {}^{4}\mathrm{He}(3.5\ \mathrm{MeV}) + \mathrm{n}(14.1\ \mathrm{MeV})$$
$$\mathrm{n} + {}^{6}\mathrm{Li} \rightarrow \mathrm{T}(2.7\ \mathrm{MeV}) + {}^{4}\mathrm{He}(2.1\ \mathrm{MeV})$$

While the first fusion reaction happens in the plasma, the second takes place in a special blanket around the plasma chamber. Since the blanket modules in a fusion reactor will be maintained and/or replaced on a regular basis, it is in principle possible to replace a fraction of the lead–lithium alloy stored in the blanket to breed tritium with fertile nuclear material like natural uranium or thorium. During plasma operation neutron irradiation of the fertile material will produce fissile materials like plutonium or uranium 233, which can be retrieved in the next maintenance cycle [36].

Moreover a 2.5 GW(th) fusion power plant will contain an onsite tritium inventory of several kilograms of tritium and will need to produce about 400 g/day of this isotope, which in principle may be used for nuclear weapons (a limited amount of tritium boost a nuclear weapon). Now tritium is not controlled by the Non-Proliferation Treaty but, as stated in [36], "there is no credible risk that a gigawatt-scale fusion power system… could be built or operated in a clandestine fashion". The same paper concludes that "if designed to accommodate appropriate safeguards, fusion power plants would present low proliferation risks compared with fission. Our analysis suggests that clandestine production of weapons materials using fusion research facilities can be considered a highly implausible scenario".

18.7 Conclusions

The energy transition necessitated by anthropogenic climate change, and the implications of the war in Ukraine on the world's energy supply markets have stimulated in recent months a lot of talks in the media and on a range of public fora about nuclear energy and fusion. This happens in a period when existing magnetic fusion experiments are achieving important results, new important facilities are under construction (like ITER, DTT and SPARC) or close to start operation (JT-60SA) and significant private capitals are being invested in fusion research. Whilst in the past excessive

optimism has at times pervaded the scientific community, now there is solid confidence that fusion will become a player in a future CO_2-free energy mix provided that enough resources will be invested in the field.

This positive moment for fusion research calls for new challenges for the scientific community. In addition to technical efforts, it is now time to start conversations about wider ethical implications of this form of energy that consider its social, environmental, and geopolitical impacts. The potential acceleration towards fusion exploitation calls for anticipating an alliance with the public to facilitate social acceptance, build public trust, make a strong case for a change of paradigm in fusion funding (a drastic increase, in particular on the public side, it is necessary in the short term to bring fusion to the plug and in general to support energy R&D) and to keep the internationally open attitude of fusion research.

Ethical thoughts on fusion should also address the dramatic problem of energy poverty. According to the International Energy Agency (IEA) [37] today 770 million people live without access to electricity, mostly in Africa and Asia. This has tragic implications on health, quality of life, education and is a drive for conflicts and migrations. In principle fusion promises "infinite" energy—and therefore a tool to contribute to solve the energy poverty problem—but for an energy source dependent on high-tech devices and infrastructure, how could it be made available widely and equitably among countries and areas of various economic and technical capacities? Will future fusion energy be available for all, or only for the richest part of the world? Answers to questions like these obviously go beyond the realm of science and involve a multiplicity of factors and actors. Nevertheless, scientists must ask themselves those questions and work on them, be prepared to go outside their laboratories and to exercise their active citizenship to communicate with the public, the governments, and the stakeholders.

In 1969 fusion science—with its laser thermometer—built a bridge between two very separate world. Half a century later we need to make our voices heard for a more peaceful and equitable world.

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Chapter 19
Promoting Integral Human Development and Peace in the Digital Age

Alessio Pecorario

Esteemed President Roberto Antonelli, Professor Luciano Maiani and Organizers,
Revered Excellencies and Authorities,
Prestigious Speakers,
Dear Friends,

I wish to convey you the most heartfelt greetings from Cardinal Michael Czerny, Prefect of the *Dicastery for Promoting Integral Human Development* (DPIHD). His Eminence asked me to assure you all of his deepest sentiments of esteem and gratitude.

19.1 Introduction

As the COVID-19 pandemic continues to exacerbate the inequities and injustices that for generations have threatened people's well-being, lives and human rights, with disproportional impact on the poorest and most vulnerable, the Holy Father renews his plea to the human family to radically change its course. Today, I am honored to share with you some insights on the work we do at the Dicastery and at the Vatican Covid Commission (VCC), within the framework of the session where we have been called to intervene ("Thinking about the future"), the broader theme of the 2022 Amaldi Conference ("Problems and progress in the time of pandemics and war") and with the aim of shedding light on our activities in "Promoting Integral Human Development and Peace in the Digital Age".

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https://doi.org/10.1007/978-3-031-29708-3_19

19.2 PART I, the Vatican Covid-19 Commission

(1) Prepare the future, no one is saved alone!

Upon the outbreak of the pandemic, Pope Francis established the VCC to respond to the series of interconnected crises that the COVID-19 virus deepened. Inspired by the teachings of the encyclicals *Laudato Si'* on the care for our common home (LS)[1] and *Fratelli Tutti* on fraternity and social friendship (FT),[2] the Commission enacts the Holy Father's call to prepare the future through science, theological reflection, and deep collaboration. Drawing on a wealth of expertise from local communities, global platforms, academic experts and in partnership with philanthropic organizations around the globe, the Commission seeks to alleviate immediate suffering and propose novel and creative strategies to usher forth a transformation towards new—more sustainable and inclusive—ways of living.

The challenges we are witnessing are epochal: interconnected and unprecedented health and socio-political crises that have taken root one piece at a time in every sector of the economy and the society, and every State of the international community, which we previously chose not to acknowledge, but now are unavoidably obvious and worsening by the minute. Violence creates an economy of exclusion that, with as a predominant 'throwaway' culture, continues to discard people, separating the poor and the marginalized from the prosperity enjoyed by the few. Millions of refugees are denied access to basic human needs or detained for lack of proper identification, left as displaced people in squalid camps and rendered stateless —or held in secretive prisons in third countries. Not to mention the twin existential threat of climate change and nuclear war that today we see with such a gravity.

As the Pope says «The pandemic has shown us that we cannot live without one another, or worse still, pitted against one another. This is why, at this critical juncture, it is our duty to rethink the future of our common home and our common project», for we can never come out of a crisis like the pandemic and be as we were before, we come out either better or worse. No one is saved alone!

(2) Integral Human Development and Catholic Social Teaching

As the pandemic entered its second year, the human family was confronted with new manifestations of longstanding inequities, including unequal access to COVID-19 vaccines leading to the emergence of new variants, economic recession and multidimensional poverty, and aggravated effects of ongoing (yet often neglected) ecological crises. Yet, we were also granted new opportunities to catalyze systemic change, so that a more caring and peaceful society could emerge from this time of urgency. Today, countless initiatives around the world are propelling this change with courage and creativity by promoting the resilience and flourishing of their communities. They are a clear demonstration that the path to preparing the future starts with the promotion of the integral development of all peoples and planet.

> Non si può promuovere lo sviluppo umano oggi senza considerare il Covid: non si può. Ci sarà un prima e un dopo. Non si può combattere il Covid senza sviluppo umano integrale e senza il dialogo con le periferie e con le Chiese di periferia. Non per caso la Commissione ha la sua base nel Dicastero per il Servizio dello Sviluppo Umano Integrale
>
> Pope Francis' Audience, 26 March 2021

By relying on the pillars of the Catholic Social Teaching, the Church speaks of integral human development meaning that:

- Development is *holistic* (not restricted to economic growth)
- Development is *for all people* (not for a few)
- Development is about *the whole human person* (not just his/her material dimension)
- Development offers *feasible models of social integration* (does not foment inequality)
- Development comprises the *care for the environment* (it is not just a "natural resource" for material growth)
- Development is the path for *peace among people* (not another cause for violence and destruction)
- Development is the path to *the good and the flourishing* which is the vocation of the human family.
- Integral human development requires *dialogue of faith & reason*

Throughout 2021, the VCC sought to monitor and adapt to the fluctuating reality of the pandemic and address the emergence of new injustices by:

- Offering the voice of the Catholic Church to highlight the interconnectedness of the present pandemic and other global crises, as well as its impact on the most vulnerable;
- Listening to local Churches and offering resources for integral action and hope for change (eg. "20 points for a universal and fair destination of vaccines for a fairer and healthier world", "Healing the planet by ensuring the right to food for all", etc.);
- Engaging decision-makers and global platforms to support them in carving a new path forward and resist temptations to return to "business as usual";
- Embodying a new way of working that responds to the Holy Father's vision for the synodal renewal of the Church.

For 2022, the Commission has set forth on a path to strengthen its communication and partnership with local Churches. To listen to their realities and to accompany them through their sufferings and support their own processes of conversion; connect change-makers across the world and shine a light on existing best practices to inspire further action. In 2022, the Commission will work to embody the new path of synodality in order to dream, prepare, and live in a better future with the people of God.

19.3 PART II Promoting Integral Human Development and Peace in the Digital Age

(1) DSSUI activities on new tech

Although the DSSUI does not intend to claim any specific expertise on the matter of new technologies (*Octogesima Adveniens*, 4), we believe, that even in such unprecedent and innovative domain, it is still our mission to offer the Church's wisdom to the world, mindful that integral development is the path for peace (*Populorum Progressio*, 76).

As Pope Francis says, in modern era technologies are not neutral (LS 114), for they are part of a single great crisis, the cry of the earth and the cry of the poor. Although each new technology (AI, blockchain, etc.) can bring a certain degree of progress that must be recognized and celebrated, what is urgent and necessary is an authentically integral approach, which protects and promotes human dignity in a society that is no longer just technological, but more and more technocratic (LS 101 and 106 et seq.). As Pope Francis notes, «*paradoxically, we have certain ancestral fears that technological development has not succeeded in eliminating; indeed, those fears have been able to hide and spread behind new technologies* (FT 27)».

Building on these theological bases, the VCC's Security Task Force (STF) has been entrusted to continue the activities on the ethics of new technologies started at the foundation of the DPIHD. Two major international conferences have resulted from this work so far: "The Common Good in the Digital Age"[3] (16–24 September 2019) and "Promoting Integral Human Development in Times of Pandemic: New Technologies in the Post-COVID World" (9 December 2021).[4]

These events were unique opportunities for experts interested in collaborating with the Holy See on the intersection of technologies and integral human development to become acquainted with the Vatican entities and each other, with a view towards establishing a network of experts and begin further processes regarding new technologies across the Church. Externally to the Holy See, we sought to address the authentic need of the scientific, economic, and business worlds and international institutions for an ethical discussion on the opportunities and risks connected to the technological progress of society.

List of (some of the) participants from the past events
"The Common Good In The Digital Age" (September 2019)
· Mr. **Alfred Berkeley**, Princeton Capital Management, Former President of NASDAQ Stock Market, Inc. from 1996 until 2000 and Advisor on Cyber Security for three US presidents, USA
· Prof. **Anna Abram**, Margaret Beaufort Institute of Theology, University of Cambridge, United Kingdom
· Dr. **Antonio Missiroli**, North Atlantic Treaty Organization—Deputy Secretary General, Brussels, Belgium
· Mr. **Aziz Ahmad**, UTC Associates, Inc—CEO, New York, USA
· Mr. **Gavin Corn**, Facebook—Associate General Counsel and Director of the Cyber Security Law Team, Sunnyvale, CA, USA
· Mr. **Jim Welsh**, Western Digital—Senior Vice President, Los Altos, USA
· Mr. **Malcom Wright**, Diginex—Chief Compliance Officer, Hong Kong
· Ms. **Mitchell Baker**, Mozilla—Executive Chairwoman, Mountain View, USA
· Ms. **Nadezhda Arbatova**, IMEMO, Russian Academy of Sciences—Head of Department on European Political Studies, Moscow, Russia
"New Technologies For Peace And Integral Human Development" (December 2021)
· Dr. **Jovan Kurbalija**, Diplo Foundation, Founder And Director, Geneva, Switzerland
· Dr. **Maryann Cusimano Love**, Catholic University of America, Washington D.C., US
· Dr. **Paolo Gianturco**, Deloitte Italia, Milan, Italy
· Dr. **Lyndon Burford**, King's College London, London, United Kingdom
· Dr. **Kristina Hook**, Kennesaw State University, US
· Ms. **Danielle Mclaughlin**, Altimeter Group, New York, US
· Prof. **Francesco Silvestri**, TOChina Hub; Istituto Commercio Estero Italia, Rome/Turin, Italy; Shanghai, China
· Ms. **Marie Dennis**, Pax Christi International, Washington D.C., US
· Dr. **Gian Piero Siroli**, Conseil Européen pour la Recherche Nucléaire (CERN) and Pugwash Conferences on Science and World Affairs, Geneva, Switzerland
· Dr. **Preston Mcintyre**, Holding Space AD, CEO, Abu Dhabi, United Arab Emirates
· Dr. **Page Stoutland**, Nuclear Threat Initiative, New York, US

(2) **STF's future projects**

The STF is deepening the reflection on the ethical implications of the development and diffusion of new technologies through the reinforcement of its new network of experts and partners inside and outside the Vatican. More in particular, we seek to reach the margins, through a more and more interreligious and intercultural approach, so as to capture their perspective on certain challenges in the technological field. There will be a greater effort to listen to local contexts, possibly drawing on the broader networks of the VCC.

The following domains –among many others– will be explored:

(i) the urgency to create international norms around new technologies
(ii) cybersecurity, which is continually evolving, and exploring IoT application vulnerability to hacking attempts
(iii) the benefits and risks around FinTech and the responsibility of financial actors to address ethical concerns
(iv) the issues faced by workers following the pandemic, highlighting the specific burden digitalization of work can bring on women who provide care work
(v) bridging the digital divide by promoting education around new technologies to populations currently without access
(vi) the use of artificial intelligence (AI) in monitoring hate speech, defamation and discrimination and many others.

In leading this project, and here we approach closer the theme of this conference, the STF retains as a **foundational paradigm** the concept of "Integral Security", i.e. the need to take into account also economic and social elements that broaden what has been understood so far by the term "security."

Integral Security

The concept of "Integral Security" has never been clearly defined by any official document of the *Holy See*. However, this concept is contained in some official speeches and interventions and can be derived from the concepts of "Integral Human Development" and "Integral Ecology", introduced in the Encyclical letter *Laudato Si',* as well as other pontifical documents

In the *Laudato Si,* Pope Francis goes beyond the idea of traditional green practices to call for a more integrated and inclusive approach that takes into account the political, social, economic, and environmental problems. Moreover, Pope Francis emphasizes the relationships between the human being, its societies, and the ecosystem

On the same level, already in the Conciliar document *Gaudium et Spes* it is explained that «*Peace is not merely the absence of war, nor can it be reduced solely to the maintenance of a balance of power between enemies*». In line with this vision, the Holy See has always proposed an approach to disarmament and to security that reflects the multidimensionality of such topic and that aims to develop a world that is built on mutual trust and not «*on a false sense of security sustained by a mentality of fear and mistrust*»

"Integral Security" was at the center of the intervention of H.E. Card. Parolin, Secretary of State, at the STF's webinar "Advancing integral disarmament in times of pandemic", hosted by the DPIHD in collaboration with the *Strategic Concept for the Removal of Arms and Proliferation* in support of a global ceasefire, and has been utilized in other interventions and speeches in the last years[5]

As the *Holy See* has repeatedly emphasized, a correct concept of security calls into question elements not only of a political-military nature but also of an ethical-moral, juridical and socio-economic nature. This is what we can rightly describe as integral security

Our reconsidered concept of security should be based on this awareness, on looking forward to a coherent approach to security in light of the modern-day threats

Therefore, "Integral Security" can be defined as a broader an inclusive concept of "security", that is better suited to answer to the present treats the world is facing because takes into account the different dimensions related to human security in relation to the ideas of Integral Ecology and Integral Human Development: «*in the end, a peace which is not the result of integral development will be doomed; it will always spawn new conflicts and various forms of violence*». (EG 219)

It may sound paradoxical in our times—where «trust […] ceased to exist» (*Caritas in Veritate*, 35) —but our (integral) security coincides with the (integral) security of the others and depends on the «*the same fraternal spirit of care and closeness that marked the Good Samaritan*», for «*Love* […] *is more than just a series of benevolent actions. Those actions have their source in a union increasingly directed towards others, considering them of value, worthy, pleasing and beautiful apart from their physical or moral appearances. Our love for others, for who they are, moves us to seek the best for their lives. Only by cultivating this way of relating to one another will we make possible a social friendship that excludes no one and a fraternity that is open to all*» (FT 79 and 94)

A coherent "integral security" approach allows us to overcome the tensions we live between our individual moment and the greater, brighter horizon of the utopian future as the final cause which draws us to itself, in order to vivify what Pope Francis sees as a first principle for progress in building a people, for "time is greater than space": «*Giving priority to time means being concerned about initiating processes rather than possessing spaces*» (EG 222). Likewise, integral security requires acknowledging one of others principle that Pope Francis proclaims as indispensable for the building of friendship in society, "unity is greater than conflict": «*the message of peace is not about a negotiated settlement but rather the conviction that the unity brought by the Spirit can harmonize every diversity. It overcomes every conflict by creating a new and promising synthesis. Diversity is a beautiful thing when it can constantly enter into a process of reconciliation and seal a sort of cultural covenant resulting in a "reconciled diversity"* (EG 230)». Finally, "the whole is greater than the part, but it is also greater than the sum of its parts": «*we can work on a small scale, in our own neighbourhood, but with a larger perspective. Nor do people who wholeheartedly enter into the life of a community need to lose their individualism or hide their identity; instead, they receive new impulses to personal growth* (EG 235)»

19.4 Conclusions

One of the most urgent issues of the post-pandemic world is the erosion of trust and the social contract. Trust is both a product of and a precondition for the prevention of violence, both direct and structural, so it is vital to protect this cultural value. We need to rediscover the authentic meaning of entering dialogue among ourselves. That is why Pope Francis does not speak of "exercise of encounter," but rather of a "culture of encounter".[6] New technologies are being used to erode trust but could also play a role in building it –for example, the internet and digital tools are being used successfully in nonviolent strategies to prevent or transform violence and to build just peace. Blockchain might be useful in building a new arms verification system, small scale. There exist hundreds of local projects using technology for the common good from the bottom up in economy, ecology and health. Utilizing the moral imagination to develop theoretical uses of new technologies that serve the common good is greatly needed at this time of history.

As I have tried to show, the Church has a particular ability to link global philosophical and theoretical reflection with local practical wisdom to practice encounter in specific contexts. In the case of new technologies, the Church can first develop positions on the ethics of the uses of new technologies, drawing on Catholic social teaching. It can present local and global wisdom to international fora and campaign for concrete action. It can facilitate connections between various actors across the world and can host discussions among them. Then, upon further reflection on the efficacy of its practice, always according to the guidelines of true encounter and integral human development, it can change its positions based on global developments. In this way, a culture of encounter is constantly fostered, and new technologies may eventually be collaboratively and ethically governed.

Notes

1. Available at: https://www.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html.
2. Available at: https://www.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20201003_enciclica-fratelli-tutti.html.
3. Available at: https://www.digitalage19.org/.
4. Available at: https://www.humandevelopment.va/en/eventi/2021/nuove-tecnologie-e-nel-mondo-post-covid.html.
5. Available at: https://www.humandevelopment.va/en/eventi/2021/advancing-integral-human-development-in-times-of-pandemic.html#:~:text=On%2023rd%20March%202021%20at,event%20%E2%80%9CAdvancing%20integral%20disarmament%20in.
6. Pope Francis, Morning meditation in the chapel of the Domus Sanctae Marthae, *For a culture of encounter*, 13 September 2016. Available at: https://www.vatican.va/content/francesco/en/cotidie/2016/documents/papa-francesco-cotidie_20160913_for-a-culture-of-encounter.html.

Chapter 20
Verifying Nuclear Disarmament—Old Challenges, New Options

Götz Neuneck

Abstract In recent decades, verification methods, technologies and procedures have been significantly developed further, both technically and procedurally. The competence and expertise of the IAEA and the CTBTO have been considerably improved and national as well as international verification research programmes have been developed. A global verification culture with a lot of knowledge, expertise and experiences has been evolved in some areas. When it comes to the concrete reductions and the credible destruction of nuclear warheads, verification efforts today focus on delivery systems and the number of deployed warheads. Under New START, the USA and Russia are verifying their bilateral obligations until 2026 based on bilateral inspections. Transparency of the current global NWSs arsenal with regard to the exact number of warheads, their operational status, storage and production sites including the fissile material is not existing yet. More R&D is necessary to develop new verification tools. Yet, the international community is not part of the concrete dismantlement of nuclear warheads that are no longer needed or the fissile material released in the process. "Transparency and irreversibility" as well as "safety and security" and non-proliferation standards are key disarmament criteria which have to be applied to future reduction cycles. A dismantling or destruction of a nuclear warhead under the control of foreign inspectors has not yet taken place due to the proliferation concerns under der Non-Proliferation Treaty Art. II and III, which prohibit the disclosure of sensitive information, which would take place if inspectors from NNWS were involved in the dismantlement process and if they have direct insight into the design and composition of the warhead. It is therefore clear that reliable verification of the dismantlement and destruction of a warhead must be a central element of future multilateral nuclear disarmament. The NPT and the TPNW verification demands imply different scenarios, methods and requirements

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for such options. It is important to understand the existing verification measures and capabilities, so that reduction and elimination proposals cannot be rejected due to their alleged ineffectiveness. Additionally, it is also clear that the vision of ultimately eliminating nuclear weapons worldwide will not be achieved in one big step but in a step-by-step approach and needs specific verification arrangements for multiple scenarios.

20.1 Introduction

Although the global nuclear arsenals have numerically declined to about 13.000 warheads worldwide since their peak in 1987, the remaining nuclear weapons are still a global threat [21]. The decline of nuclear warheads based on the New-START obligations occurs mainly because the USA and Russia are dismantling retired nuclear warheads. According to a Fact Sheet from 2021, the United States dismantled 11,683 nuclear warheads between 1994 through 2020.[1] There are several historical examples of nuclear weapon removals from past deployment [14], 149. On the other side, all NWS have expensive programmes under way to modernize their nuclear arsenals. The international arms control network is permanently weakened by treaty terminations (INF Treaty, JCPOA) or blocked negotiations (New START) [17]. In all of these cases, intensified verification measures play an important role: In the case of the INF Treaty, the accusations of the United States and Russia could have been clarified through mutual inspections. The debate about a "denuclearisation of North Korea" raised some hopes, but central questions such as the disclosure of North Korea's nuclear potential by a baseline declaration and its gradual verification have not been implemented. Even far-reaching, in-depth and so far successful monitoring by the IAEA, as in the case of Iran through the Joint Comprehensive Plan of Action (JCPOA), does not prevent in 2015 the Trump-Administration from terminating the Iran Agreement of 2015.

The reasons for this negative trend are more political than technical, but they illustrate how central, sensitive and important adequate nuclear disarmament verification (NDV) of agreements and treaty obligations are against the background of building confidence and the real will to cooperate in the spirit of further nuclear disarmament. This contribution explains first, what verification is and which challenges are ahead. The second section describes the core steps for future disarmament, which is the dismantlement and elimination of nuclear warheads and nuclear-related facilities. Several initiatives and studies in the last decade have produced important lessons about NDV (third section) and have raised technical important experiences. The fourth section compares the requirements for future disarmament treaties. The fifth section concludes the contribution.

[1] Approximately 2.000 additional nuclear warheads are retired and awaiting nuclear dismantlement. See Fact Sheet: Transparency in the U.S. Nuclear Weapons Stockpile, October 5, 2021.

20.2 What is Verification?

Nuclear Disarmament is the concrete and verifiable irreversible reduction, dismantlement, destruction or elimination of nuclear weapons from a national military nuclear arsenal. The current reductions and the destruction of retired nuclear warheads (NW) and their sub-components has so far been organized and executed by the NWS on their national basis [10]. In the case of far-reaching nuclear disarmament arrangements, however, the irreversible elimination of nuclear warheads, mission-critical facilities or weapons-grade material (i.e. first and foremost plutonium or highly enriched uranium) creates new technical, legal and economic challenges. An additional challenge for sustainable nuclear disarmament is also to prevent states from rearming by activating hidden arsenals or by relaunching a military nuclear programme.

In 1986, Jerome B. Wiesner observed that "understanding verification needs and capabilities is important because too often weapons reduction and elimination proposals are rejected with the argument that they cannot be adequately verified" [22, xiii].

Several remarkable functions of verification can be identified: In general, it allows state parties to assess the implementation of an agreement thus fostering trust and confidence between state parties. More concrete, "adequate" verification measures discourages non-compliance with treaty provisions and can give timely warning of violations. In sum, if working it can create confidence that a treaty regime including the verification methods is functioning as intended and that state parties are in compliance with an international agreement. This is not only in the interest of all state parties but can also be an important instrument to solve emerging issues and conflicts. Fetter and Oelrich stated in 2010 the obvious: "Most nuclear-weapon states would be willing to eliminate their nuclear weapons only if they could be confident that other countries-especially potential adversaries- had also eliminated theirs [4, 27].

Verification can be derived from the Latin "veritas facere": In other words, it is about demonstrating that a presumed or asserted fact is "true" or accurate within a contractually defined framework. The basis for agreed verification is a treaty or an agreement that regulates the verification of the presence or absence of certain contractual items such as NWs. So far, the withdrawal of nuclear warheads from an active operational status is a dominant paradigm of nuclear disarmament.[2] In the future, the scope of a disarmament treaty can thus be the entire military and non-military part of the fuel cycle creating new challenges for NDV. Therefore, verification measures can be applied to the removal or storage of non-active NWs but also the dismantlement and destruction of NWs, nuclear facilities, testing ranges or other military-relevant sites of the military nuclear fuel cycle.

Depending on the involvement of the state actors, verification can be carried out unilaterally, bilaterally or multilaterally. Unilateral verification of the destruction of a military nuclear programme occurred in the case of Iraq, where UN missions carried out the dismantling of facilities and materials after the Second Gulf War in 1991.

[2] A UNIDIR study has recently shown that the absence of nuclear weapons can be well verified in the case of a withdrawal (UNIDIR 2018).

Within the framework of the UN missions UNSCOM/UNMOVIC it became apparent that this was a years-long undertaking, involving high costs, political tensions, extensive inspections and the training of inspectors from many co-operating states. Another case is South Africa, which voluntarily abandoned its military programme from 1993. The IAEA, which accompanied the dismantling (e.g. by reviewing historical documents), was only able to confirm in 2010 that the military-relevant fissile material is now only used for "peaceful activities". Verification in the comprehensive sense therefore requires not only a reliable mechanism, proven verification methods (inspections, personnel, technologies), but also an executive agency such as the IAEA. The IAEA, however, does not yet have an explicit disarmament mandate [16]. Verification can also be supported by the application of "National Technical Means" (NTM), i.e. national reconnaissance sources such as satellites photos or "Open Source Intelligence", which are data openly available to civil society.

The International Partnership for Nuclear Disarmament Verification (IPNDV) describes verification as "the iterative and deliberative policy process of using collected data to assess whether a state party is in compliance with the provisions of an international treaty/agreement." Procedures such as inspections and the use of technologies help to collect relevant data about the implementation of treaty obligations. The success of verification measures is dependent on the subject and the scope of the verification obligations, methods, tools and the skills of inspectors.

There are important verification demands based on existing principles such as Non-Proliferation, Safety and Security or Irreversibility. The NPT Art. II/III instigate that there is no release of proliferation-sensitive information to other state parties. Inspectors must be protected against any radiation release and have to accept safety and security regulation of critical facilities such as military bases or weapon assembly areas. US demands for the denuclearization of DPRK programme speaks about "verifiable, irreversible and transparent" measures. Irreversibility means the quality or state of a process so that the dismantled object (f.e. a nuclear warhead) is not being able to be reversed.

20.3 The Dismantlement Process: Challenges and Technologies

Until now, nuclear arms control treaties such as the INF-treaty or New START but also multilateral nuclear treaties such as the Nonproliferation Treaty (NPT) or the Treaty on the Prohibition of Nuclear Weapons (TPNW) do not explicitly define what a nuclear warhead (NW) is.[3] A future disarmament treaty might include a list of identified NWs for the elimination with specific technical characteristics. It is also obvious that a NW is a military device consisting mainly of nuclear material, explosives and incendiary charges in a configuration of producing a nuclear explosion.

[3] For the different linguistic, cultural and technical differences see: [8].

Mostly, NWs are smaller than their carrier systems and not easy to detect. The warhead verification and dismantlement process starts with a baseline declaration by each involved NWS about the numbers and location of all nuclear warheads earmarked for the dismantlement process. Additionally, the type and operational status of a NW might be interesting if the dismantlement process starts at an operational base. (See [4, 35ff]). Inspectors need a list of facilities to be inspected including site diagrams and safety regulations etc. Later on, periodic and updated declarations and notifications would complement the reduction process to get a snapshot of the nuclear stockpile. Basic dismantlement steps across the nuclear weapons lifecycle have been divided in the IPNDV project in 14 key steps (Fig. 20.1). Although the dismantlement of "old and dysfunctional" NW and the destruction of core components of NWs under strict national control is a practised standard procedure in NWS. As a multilateral procedure with inspection teams from multiple countries, this process organized under international control would be a very new challenge for a host state and future inspection teams.

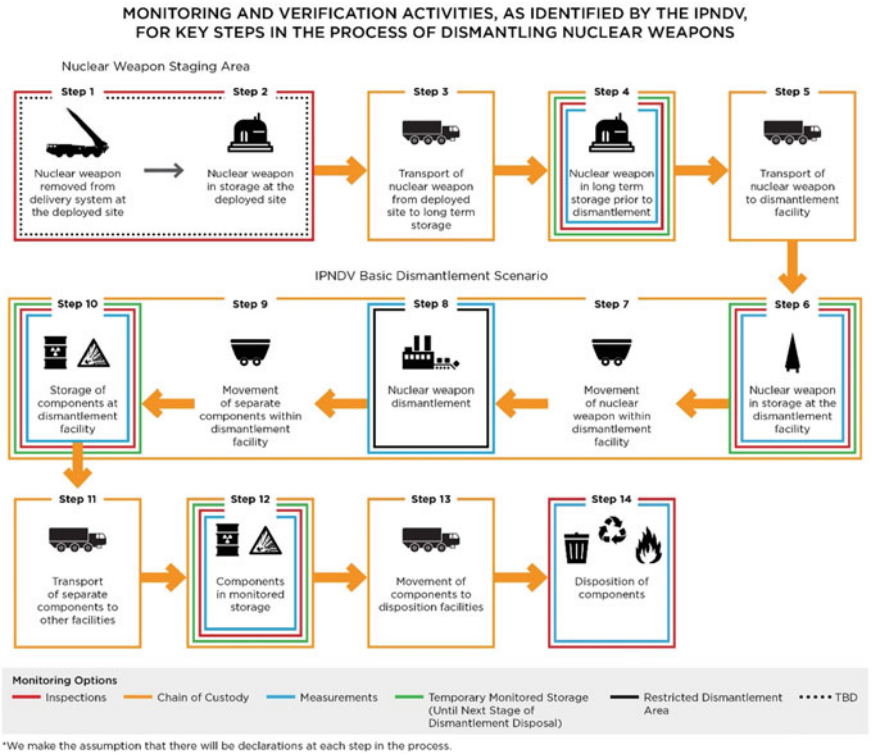

Fig. 20.1 Fourteen steps as identified by IPNDV in the process to dismantle nuclear warheads [11, 9]

At the weapon staging area warheads have to be removed, disabled (step 1) and securely stored at the deployment site (step 2). Then the defunct NW will be transported in special containers and stored in storage bunkers. Inspectors will accompany this process and have to confirm that the warheads have been removed from the delivery system. The use of gamma detectors or neutron radiography has to be negotiated and certified earlier to support the NW authentication which is a complex technical challenge due to the fact that an inspected party does not reveal any secret information about their NWs.[4] The next step (3) is the transport of the warhead from the deployed site to a long-term storage area. The containerized warhead might be transported on a truck in special containers which are sealed or marked by a "unique identifier". Inspectors have to maintain the chain of custody by accompanying the transport. The warheads prior to dismantlement will be stored in long-term storages (step 4). Inspectors can exercise routinely to check the inventory, the integrity of the buildings using seals and monitoring equipment.[5] Step 5 is the transport of the containerized warhead to a dedicated dismantlement facility in which the warheads are stored (6) and later on dismantled (7/8). Such facilities do not exist yet, but these activities can be executed in special disassembly areas close to NW maintenance site. A key objective is here that the inspectors can confirm that each accountable item was dismantled. Thermal neutron cameras or information barriers have been developed and certified to support this process. Nuclear warhead dismantlement is the process of physical separation of high explosives and other components (see Table 20.1) from a nuclear warhead pit and other nuclear materials so that it can no longer produce a nuclear yield. This is a complex technical process. A key question is here how will the inspectors be sure that the disassembled components come from the treaty-limited warhead and not from a dummy device? The warhead components have to be separated, moved (9) and stored (10) at the dismantlement facility under special safety and security regulations. Some components (f.e. High explosives) can be destroyed at the facility or sent to other locations. Other Components can be transported to monitored storages (12) or moved to special disposition facilities (13/14).

Critical questions remain and the challenges for the inspections are not trivial: Inspectors will only see containers entering the facility and other containers leaving the facility all the time. They also cannot be present during the central dismantlement step. Under these assumptions, how do the inspectorate knows the warhead has been dismantled? Special technology assisted verification measures can help here to fulfil the mission steps (see Table 20.2). Verification equipment has to be tested, certified and the operators have to be trained to handle the measurements under a variety of situations and cases. Passive radiation equipment is not foolproof and methods exist to shield detection.[6] After all, the verification has to be accepted by state parties. Fissile material, mostly Plutonium, High-Enriched Uranium in different

[4] See for example: Göttsche and Kirchner [7].

[5] So called "Information barriers" have been developed to analyse the measured radiation data from the warhead without revealing sensitive design information from the warhead.

[6] See Steve Fetter; Oleg F. Prilutski and Stanislav N. Rodionov in: Altmann and Rotblat [1], 58.

Table 20.1 Subcomponents of a typical Nuclear Warhead [23, 37]. (Materials are in bold)

Physics package	Electronic package	Other components
Detonators High Explosives **Beryllium** Depleted **Uranium** **High Enriched Uranium** **Plutonium** **Lithium Deuteride** **Plastic Foam** Neutron Generators Tritium/Deuterium Gas Canisters	**Lead solder and other metals** Thermal Batteries Encapsulating Material Electrical Components **(PCBs)** **Asbestos** Cables	Electromechanical devices Functional Mechanical Devices Electronic Components Electric Cables Parachutes and explosives Nonfunctional Mechanical Parts Residuals: O-Rings, Seals, Fasteners

physical forms could have classified properties and need special verification methods. Radiation portal monitoring can assist to detect the movement of radiation emitting items. Different variation of seals (adhesive, fiberoptics, active) can help to ensure no evidence of manipulation. 3D Surveillance with change detection algorithm can help to monitor sensitive areas. Shea [20] has collected and described several new candidates from R&D such as advanced information barriers, thermal neutron cameras, Zero-Knowledge protocols, verification using nuclear resonance fluorescence and muon verification. Verified dismantlement is only one aspect of a broader disarmament framework (See [6]). Special research on Fissile Material Regimes including stockpile verification is necessary (see [2]).

The full nuclear weapon life cycle consists of important sub-elements such fissile material production facilities, nuclear weapon assembly, maintenance of the stockpile, storage and disassembly sites and disposition. Four broad categories for future disarmament are possible: (1) Reductions of nuclear warheads including the removal and dismantlement of these and the destruction of warhead components. (2) Limitations of nuclear warheads including the elimination of a specified category or type of NWs and the confirmation of remaining operational warheads. (3) The elimination and abolition of a full nuclear arsenal to Zero and (4) maintaining the "zero warhead status" of a then NNWS. Here it has to be made sure that the dismantled nuclear warheads or nuclear cannot be reversed. The application of different verification technologies must have an "adequate confidence" that other NWS have eliminated a specific number of nuclear warheads or the full arsenal over time. Fetter and Oelrich [4, 27] wrote in 2010 that "adequate" means that "the residual uncertainties would be tolerable, taking into account the enforcement mechanism put into place to protect against and remediate cheating and to punish those responsible." Uncertainties in the beginning of a dismantlement process might be acceptable for some time. At the end of such a process each of the nuclear weapon cycle must be subject to inspections or reliable monitoring measures to confirm the irreversibility of such measures. Moving

Table 20.2 Verification tools and techniques that require further research, development and testing [5, 116]

Verification purposes	Examples of verification tools and techniques
Warhead and military fissile materials authentication by attribute and template systems	Gamma spectrometry
	Passive neutron multiplicity counting
	Active methods, such as neutron interrogation, neutron imaging and nuclear resonance fluorescence
	Zero-knowledge protocol systems
Unique identification	Ultrasonic intrinsic tag
	RuBee tag
Continuity of knowledge	Unique identification tools
	Unattended monitoring, for example, using cameras and sensors
	Seals
	Managed access
Measures to verify the completeness of declarations	Nuclear archaeology (past fissile materials production)
	Challenge inspections at suspicious sites
	Open source and intelligence data analyses
	Satellite imagery

closer to global Zero, uncertainties and ambiguities are no longer acceptable for state parties.

20.4 Recent Verification Experiences and Initiatives

Whenever the implementation of disarmament at the political level falters and reaches an impasse, the further development of verification procedures can keep the arms control agenda alive and close technological and conceptual gaps. An example of this is the Group of Scientific Experts (GSE), which met for years in Geneva during the Cold War to further develop cross-bloc verification technologies until the methods were taken up by the Comprehensive Test Ban Treaty with appropriate political support in the 1980s/90 s.

The main component of nuclear disarmament to date has been the deactivation and removal of nuclear warheads from delivery systems or active nuclear storages as part of the bilateral disarmament of the USA and Russia. Within the framework of the INF Treaty of 1987, the complete withdrawal of ground-based medium-range missiles stationed in Europe (i.e. launchers, missiles and support equipment) from NATO and the Warsaw Pact could be verified fully implemented through inspections. Not only new inspection procedures were introduced, but also the monitoring of

the transport of INF missiles from the production sites was supervised. The START treaties made it possible to verify the reduction of strategic nuclear warheads between the USA and Russia through mutual inspections and the use of NTMs, especially with regard to the delivery systems relevant to the treaty [10]. The New START Treaty of 2010 introduced the determination of the exact number of deployed warheads on strategic missiles, including removal or conversion to conventional warheads [19]. Ten inspections can be carried out per year. The use of radiation detection equipment is also permitted for the first time [10].

Especially with regard to the disarmament commitment of the NWS to the NNWS under the NPT, multilateral verification is of great importance. The IAEA's safeguards system has been developed considerably after severe setbacks [16]. Established methods are material accounting, inspections (with "managed access") or technical measures (CCTV, seals, tags etc.). Classical safeguards and inspection procedures, developed and executed by the IAEA can be a powerful tool for future dismantlement scenarios. The JCPOA includes production technologies such as centrifuges and goes far beyond the comprehensive obligations of the Additional Protocol. In addition to the IAEA, the (provisional) monitoring organisation CTBTO was established in Vienna within the framework of the CTBT, which has not yet entered into force. This organisation sets up and operates a worldwide measuring network that makes it possible to detect nuclear weapons tests and to precisely determine the explosive strength and location based on four technologies based on the measurement of seismic signals, radionuclides, infrasound and hydro acoustics. Even though some states are preventing the treaty from coming into force by refusing to ratify it, the technical progress is impressive, has reached a high international standard and has strengthened the taboo on new nuclear testing.[7] In other arms control areas such as in the 1993 Chemical Weapon Convention (CWC) and the 1990 Treaty of Conventional Forces in Europe (CFE) elaborated inspection protocols (f.e. on-site inspections) have been developed and executed.

20.4.1 Historical and Current Initiatives for NDV

In the last decade science-based studies and projects have been materialized.[8] In the "Black Sea Experiment", organized by NRDC and the Russian Academy of Science, scientists were allowed to conduct radiation measurements to determine whether a nuclear warhead was on board of a Soviet nuclear-armed cruiser. As early as 1996–2002, the USA and Russia, together with the IAEA, developed the "Information Barrier concept", among other things, within the framework of the Trilateral Initiative. In 2002 a UK-US Project started to discuss and elaborate issues of reciprocity, intrusiveness and managing access for foreign personnel. In recent years, several initiatives and projects by individual states have begun to discuss and

[7] See for an overview Göttsche et al. [5], 2.

[8] See f.e. the seminal books by Tsipis and Hafemeister [22], Altmann and Rotblat [1] or OTA [23].

to expand the technical and procedural basis of nuclear disarmament verification (NDV) (see Table 20.3). Norway and the UK opened the cooperation of a NWS with an NNWS, showed the possibilities of deepened technical cooperation, and conducted three interesting exercises on "Managed Access" between 2008–2010. It also underlines that a NNWS can do research for identification technologies such as "tags and seals".

In 2014, the US State Department and the Nuclear Threat Initiative initiated the "International Partnership for Nuclear Disarmament Verification" (IPNDV), in which 25 states cooperate in working groups to develop the technical foundations of nuclear disarmament verification (see for details: [9]). The scope ranges from innovative technological methods to the concrete organisation of inspections and declarations, the training standards of international inspectors and future disarmament scenarios. While in the first phase IPNDV dealt in detail with the various aspects of monitoring and verification of the 14 steps from warhead separation and dismantling to transport, the second phase focuses on practical exercises. For example, a joint exercise was conducted in 2019 and 2022 at the Jülich Research Centre, which was jointly organised by France and Germany. In the report of the 1st phase, it was agreed

Table 20.3 Major projects and exercises related to international collaboration on NDV (based on Göttsche et al. [5], 113)

Project	Research areas	Results/remarks
Trilateral Initiative (Russia, USA, IAEA)	Information barrier development, inventory monitoring systems	Cooperation between two nuclear weapon states, IAEA
US–UK cooperation to address technical challenges in verification of nuclear disarmament	Managed access, measurement technologies, information barrier development, chain of custody	Two exercises in the UK 2002 and the US in 2006
Pilot Verification Project (Nuclear Threat Initiative NTI)	Proposals for: baseline declarations, global verification capacity, societal verification	Multinational cooperation
United Kingdom—Norway Initiative (UKNI)	Managed access, information barrier development, confidence in verification processes	Strating 2007 for the Cooperation between a NWS and NNWS
International Partnership for Nuclear Disarmament Verification (IPNDV)	A forum for partner states to develop the technical and procedural foundations of NDV	Since 2015 (25 states including 5 NWS)
QUAD Nuclear Verification Partnership by the USA, United Kingdom, Norway, Sweden	Simulation Exercise LETTERPRESS in October 2017 to provide a testbed for monitoring and evaluation. Logistics, Communication, and training of a NW removed from an operational base	Cooperation and exercise between two NWS (US-UK) and two NNWS (NOR-SWE)
NuDiVe: French-German Exercise 2019 and 2022	Two practical exercises at the Research Center in Jülich	Experiences to assess chain of custody concepts to check the diversion risks

that "safety and security, non-proliferation and classification aspects can be successfully addressed in a future nuclear disarmament agreement" [11]. Even if IPNDV cannot solve the arms-policy deadlock, systematic technical work by the international community is needed to develop new implementable verification concepts and tools. Whether it is the verification of a limited number of warheads, a full arsenal of warheads or associated production facilities, in the international context this disarmament process must be accompanied reliably, credibly and efficiently by international inspectors. IPNDV is already contributing to confidence building between NWS and the NNWS, strengthening networking and opening up new questions that have been overlooked so far. It also clearly shows which states are interested in progress in disarmament verification. International disarmament verification also includes research groups from civil society (e.g. VERTIC or NTI) or academia (Princeton, MIT, King's College, U Hamburg, RWTH Aachen, etc.). It is desirable and necessary that more states participate in research and development. A report of the EU Non-Proliferation Consortium worked out a list of recommendations which can be picked up by the European Union to strengthen NDV research and developments [5].

In 2017 a UN Group of Governmental Experts (UN-GGE) started its work based on the UN Resolution (A/RES/74/50) in Geneva to further considering verification in advancing nuclear disarmament, on a basis of equitable geographical representation.[9] The final report A/74/90 underlines that "there is a need for a continued international examination of the issue in all its aspects, including verification". All these activities show that, despite the reluctance of some states to disarm, there is a growing desire that credible and reliable verification of disarmament against the background of central principles such as non-proliferation, security or irreversibility requires further analytical work, in which other states, civil society and the scientific community can continue to make important contributions. Better networking of the growing community would certainly be useful. It is also clear that future disarmament treaties require different specified verification tools and procedures.

20.5 Requirements from the NPT and the TPNW: Different Scenarios and Challenges

Despite the global disappointment with the lack of progress on nuclear disarmament and the rapidly deteriorating political climate, it is in the interest of disarmament advocates that adequate verification solutions are further developed, tested and institutionalised to achieve more confidence and certainty in the reduction and eventual elimination of today's overly large global arsenals. Feasible verification is of utmost importance for both, the classical Non-Proliferation Treaty (NPT) and the Treaty on

[9] The 25 Members are the classical NWS plus India and Pakistan, from America (Canada, Argentina, Brazil, Chile, Mexico), Australia, from Africa (Algeria, Egypt, Jordan, Nigeria, South Africa), from Asia (Kazakhstan, Japan) and from Europe (Germany, Hungary, Northern Island, Romania, Sweden).

the Prohibition of Nuclear Weapons (TPNW), also with regard to a world without nuclear weapons. The NPT under Art VI connects verification with "a treaty on general and complete disarmament under strict and effective international control", which can only be reached by realistic and intrusive verification measures. The verification of existing treaty provisions starting with the usual safeguards obligations, the Additional Protocol or special inspections by the IAEA are equally necessary. A future Fissile Material Treaty (FMT) also can lay the foundation of verifying and monitoring special weapon-related fissile materials, which are released after the dismantlement. The NPT Safeguards Regime (incl. NSG etc.) and the TPNW Verification measures overlap as well as a future "Fissile Material Control Regime" (not yet existing). With regard to the TPNW, it must be ensured that a state has eliminated all its nuclear weapons, production facilities and weapons-usable material. Finally, in a world without nuclear weapons, it must be guaranteed that no state possesses clandestine stockpiles of weapons-grade material or nuclear weapons and that it maintains a state of nuclear-weapon-free status.

Whereas the NPT from 1970 and its eleven articles do not call for or regulate the destruction of NWs, the Treaty on the Prohibition of Nuclear Weapons TPNW calls in article 2 and 4 for the verifiable, time-bound, transparent and irreversible elimination of the state party's nuclear programme. Key is article 1 which determines that "*Each State Party undertakes never under any circumstances to: (a) develop, test, produce, manufacture, otherwise acquire, possess or stockpile NWs or other nuclear explosive devices*".[10]

If a nuclear-armed state decides to give up its nuclear programme to become a state party of the TPNW, it is committed to immediately remove their "nuclear weapons or other nuclear explosive devices "*from operational status, and destroy them as soon as possible but not later than a deadline to be determined by the first meeting of States Parties, in accordance with a legally binding, time-bound plan for the verified and irreversible elimination of that State Party's nuclear-weapon programme, including the elimination or irreversible conversion of all nuclear-weapons-related facilities.*" (Art 4.2). Also, no later than 60 days after the entry into force of the Treaty for that State Party the State Party, shall submit a "plan to the States Parties or to a competent international authority designated by the States Parties."

The TPNW says in Article 4.6: "*The state parties shall designate a competent international authority or authorities to negotiate and verify the irreversible elimination of NWs programmes, including the elimination or irreversible conversion of all nuclear weapons-related facilities in accordance with para. 1, 2, and 3 of this article*". Such an International Authority shall report the elimination of the nuclear programme or the "*irreversible conversion of all nuclear-weapon related facilities to the state parties*". (Art. 4.1) The TPNW might need an independent verification regime or a new verification organization as well as inspections, protocols and technologies to

[10] The TPNW was adopted by a UN Conference on 7 July 2017 (by a vote of 122 States in favour, with one vote against and one abstention and opened for signature by the Secretary-General of the United Nations on 20 September 2017. Following the ratification of 50 countries, it entered into force on 22 January 2021. In May 2022, the TPNW has 61 parties: 58 states have ratified it, and another 3 have acceded to it. See: https://treaties.unoda.org/t/tpnw.

achieve its goals. Tom Shea has elaborated details of such an "*International Nuclear Disarmament Authority*" *(INDA)* in details [20, 21ff].

The TPNW requires that each nuclear-armed State Party which becomes a TPNW member first has to eliminate its nuclear inventory, second eliminate, or irreversibly convert its nuclear weapon facilities to a peaceful use and then has to commit to never again produce nuclear weapons (long-term and continuous). Kütt and Mian estimate that the weapon destruction of a nuclear programme can be achieved in less than ten years "if they gave this task priority" [13, 426]. The conditions for the destruction of the military stockpile are easier for a state which gives up its nuclear weapon status in one step entirely but needs much preparation, openness and political hedging. Scenarios with step-by-step roadmaps for the dismantlement of only parts or with high numbers of warheads and limited dismantlement capability while still preserving operative nuclear weapons at military bases will need more time and efforts.

The TPNW stipulates that these undertakings will and can be verified to confirm that NWS Parties abiding by the treaty obligations which includes to maintain the NNW status. Most of the member states of the TPNW are Non-nuclear weapon states. So it is easy for them to fulfil the conditions to become a member of TPNW without any destruction requirements. They have neither nuclear weapons or other nuclear explosive devices nor a nuclear military-related infrastructure on their territory. This can be ascertained also by their NNWS status of the NPT. Another case is the removal of non-nuclear weapon hosting states. The maintenance cycles of deployed nuclear weapons with special aircraft and transportation facilities are common practice, so that the quick removal of warheads to the nuclear possessor state can be done in a very short time. The measurement of absence of nuclear weapons would be also easier than the dismantlement under multilateral control. The capability of states for this enterprise is very varying depending on the resources, political will and technical expertise. A recent study by the U.S. National Academies of Sciences, Engineering, and Medicine came to the conclusion that "the United States needs a sustained and integrated monitoring, detection and verification program that stewards capabilities; meets future technology, operations, and capacity needs; and minimizes surprise." [15, 1].

20.6 Conclusions

It can be concluded that Nuclear Disarmament Verification (NDV) is a complex technical and legal enterprise if the dismantlement and destruction of nuclear warheads is serious and enshrined in future nuclear reduction treaties. Key principles are non-proliferation, disarmament obligations, safety and security, irreversibility, transparency. They have to be accepted and negotiated by all member states of such a treaty. There are technologies available for different NDV steps which can help to reach the different verification objectives, f.e. to maintain the chain of custody and the managed access to sensitive areas. More R&D in the context of the civil society,

science and diplomacy to assist the NDV processes under the NPT and the TPNW. A way forward for the NPT is a commitment by the P5 members to abide by Art. VI, putting a cap on the existing nuclear warheads and start working on a verification, monitoring and dismantlement regime. If a NWS state enters the TPNW there are three key phases necessary: a comprehensive baseline declaration of its nuclear inventory and a roadmap to eliminate the arsenal "under strict international control". This includes the elimination or irreversibly conversion of its NW-related facilities to peaceful use and an accounting and storage system for the fissile material. The last criterion is commitment never being capable to produce nuclear weapons which makes inspections necessary at all locations in a country and the capability of an international authority to monitor and verify such verification objectives.

For future disarmament scenarios, regional or global verification regimes adapted to the respective object of the treaty must be designed, tested and trained. This requires technological measures, comprehensive inspections or selective methods such as suspicion inspections as well as concepts such as "social verification" or a combination of all these elements. All this can only be worked out, tested and implemented through the joint efforts of civil society, politics and science. More work is needed in the years to come to prepare future disarmament scenarios.

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Chapter 21
Preserving and Updating Strategic Stability

Alexey Arbatov

A number of justifications of the special military operation launched by Russia on February 24 2022 are officially put forward. Political scientists would put it prosaically: the essence of the military operation is to using force to return Ukraine to the sphere of influence of Russia, in which it has been for about three and a half centuries—from the Pereyaslavskaya Rada (1654) to the Belovezhskaya Pushcha (1991). There is no doubt, that a great tragedy is unfolding: Russia has lost thousands of soldiers and officers killed and wounded, and Ukraine—even more, a lot of civilians are dying, destruction of economy and environment is expanding.

Moreover, the threat of nuclear weapons employment entered the picture from the very beginning. The president of the Russian Federation clearly meant it in his speech on February 24, and gave an order to bring the deterrence forces into a special mode of combat duty just a couple of days after the launch of the offensive operation. This was a warning to the West not to interfere in the Russian military actions in Ukraine, although the United States and NATO have repeatedly stated that they would not get directly involved in hostilities.

As stated by Putin, it was a response to economic sanctions and aggressive statements by some Western leaders addressing Russia. Russian Military Doctrine supposes the possibility of using nuclear weapons only in two cases: firstly, in response to an attack on Russia and its allies using nuclear and other weapons of mass destruction, and secondly, in response to aggression with conventional weapons, which threatens the very existence of the Russian state itself. The Doctrine does not mention aggressive rhetoric or economic sanctions.

Of course, the doctrine is not a dogma, and the president has a broad leeway in authorizing the use of nuclear weapons. He is limited only by military-technical capabilities, which are determined by the fact that neither the United States nor

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Russia can strike the other side first and prevent its destructive response. For good reason, the five leading nuclear powers in January 2022 adopted a declaration, which again declared that there could be no winners in a nuclear war, and it should never be waged.

No question, there is a long distance from increasing the combat readiness of strategic forces to their launch. However, if the other side responds in the same way, then the strategic resonance of steps to gear up for war may quickly overcoming this distance with all of the consequences. With all the acuteness of the current confrontation in and around Ukraine, nuclear weapons should remain "outside the brackets" of the problem.

Still there are many scenarios of inadvertent escalation in the course of hostilities in Ukraine. Such are the consequences of Russia's strikes at communications and storages of arms delivered to Ukraine, which may expand to NATO territories. Another trigger may be Ukraine's strikes at the Russian Navy and territory (foremost at the targets on the disputable Crimea peninsula). It is also the introduction of NATO no-flight-zone in the Ukrainian airspace. In conditions of multi-front active combat actions, all kinds of military accidents are probable between Russian and NATO, which might be a spark in the powder keg.

Hence, even before reaching agreement on ceasefire in Ukraine, Russia and NATO should observe some unspoken rules of conduct and establish reliable channels of communication between military commands to prevent horizontal and vertical escalation of the armed conflict. This is a must, despite the desire of Ukraine to fight Russia back, or the wish of the West to punish Moscow, or the determination of Russia to assert its geopolitical aspirations. If escalation is prevented—the peaceful settlement will follow eventually. If not—everything else, including the fate of miserable Ukraine, Russia and the West will be catastrophic.

There can be only one way out—the political resolution of the conflict. The main task now is to immediately agree on a ceasefire and begin massive humanitarian assistance to the civilian population of Ukraine.

Further peaceful settlement will be a long and difficult process and will require international mediation. Its main elements are: Ukraine legally accepts the status of a neutral non-nuclear state, and this is recognized in the UN and the OSCE; it commits not to join military blocs and not to permit the deployment of foreign armed forces and nuclear weapons on its territory. In response, the international community recognizes and guarantees the territorial integrity within negotiated borders, sovereignty of Ukraine and respect of its statehood. Thereafter, follows the restoration of the destroyed, compensation to the victims, investigation of war crimes, the lifting of anti-Russian sanctions, and the resumption of relations between Russia and the West, including arms control process and regimes.

It seems that recently Moscow no longer raises the question of a change of government and full control of the Ukrainian territory, but demands recognition of the status of Crimea, the DPR and the LPR, as well as guarantees of the neutral status of Ukraine. Kiev is also shifting its position: it has "cooled down" to the idea of joining NATO and is ready to discuss the future of the above territories. Up to now, negotiations at various levels have been fruitless. As the experience of such conflicts shows, even a

ceasefire agreement is difficult to achieve if the parties still have hope of winning or at least gaining advantages on the battlefield to strengthen their position in subsequent negotiations. A full peaceful settlement can take years.

However, eventually the restored European security should be an indivisible whole for all OSCE countries, of course, including Russia and especially neutral states: Ukraine, Georgia, and Moldova. The NATO and CSTO alliances should not prepare to fight each other, but rather reduce and limit their armed forces and military activities by treaties, exclude the use of force against each other, prohibit medium-range missiles, and continue the process of reducing nuclear arms and strengthening strategic stability. They should cooperate in the fight against international terrorism, armed extremism, and other common threats in Europe and beyond.

Chapter 22
Present Nuclear Dangers

Paolo Cotta-Ramusino

The present global situation is full of dangers. The world has probably not known a similar dangerous environment since the Cuban Missile Crisis of 1962. But while that crisis lasted 13 days, the war in Ukraine, which is at the heart of our present dangerous situation, has been going on for about 140 days, since February 24. And there is at present no sign that the war will end soon.

Several factors lie at the origin of this war. The history of relations between what is now Ukraine and Russia is complex. Let us just recall some past causes of antagonism between Russia and Ukraine, such as the death of 4 (or more) million Ukrainian kulaks during the Stalinist period, and the support that some Ukrainians gave to the invading German troops during WW 2.

More recently, the antagonism between Russia and Ukraine was revived following the 2013 Euromaidan demonstrations protesting the government's decision to postpone the signature of the EU-Ukraine Association Agreement (resulting in the deaths of demonstrators, policemen and ordinary people), which Russia had tried to boycott in various ways. This also stimulated a growing antagonism between the Russian- and Ukrainian-speaking populations. A separatist movement in the eastern Russian-speaking part of Ukraine (the Donbas) was generated, and was repressed by the Ukrainian government. According to the UN, between 2014 and the end of 2021, altogether more than 14,000 people were killed in the Donbas region.

Paolo Cotta Ramusino: Secretary General of Pugwash Conferences on Science and World Affairs.

This article draws heavily on the Pugwash Note written by Amb. Sergio Duarte, President of Pugwash, and myself. Of course, the responsibility for what is written here rests only with me in my personal capacity.

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The Euromaidan demonstrations promoted a change in the leadership of Ukraine. President Yanukovych (linked to Russia) was induced to leave Ukraine, and a new Ukrainian leadership emerged (President Poroshenko) that promoted the Ukrainian language over Russian, strict connections with the European Union and the West in general, and later, even the separation of the Ukrainian church from the Moscow Patriarchate.

The annexation of Crimea by Russia in 2014 also raised very serious problems in Ukraine.

NATO's eastward expansion—which reached many countries bordering Russia, despite the informal mutual assurances given at the end of the Cold War between Russia and US—is also an important cause of concern in Russia. Russia is obviously worried not only about the loss of its "external zone of influence," but also about its very own integrity. Russia has 85 federal subjects including 22 Republics. Many languages are spoken in Russia. The concern here was, and is, the possible separation of these various federal subjects and the possible fragmentation of Russia stimulated by anti-Russian movements inside the former Soviet States.

On 24 February 2022, Russia invaded Ukraine. The goals initially mentioned of this invasion have shifted from forcing a new leadership in Ukraine to the occupation of the Donbas and part of the Ukrainian Black Sea shore. Understanding the Russian motivations is possible, but this is of course very different from justifying in any sense this attack. By signing the Charter of the United Nations, all states committed to refrain from the threat or use of force against the political independence and territorial integrity of any other state.

The Russian invasion of Ukraine has been certainly catastrophic for the Ukrainian population. It is now hard to assess the number of civilians and soldiers from both sides that have been killed in Ukraine since February 24, 2022. Approximate estimates of casualties are 10,000 civilians and several tens of thousands of soldiers. Ukrainian cities have been destroyed. Besides the tragedy for the Ukrainian people, concerns have been raised about the increase of tensions between Russia and most NATO countries.

Some issues:

1. NATO countries, and particularly the US and the UK, are actively providing weapons to the Ukrainian army. Since the understanding is that these weapons should possibly not be used against the territory of Russia, the continuous shipping of weapons to Ukraine has resulted in enabling the Ukrainian army to better resist the invasion on its own soil, but with the consequence of extending the duration of the war, destroying several Ukrainian cities, reducing agricultural and industrial output, endangering nuclear power plants, and increasing the number of casualties.
2. Possibly eight million Ukrainians have fled to neighboring countries and more are displaced within Ukraine itself.
3. Countries possessing nuclear weapons—particularly Russia, US and UK—are directly or indirectly involved in the war. If the tensions inside Europe grow, the risk of nuclear use cannot be excluded. This would be an unprecedented disaster.

Nuclear deterrence is believed to have been relevant, during the Cold War, for the absence of a war in Europe, but this can no longer be taken for granted. The danger of an escalation of hostilities toward the possible use of nuclear weapons is serious. Finding a workable solution is urgent, starting with a quick ceasefire.

4. The immediate consequences of the war in Ukraine are evident. In particular heavy combat is poisoning the environment and destroying the crops of grain that provide food for many parts of the world.
5. Many other aspects of the global economy are heavily affected by the war in Ukraine. The energy supply (gas and oil) for European countries is under serious constraints, inflation has crept up in most states, and there are many other negative consequences. All countries involved should work together to offset the global impact of this war, but this will not be easy.
6. The longer the war continues, the higher the risk of escalation and the closer the world would move towards the nuclear threshold.

The consequences of the war in Ukraine may also include some important negative consequences concerning nuclear proliferation. Other countries may think that if Ukraine had kept the nuclear weapons that had been located inside its territory at the time of USSR, then Russia would not have dared to attack Ukraine. Some European NATO countries (like Poland, the Baltic Republics, etc.) might consider asking the US to deploy nuclear weapons on their territories as the US is doing in Italy, Germany, Belgium, Netherlands, and Turkey. And this could possibly induce Russia to do the same, say, in Belarus.

The present nuclear risks are unfortunately not only limited to the direct consequences of the war in Ukraine.

The Iran nuclear deal (JCPOA) seems, as we write, very difficult to restore, and this is inducing Iran more and more to take the path of further developing its nuclear program. What Israel will do is also a matter of serious concern.

In South Korea and Japan, proponents of a national nuclear capability have become more vocal.

Military activities in Northeast Asia between the Koreas, the US and Japan are also a source of concern. The DPRK is obviously believing that the acquisition of nuclear weapons increased its security.

The situation regarding China, the US and Taiwan is also very worrisome. The actions and the rhetoric of the parties involved are far from reassuring.

Moreover we must always bear in mind that both India and Pakistan possess nuclear weapons and that their mutual antagonism (e.g. on the issue of Kashmir) is still very strong.

More generally, the whole architecture of security based on the Charter of the United Nations and on multilateral and bilateral treaties and other arrangements is endangered.

Peace and security are common goods: no country can feel safe and secure unless all feel the same.

In summary what could be done?

a. Promote the widest possible awareness and understanding of the present nuclear dangers;
b. Promote in particular the end of the war in Ukraine with reasonable compromises and respect for the various regional diversities, taking into account the legitimate security concerns of the different parties. The war will not be solved by further shipments of weapons but by talking and establishing effective and quick negotiations;
c. Support an urgent ceasefire in Ukraine that would permit meaningful negotiations and the start of the reconstruction of the devastated country with international help;
d. Support in all possible ways the restoration of the JCPOA;
e. Facilitate the dialogue between China and other countries about Taiwan, in order to preserve the scheme of one country with two different political systems;
f. Work for dialogue and possible cooperation between South and North Korea and, more generally, promote stability and dialogue in Northeast Asia.
g. Facilitate continuous dialogue in South Asia between India and Pakistan.

These are not at all easy tasks, but we have to remind ourselves, every single day, that nuclear danger is not an abstract concern but a dramatically serious problem that affects the entire international community.

Chapter 23
Sesame: From a 2022 Personal Point of View

Eliezer Rabinovici

- For the 20I5 Amaldi Conference proceedings I had contributed an abridged report of the detailed presentation I had given on the history of SESAME (**S**ynchrotron-light for **E**xperimental **S**cience and **A**pplications in the **M**iddle **E**ast). For a more detailed account than in the 2015 proceedings, see my personal point of view published in *Int.J.Mod.Phys.A* 32 (2017) 08, 1,741,008.

SESAME is a regional "third-generation" synchrotron light source situated in Allan, Jordan. In 2015 I stated that it will be the Middle East's first major international research center and that it is expected to become operational during 2016/2017. Indeed by 2017 the operations had started. After an even briefer introduction (mostly based on 2015 contribution) I shall describe the developments in SESAME and its vision that have occurred since. Given the 2022 events in Ukraine I shall also make some comments on them in the SESAME context.

The current Members of SESAME are Cyprus, Egypt, Iran, Israel, Jordan, Pakistan (Pakistan has taken a step back), Palestine and Turkey. Active current observers include among others: The European Union, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America.

At the risk of sounding somewhat carried away I will say that the vision driving the many persons who have contributed to this project is the belief that human beings can work together for a cause that furthers the interests of their own people and that of humanity as a whole.

Scientists of all nations have a common language—science and many of them have a track record of participation in successful international collaborations such as those at CERN. Scientists are neither better nor worse than other human beings, but given the privilege of knowledge it is our duty to try our best to be a bridge for

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understanding—Science for Understanding. I prefer this terminology over the slogan Science for Peace. During my life I have found the cause of achieving the so-called "just and lasting peace" leading to much more bloodshed than more peace.

The 2015 contribution ended by describing how an Israeli initiative followed by Jordan, Iran and Turkey revived SESAME. The follow-up financial contribution of Italy under the leadership of Professor F. Ferroni and a crucial intervention of Rolf Heuer the then Director led finally to the EU supporting the SESAME project.

The essential EU support was led by the commissioner Carlos Moedas, as well as I. Smith and B. Fabiane. This was a watershed period for SESAME. The threshold between a dream and reality was now irrevocably crossed.

In the period 2015–2017 the hardware needed for SESAME was designed and assembled by joint CERN/SESAME teams at CERN.

It was gratifying to see the excitement of those members of the teams, not just from the region involved. Their eyes were literally shining when they reflected on the value of what they were doing.

The components were then shipped to SESAME, this time not to be stored in boxes, as the old German machine is, but to become the backbone of a modern light source.

The pace of events had finally accelerated, a star-studded inauguration (including among many others the DGs of CERN, UNESCO, Israeli science ministry, the king of Jordan, the EU commissioner of research), this time a real one as far as the machine is concerned. In the ceremony, amazingly, the political delegates of different member states listened to each other without leaving the room (as is the practice in other international organizations) and what was even more unique was that each member state delegate taking the podium gave essentially the same speech. As if for once they all instructed their speech writers to say the same thing, namely, "We are trying here to achieve understanding via collaboration".

At that moment the baton was passed from one ex-DG of CERN—Chris Llewellyn Smith to another, Rolf Heuer. The Sesame Council is the only world Organization (except CERN) which benefitted from the fact that all its Council President were ex-DGs of CERN.

This with two beamlines running on a shoe-string budget, but running nevertheless. SESAME started producing science. From my point of view, I noted that first time ever, Israeli scientists did high quality research at a facility established on the soil of an Arab country, Jordan.

This unique facility started operating in uncanny normality. Proposals for experiments were submitted, refereed, and spots were allocated to the experiments chosen. Data was gathered, analyzed, and the results were and are being published in first-rate journals.

Thanks to the help of the EU, SESAME was to become the FIRST green light source, its energy generated by solar power. This also had the added bonus of stabilizing the energy bill of the machine.

Then came Covid-19 and the challenge to operate a machine in such circumstances. SESAME's handling of the situation was second to none.

As we are coming out of the present Covid period so has SESAME.

More experiments performed and more papers in all fields of science published. Myself I was elected for the second time as a Vice-President of the SESAME council. Under the Presidency of Heuer we streamlined the council meetings and started dealing in earnest with the issues that any light source faces. Science brings a semblance of normality even to our region.

A third beam line is now being added and plans for more are at advanced stages. There is concern that the only component used from Bessy, the Microtron, may break down, thus endangering the operation of the whole machine. We continue to operate on a shoe-string budget marveling at the ingenuity of the SESAME staff and being sad about the seemingly budget indifference of many of the parties involved. World Media was less indifferent: the BBC, New York Times, Le Monde, Washington Post, Brussels Libre, The Arab Weekly as well as regional newspapers and TV stations did cover various aspects of SESAME.

The AAAS has highlighted the significance of SESAME by recognizing five founding fathers of SESAME and awarding them the AAAS prize For Science Diplomacy. They are Chris Llewellyn Smith (UK, CERN), Eliezer Rabinovici (ISRAEL), Zehra Sayers (TURKEY), Herwig Schopper (GERMANY, CERN) and Khaled Toukan (JORDAN).

I shall now allow myself to propose some headlines befitting SESAME.

> So far, the drive of the scientists and many others has taken their governments to a place they most likely never dreamt to be at.
>
> And… so far… the governments did not blink.

Maintaining this attitude in a stormy political environment is very difficult and not enough appreciated and yet, one miracle was achieved. One has shown that the people in the region can work together for their own benefit and the benefit of humanity. However, "from now on SESAME will be judged more and more by the quality of the science it produces". High- quality science requires appropriate funding and help. SESAME needs them. My dream is that in the not so distant future people will be able to point to a significant discovery and say "This was discovered at SESAME".

Writing this in June 2022 I need to make a comment on the impact that the invasion of Ukraine by the Russian Federation had on CERN.

Here I mean the impact it had on holding on to the vision and human mission of CERN.

In many ways SESAME is a very special child of CERN. Sometimes we find that our children can teach us important lessons.

As President of the CERN Council in 2022 I can say that the way in which the member states of SESAME conducted themselves during the decades of storms that affect our region can now serve as benchmark of how to keep bridges for understanding under the most trying circumstances. The SESAME spirit (so far) being a lighthouse even to the CERN Council.