Options for International Cooperation under Article X of the Biological and Toxin Weapons Convention

Under Article X of the Biological and Toxin Weapons Convention (BWC) states parties:

'… undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the use of bacteriological (biological) agents and toxins for peaceful purposes. Parties to the Convention in a position to do so shall also cooperate in contributing individually or together with other States or international organizations to the further development and application of scientific discoveries in the field of bacteriology (biology) for prevention of disease, or for other peaceful purposes.'

The article also states:

'(2) This Convention shall be implemented in a manner designed to avoid hampering the economic or technological development of States Parties to the Convention or international cooperation in the field of peaceful bacteriological (biological) activities, including the international exchange of bacteriological (biological) agents and toxins and equipment for the processing, use or production of bacteriological (biological) agents and toxins for peaceful purposes in accordance with the provisions of the Convention.'

Article X appears to have received little attention during the construction of the Biological and Toxin Weapons Convention (BWC). However, as the Convention has evolved Article X has become increasingly important to many states, to the extent that progress in the Eighth

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Trust & Verify

Autumn 2016 • Issue Number 154 • ISSN 0966–9221

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Review Conference in November 2016 will be dependent on a balanced package of measures, including measures that attend to this article.

Accordingly, this short paper outlines some options for improving the implementation of Article X that states parties may wish to consider at the Eighth Review Conference. The paper begins by outlining the origins and evolution of Article X over the course of the BWC's history. It then proceeds to discuss the changing expectations of states from this article (and the limits of what can realistically be expected) before presenting some options to move Article X forward, based on activities undertaken in other fields.

Origins and evolution of Article X

It has long been recognised that the agents, equipment and materials required for biological warfare are dual-use, in that they could be applied for both peaceful and hostile purposes. Early efforts towards the integration of a provision on peaceful purposes in biological disarmament measures can be seen in Article X of the Socialist states' Draft Convention on Bacteriological (biological) Weapons from March 1971. The language in this early Soviet proposal drew, in part, from Article IV of the Nuclear Non-Proliferation Treaty. The language was kept mostly unchanged in subsequent drafts, except for the addition of text from Neutral and Non-Aligned states 'directed towards the promotion of co-operation' in August of 1971. The Article appears to have been 'generally found constructive' with little to suggest it proved divisive. The US Ambassador to the Committee on Disarmament said at the time that he believed the '… article, perhaps more than any other, reflects the basic objective of our negotiations: to turn scientific efforts from the paths of destruction to the service of mankind'.

However, as early as the First Review Conference, expectations over the function and focus of Article X began to diverge. This divergence was compounded by changes in the perceived value of biotechnology, creating a growing sense of division around Article X. The situation improved little during the 1990s with Article X becoming one of four 'equally important' areas that were increasingly divisive during the Ad Hoc Group (AHG) negotiations under the Convention.

Since the conclusion of the work of the AHG, Article X has continued to prove divisive. At the Sixth Review Conference, proposals for Article X and Article IV Action Plans effectively cancelled each other out. The Seventh Review Conference saw a repetition of 'well-known points of conflict', with Western states seeking to narrow the focus of the Article around disease-related activities, and others (principally from the NAM) attempting to broaden its focus.

Expectations under Article X

As such, the passage of time has generated a divergence of expectations around the focus and function of Article X. Regarding the function, an AHG 'friend of the chair' paper argued that the language can be interpreted as having a 'promotional aspect and a regulatory aspect'. The NAM has increasingly emphasised the promotional aspect of Article X, while some other states have emphasised the obligation to avoid hindering international cooperation and/or technology transfer. Regarding the focus, as Table 1 illustrates, the range of activities specifically linked to Article X has grown considerably as the convention has evolved. Notably, through internal or external activities many of these measures have been taken forward. The Seventh Review Conference agreed on a database system to facilitate assistance requests and offers. World Health Organization activities, such as the implementation of the International Health Regulations, have advanced global disease monitoring. The rise of the internet (as well as the recent trend towards 'open access' publications) has to some extent facilitated a greater international exchange of information.

A dose of realism

It is not unreasonable for states - particularly those untroubled by the threat of biological weapons but facing very real challenges from natural disease outbreaks - to expect some form of incentive for signing and ratifying the BWC. However, there is also a need for a dose of realism in expectations surrounding Article X. First, for many the BWC is not a development treaty, but a disarmament agreement intended to build security through the prohibition of a particular means of warfare. Moreover, there are already several cooperative activities taking place outside the convention that should not be duplicated. Second, as successive review conferences have pointed out, the private sector plays an important role, with technology frequently under control of private industry, not states. Third, the literature on technology transfer and capacity development points to the importance of recipient states' capacity. Making the most of cooperative activities requires effort on the part of the recipient, such as the provision of political will, institutional resources and the development of skills, competencies and a suitable environment to effectively absorb technology transfers. Finally, as noted during the AHG, any attainable measure for Article X must be reasonably inexpensive, easy to implement and not require disclosure of intellectual property.

Options for Article X

While there is a need for realism, it is also apparent that progress at the Eighth Review Conference will require a balanced package of measures, and the implementation of Article X will form a significant part of that balance. Accordingly, what follows is a series of ideas taken from past BWC proposals and other international agreements. These are intended as 'balanceable' food-for-thought for those seeking options in this area.

Measure	RC1	RC2	RC3	RC4	RC6	RC7
Increase/promote scientific and technological co-operation	•	•	•	•	•	•
Transfer and exchange of information	•	•	•	•	•	•
Training of personnel/capacity building	•	•	•	•	•	•
Transfer of materials and equipment	•	•	•	•	•	•
Background materials on Article X (by UN Secretariat or ISU)	•	•	•	•	•	•
Active promotion of contracts (including by ISU)		•	•	•	•	
Greater co-operation in international public health/disease control		•	•	•	•	•
Coordination through UN system		•	•	•	•	•
Co-ordination/improvement of national & regional programmes		•	•	•	•	•
Bilateral, regional and multi-regional agreements related to disease		•	•	•	•	•
Institutional ways of ensuring multilateral cooperation		•	•	•	•	•
Inclusion on the agenda of a relevant United Nations body		•	•	•		
Information on implementation of Art X to Secretary-General/ISU			•	•	•	•
Participation of/measures by specialised agencies			•	•	•	•
Information, assistance or communications on disease surveillance & detections systems			•	•	•	
Establishment of a world data bank			•	•		
Study of the influence of enhanced radioactivity on microorganisms			•			
Programme or promotion of vaccine development including public-private partnership			•	•	•	•
The promotion of programmes for the exchange and training of scientists and experts				•		•
Develop emergency and disaster management plans					•	•
Review national regulations on exchanges and transfers						•
Capacity-building, in biosafety, biosecurity, disease detection, reporting and response.						•

Article X reports

Some states parties have submitted information on Article X activities either as background for Review Conferences or during Intersessional Process meetings (see for example BWC/MSP/2015/INF.2 and INF.2). At the Seventh Review Conference, such national submissions averaged fewer than two and a half pages in length. Their content ranged significantly from short statements on compliance with Article X, to longer illustrative lists of relevant activities, to statements and proposals for Article X-related activities and mechanisms. If these reports are considered as potentially useful, a common format for such reports—potentially adapting prior work in the AHG (see BWC/AD HOC GROUP/WP.350)—could be developed to generate more concrete and consistent data. This data could include what states are doing in respect to Article X, and could identify particular needs of states parties related to Article X, such as specific requests for equipment, materials and scientific and technological information. Such an approach could be useful in the development of background information on trends in relation to Article X. It could also be used to inform subsequent discussion in this area, perhaps even feeding into the initiation of an iterative process of determining reasonable expectations under Article X.

Appoint an ISU 'Cooperation officer'

As Finland stated in its address to the 2016 BWC Preparatory Committee, the Implementation Support Unit (ISU) is not 'an operational agency in the field of international cooperation'. Nevertheless, if states are serious about international cooperation and technology transfer under the BWC, then there would be value in expanding the ISU to include a cooperation officer. This officer could be tasked with, among other things, actively working on the identification, collation and circulation of opportunities for relevant cooperation and capacity building, such as scholarships, e-learning courses, and funding opportunities. Focused attention on Article X and the active identification and sharing of opportunities is likely to be a prerequisite for enhancing the effectiveness of this Article. Such efforts could be used to populate the existing database and facilitate a process of matchmaking offers with needs. A cooperation officer could, moreover, play a role in informing states parties of opportunities for coordinating cooperation with other relevant international and regional organisations.

Peer review of Article X

Several states have embarked upon some form of BWC-related peer review process. Most of these focus on aspects of the national implementation of the BWC and, as was pointed out in the Preparatory Committee, such reviews are a form of cooperation in and of themselves. However, building on the Organisation for Economic Co-operation and Development's Development Assistance Committee (DAC) review process, a potential option may be consideration of a process of voluntary peer review of national activities in relation to Article X. This could 'provide in-depth examinations of development systems and policies, including lessons learned'. Article X reports and other materials could be used to inform desk-based review activities related to the article, intending to develop an understanding of how technology transfer and receipt could be optimised.

Alternatively, a voluntary peer review of international cooperation with a particular focus on disease prevention could be undertaken. This could (among other things):

- Look at states parties' capacity and preparedness to respond to and prevent deliberately caused outbreaks of disease;
- Identify problems and best practices, share experience, and foster coordination;
- Establish contacts between different national agencies and international actors of relevance to the prevention of deliberately caused disease; and
- Ultimately assist in improving individual and collective performance and understanding of such activities.

Such an approach could begin a technical process - using national experts in disease response, public health and investigation - of reviewing a state's capacity and preparedness to deal with deliberate attacks through the BWC with participation from other organisations.

Consistent with the DAC model, a more ambitious Article X peer review process could be developed through visits that 'gain an understanding of how policies are implemented.' (See Information Note on the DAC Peer Review Process, OECD). During AHG discussions, several states raised the idea of cooperation visits to facilities with the aim of providing technical assistance on biosafety and security, regulations, diagnostic techniques, as well as the provision of technical knowledge to solve problems identified by states parties.

Regional technical workshops

The 2016 Preparatory Committee indicated that there is widespread support for further work on science and technology. Scientific or technical conferences provide a key mechanism for the exchange of scientific and technological information, and they stimulate cooperation in the life sciences. Another option may, therefore, be organising a technical workshop (or a series of regional workshops) where scientists from around the world could exchange knowledge and share advances in topics of relevance to the BWC, such as disease detection and response. These meetings could be located in United Nations regional centres, such as the UN Regional Centre for Peace, Disarmament and Development in Latin America and the Caribbean or the UN Regional Centre for Peace and Disarmament in Africa. These could complement future science- and technology-related activities under the Convention, building on several existing models such as Agricultural Technical Cooperation Working Group (ATCWG) workshops on Capacity Building for Emerging Infectious Diseases.

Article X Working Group

A further option for consideration is an Article X Working Group of some form, mandated over the course of the next intersessional period to identify and share opportunities for promoting peaceful international cooperation and capacity building. The Group could also be tasked to identify gaps and obstacles that need to be addressed and to explore methods for dealing with any problems that might arise related to the implementation of Article X. To ensure continuity and focus, there would be benefits to appointing a Chair of the Working Group for the duration of the intersessional period. The Chair, with the support of the ISU, could usefully identify and invite experts in particular areas, such as technology transfer, to inform the group's discussion. There would also be considerable benefits if such a group were able to build on expert contributions and discussions and, in circumstances where consensus existed, make recommendations for consideration at subsequent meetings of states parties.

Reflections

The negotiation record indicates that Article X was considered important when it was introduced into the text in 1971. Indeed, as Ambassador Ene of Romania recalled in his statement to the First Review Conference, Article X 'occupied a special place in the structure of the Convention'. It also appears to have been uncontroversial in the early 1970s. However, recent history suggests that Article X could prove divisive at the Eighth BWC Review Conference in November. While the different interpretations of the Article that have emerged since the 1980s are unlikely to be resolved at the Review Conference, the extent of division which may emerge is likely to depend on the preparations of states parties. To this end, the discussions and understandings achieved during the standing agenda item on Article X (and Article VII) during the last intersessional process and the two-part Preparatory Committee should serve states parties well. Indeed, already there are several proposals on the table for states parties to consider.

If states parties are to move beyond the repetition and recycling of traditional debates over Article X, experience suggests that proposals need to be concrete, relatively inexpensive, feasible, and not impinge upon private sector interests. It would also be beneficial if they were both ambitious in scope and submitted early. With this in mind, this paper has identified five potential additional options for consideration in relation to Article X. These options are unlikely to satisfy the expectations of all states. However, these options could aid in the development of a balanced package of measures during the Eighth Review Conference, which would advance international cooperation in a manner that both complements and enhances proposals in other areas.

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This article is based in part on work undertaken as part of a joint University College London-Harvard Sussex Program project funded through an Arts and Humanities Research Council (AHRC) grant AH/K003496/1 Understanding Biological Disarmament: The Historical Context of the Biological Weapons Convention.

The CTBT International Monitoring System: A tale of two tests

On 9 September 2016, the Democratic People's Republic of Korea (DPRK) conducted its fifth nuclear test at the Punggye-ri nuclear test site, marking the 68th anniversary since the founding of the communist regime. The South Korean Defence Ministry estimates that the detonation generated an explosion roughly equivalent to 10 kilotons of TNT, comparable to the bomb dropped on Hiroshima.

After the nuclear test the Korean Central News Agency reported that the DPRK has developed a 'nuclear warhead that has been standardised to be able to be mounted on strategic ballistic rockets.' Moreover, according to Siegfried Hecker, a former Director of the Los Alamos National Laboratory, and one of few Westerners to have ever visited North Korea's nuclear establishment, the country will have enough fissile material by the end of the year for 20 atomic weapons. The South Korean Defence Ministry has said that the North might be ready to conduct another test at any time.

These test explosions have challenged international efforts to ban such explosions, such as the Comprehensive Nuclear-Test-Ban Treaty of 1996, which aims to ban all types of nuclear explosions, whether civilian or military, in all environments—underground, in the atmosphere, underwater, in outer space, and on the Earth's surface. Among the main reasons for banning nuclear tests are the hazardous fallout of nuclear explosions, and the development of more powerful nuclear devices. Another reason is prominent in the case of North Korea, whereby neighbours see its programme as an existential threat. Nuclear testing is fundamental for states to affirm the reliability and analyse improvements of their nuclear weapons. It is essential for the success of the CTBT that breaches are promptly detected in order to disincentivise states from testing. Thus, it is important to have the capabilities to detect explosions, and develop methods to provide information about the type of device used, its yield, and the test environment.

The Treaty establishes a verification regime to monitor and detect nuclear explosions anywhere in the world. This article will give an overview of the verification regime, focusing mostly on its remote detection capabilities, and it will assess its success in relation to North Korea's first and fourth nuclear tests based on the speed of detection, accuracy of information and facilitation of on-site inspections. The purpose for choosing these two tests is analysing the performance of the verification system over time. The most recent test is not used in this analysis because at the time of writing the information is too scarce for a meaningful assessment. Moreover, the fourth test was conducted in the same year as the recent test, so it is an adequate substitute in terms of examining the capability of the system.

The International Monitoring System

The CTBT verification regime is composed of two parts. The first is a worldwide International Monitoring System (IMS) for the detection of nuclear explosions. The second involves on-site inspections (OSI) at locations where the IMS suggests that a nuclear test has been conducted.

The IMS is designed as a remote sensing mechanism for nuclear explosions worldwide and in any environment. When fully implemented, the IMS system will consist of 337 facilities, including sixteen laboratories, built in 89 countries. The system incorporates different technologies to detect nuclear tests, including seismic, infrasound, hydroacoustic, and radionuclide monitoring. When completed the IMS will consist of 50 primary and 120 auxiliary seismic stations, 60 infrasound stations, 11 hydroacoustic stations, and 80 radionuclide stations.

Seismic monitoring principally focuses on discovering tests that have occurred underground. It records events that create seismic waves such as earthquakes, volcanic eruptions, meteor impacts and nuclear tests. Each phenomenon creates body and surface waves, which are spread along the Earth's interior and surface, respectively, in the form of vibrations. Infrasound stations listen to atmospheric sound waves to detect nuclear tests occurring above the ground. The technology can identify extremely low frequencies (under 20 Hz), which are inaudible for humans and travel for thousands of kilometres. However, infrasound detection is seen as a 'complementary source of data' because it cannot provide as accurate information as seismology. Hydroacoustic technology uses sound waves propagated through water to detect nuclear tests conducted underwater. Sound propagates more efficiently through water than air, so explosions can be observed at significantly greater distances compared to atmospheric transmission. Only eleven hydroacoustic stations are required for global coverage.

Radionuclide detection is different compared to the previous three monitoring techniques, in that it does not identify waves from an explosion. The purpose of this detection mechanism is to ascertain whether an explosion is nuclear by measuring the presence of radioactive material and noble gases. It can be used for tests that have occurred in any environment, including underground, because radioactive particles might escape containment measures. The most prominent noble gasses that can be monitored are isotopes of Xenon, Argon-37 and Krypton-85. However, the CTBTO—the organisation tasked with the treaty's implementation—focuses mainly on Xenon isotopes because they have adequate half-lives (the time it takes for a radioisotope to lose half of its initial mass), low background presence, and are produced in large quantities during a nuclear test.

North Korea's 2006 test

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A picture taken by the CTBTO of the Yellowknife radionuclide station, Canada, part of the IMS and responsible for the detection of Xenon-133 after the 2006 DPRK nuclear test. Photo from the Official CTBTO Photostream. Used under the Creative Commons Attribution 2.0 Generic license.

clear tests based on the speed of detection, accuracy of information and facilitation of on-site inspections. The purpose for choosing these two tests is analysing the performance of the verification system over time. The most recent test is not used in this analysis because at the time of writing the information is too scarce for a meaningful assessment. Moreover, the fourth test was conducted in the same year as the recent test, so it is an adequate substitute in terms of examining the capability of the system.

The Provisional Technical Secretariat issued a so-called Reviewed Event Bulletin (REB) on 11 October. By collecting information from a total of 22 seismic stations, the International Data Centre (IDC), which processes and analyses the information collected, was able to confirm the time of the seismic event and reduce the size of the area where the event occurred to 880 square kilometres, which is within the maximum size of 1,000 square kilometres for an on-site inspections as mandated by the treaty.

The application of specific screening criteria pointed at the man-made nature of the event in North Korea. With the CTBT neither in force nor counting North Korea among its member states, the ultimate proof rested on the detection of noble gases by radionuclide stations. At the time, only ten stations of that type were installed and delivering data to the IDC. The closest ones were in Ulaanbaatar, Mongolia; Spitsbergen, Norway; Stockholm, Sweden; and Yellowknife, Canada. The atmospheric conditions did not favour the detection by stations located west of North Korea (as atmospheric circulation was from west to east), making Yellowknife, which lies 7,000 kilometres away, the station most suitable for detection.

On 21 and 25 October, Yellowknife registered peaks in the values of xenon-133, with lower measurements between 22 and 24 October (see Trust & Verify No. 123). Thanks to the application of atmospheric transport modelling (ATM)—which models the movement of particles in the atmosphere—analysts traced back the particles and pointed to their compatibility with the seismic event detected in North Korea. At the same time, it was possible to exclude other sources that might have interfered with the measurements, such as the Chalk River Laboratory 180 km east of Ottawa.

North Korea's January 2016 test

In the early hours of 6 January 2016, North Korea media agencies reported that the state had successfully tested a miniaturised hydrogen bomb at the underground test site Punggye-ri as an act of self-defence against US aggression. This was the first claim that the DPRK was able to produce a thermonuclear warhead, which is much more powerful than a regular atomic fission bomb as a result of the fusion of hydrogen isotopes, deuterium and tritium. Nevertheless, John Carlson, an Australian non-proliferation expert, remains sceptical whether North Korea actually tested a hydrogen bomb. In a January 2016 article in the Guardian, he theorised that the regime might have produced a "boosted explosion", which uses fusion to enhance the fission rate of fissile material, thereby increasing the explosive yield. In this manner, the main contribution to the final yield comes form the fission process.

On the day of the nuclear explosion, 27 primary seismic stations detected an unusual seismic event. After 24 hours, 77 stations provided information related to the test, and after a revision it was measured that the incident had a magnitude of 4.85. The detonation was detected on the territory of the DPRK in a similar area where the previous North Korean nuclear tests were carried out near Punggye-ri. Moreover, the seismic stations monitored similar waveforms to the DPRK's third nuclear test in 2013. Based on the information received from the seismic primary and auxiliary stations, the CTBTO was able to triangulate the location to an area of 214 square kilometres, which is adequate in relation to the allowed area of 1000 square kilometres for OSI as prescribed by the treaty.

Radionuclide stations could not immediately detect any radioactive particles or noble gases because it takes time for them to travel through the atmosphere before being picked up. Nevertheless, the last CTBTO update on 11 March 2016 stated that the radionuclide facilities did not detect any material that could suggest that the explosion was nuclear. This could suggest that the North Korean authorities might have been successful in preventing leaks of particles and gasses from the underground test. The IMS system detected some radionuclide particles, but it could not determine their source. Therefore, there is no conclusive evidence to suggest that a nuclear weapon was tested.

An analysis of IMS performance

At the time of the first North Korean nuclear test in 2006 the IMS was less than 60 percent complete. Yet it managed to detect conclusively the seismic activity caused by the detonation of the nuclear device in the same day. Even more significantly, the first test immediately proved the effectiveness of the radionuclide detection mechanism, which is important in providing proof about the nuclear nature of an event. Additionally, the overall response provided by the IDC was also within the timeframe set forth in the treaty provisions. The possession of the capabilities to swiftly identify nuclear testing allows the CTBTO to provide the international community with the necessary information to respond and take adequate measures. Thus, the verification regime strengthens states' confidence in the convention's ability to answer their security concerns.

The January 2016 event provided once again encouraging results with regard to the capabilities of the IMS. In that occasion the REB used data sent by a total of 77 seismic stations (at the time of the test 42 primary and 107 auxiliary stations were certified), 55 more than in the 2006 case. The analysis by the personnel of the IDC narrowed down the location of the test to an area of 214 square kilometres, down from 880 square kilometres in 2006. In the event of an on-site inspection, the smaller the area, the more efficient and effective the efforts of the investigation team will be. Nevertheless, no radionuclide station managed to provide evidence that the seismic signals were caused by a nuclear explosion. This may be due to several causes, among which the chance that atmospheric circulation did not favour the detection by any of the stations, or the possibility that the DPRK managed to avoid any leak of radioisotopes and noble gases. This clearly shows a limit of the IMS in providing ultimate evidence of the nuclear nature of an incident. However, the IDC were able to use information collected from other events to strengthen their inference that it was indeed a nuclear test. When an event occurs close to a previous location and is of about the same magnitude, a waveforms comparison can provide useful insight. As in the previous case, another positive aspect is that the overall response from the verification mechanism was within the time limits established by the convention.

Conclusions

It is possible to claim that the verification regime established by the CTBT allows for the confident detection of nuclear tests. It is unlikely that a nuclear event would go undetected by the seismic stations. Infrasound and hydroacoustic stations provide additional means of detection, and the former have proved effective in 2013, as they contributed to the detection of that year's test. On that occasion, in addition to the prompt response by the IDC, it was also possible to narrow the location of the test site down to an area of 181 square kilometres. Although radionuclide stations have not reported unusual values of radioisotopes so far this year, they proved effective twice, in 2006 and 2013. Even in the absence of detections by radioisotope stations, once into force the convention would grant the possibility to find conclusive evidence thanks to the on-site inspection mechanism. The improvements to the IMS since 2006 would make any hypothetical OSI much easier and much more effective. In the end, this would grant member states a reliable verification regime that would secure them from cheating by other states parties. The real challenge ahead continues to be the entry into force of the treaty.

Simeon Dukic and Matteo Zerini

Monitoring of the Minsk Agreement

By Matteo Zerini

More than two years have passed since the conflict in eastern Ukraine broke out. Although large-scale operations have ended, the conflict simmers, and low-intensity violence looks like the new normal in the war-torn regions of eastern Ukraine. The situation on the ground is regulated by the terms set forth by the so-called "Minsk II" agreement of February 2015, which rescued the failing Minsk Protocol of September 2014, and its October 2015 Addendum.

More recently, the Trilateral Contact Group—created after a meeting between the presidents of Russia and Ukraine in Normandy on 6 June 2014 and involving the two countries plus a representative of the OSCE—agreed upon the "Framework Decision relating to disengagement of forces and hardware". Overall, the agreements provide for the cessation of hostilities, create security zones of different width tailored to the capabilities of weapons systems, and require the withdrawal of foreign armed formations from Ukrainian territory.

Monitoring fragility …

The OSCE mission already present on the field, the Special Monitoring Mission (SMM, deployed in Ukraine since 22 March 2014) was tasked with the monitoring of the Minsk II implementation. At first, the mission was 100-man-strong but now comprises more than 700 international monitors, with an option to boost numbers to 1,000, if needed. The vast majority of monitors operate in the regions of Donetsk and Luhansk. They are joined in their efforts by more than 310 Ukrainian staffers and almost 100 more international staff.

Daily reports issued by the SMM portray a fragile situation on the ground. At the beginning of August increased tensions between Russia and Ukraine led to fears of an imminent resumption of hostilities, while OSCE monitors reported a dramatic increase in ceasefire violations later in the same month. By 1 September, on the occasion of the start of the new school year, the situation stabilised, but many incidents continue to be reported. The latest status report identified the Donetsk airport-Yasinuvata-Avdlivka as the epicentre of violence, while several risk factors contribute to the volatility across the Donbass.

… troublesome violations …

In open violation of the terms of the truce, the monitors have been able to spot weapons beyond withdrawal lines in several instances. In the daily report for 3 October, for example, the SMM reported an anti-tank guided missile fitted on an infantry fighting vehicle in Stanytsia Luhanska. Also, monitors noted 14 Luhansk People Republic's (LPR) tanks outside assigned areas. The SSM found missing 5 D-30 towed howitzers and one 122mm multiple launch rocket system from an LPR heavy weaponry permanent storage site. Transgressions occur on both sides. For example, 18 152mm towed howitzers were observed in Ukrainian Armed Forces holding areas, and the monitors noted that 18 such weapons have been missing since 8 July 2016.

… and unwarranted restrictions

The SMM is subject to major impediments to the fulfilment of its duties because of the repeated violations of its freedom of movement by all the parties to the conflict. In a thematic report issued in August, the mission noted 692 restrictions of its freedom of movement in the first six months of 2016. Separatists were responsible for 80 percent of them, Ukrainian forces for 14 percent, while 6 percent took place in areas of undetermined control.

Incidents have been caused by armed formations of the Donetsk People Republic (DPR) as well as the LPR. At the beginning of the year monitors were forced to the ground at gunpoint and detained by DPR units. There has been repeated instances of the SMM coming under small-arms fire. In June it was caught in mortar shelling.

These violations prevent the SMM from getting access to certain areas to monitor the respect of the withdrawal lines and the disengagement of forces. The mission highlighted a direct correlation between increased tension in certain zones and restrictions to the freedom of movement of the mission.

Drone harassment

To fulfil their tasks monitors have started to use surveillance drones, but even those are harassed. On several occasions, they have been jammed, and they have under direct fire at least six different times, sustaining damage twice. The SMM lost communications with seven drones, and in one instance this occurred only minutes after the vehicle spotted a 9K35 Strela-10 (120mm surface-to-air missile system) in a DPR-controlled territory.

The situation is aggravated by the climate of impunity that surrounds violations. The Joint Center for Control and Coordination (JCCC), responsible for facilitating the implementation of the ceasefire, has been so far not been able to push the parties towards a stricter compliance with the rights of the SMM. The potential long-term consequence of the lack of follow-up to infractions is that parties could be emboldened and commit more violations in the future, hampering the sustainability of the ceasefire.

Verifying a Ban on Lethal Autonomous Weapons Systems

By Lisa Gridley

Since 2012 there has been a growing momentum of support for a ban on Lethal Autonomous Weapons Systems (LAWS) or 'Killer Robots'. These technologies have prompted a moral, ethical, and legal debate on whether or not a robot should have the ability to deploy lethal force autonomously. Automated weapons platforms and delivery systems (such as drones) are developing quickly, so this debate is an important one for the international community.

The Campaign to Stop Killer Robots

The Campaign to Stop Killer Robot—a group of non-governmental organisations that recognise the threat that these technologies pose—leads the debate and movement towards a pre-emptive ban on LAWS. Their efforts are supported by two reports from the UN Special Rapporteur on extrajudicial, summary, or arbitrary executions (released in 2013 and 2016) that called for a moratorium, and then an outright ban, on the development and use of LAWS. Similarly, more than 3,000 artificial intelligence scientists and related professionals called for a ban on LAWS in an open letter in 2015.

The work of the Campaign, other organisations, and states led the 2013 Convention on Conventional Weapons (CCW) annual Meeting of States Parties to mandate an informal meeting of experts to discuss the issue. The third of these meetings, held in April 2016, agreed on a set of recommendations for consideration by the Fifth CCW Review Conference, due to be held later this year. These recommendations included a call to establish a Group of Governmental Experts to discuss a working definition of LAWS and how LAWS relate to and may comply with humanitarian law.

These informal meetings of experts, occurring annually since 2014, have seen an increasing trend in the level of engagement of the participating states. While only 14 states have consistently supported a total ban, the number of states discussing the issue in multilateral forums has ballooned from 44 in 2013 to 67 in 2016. The majority of these support further multilateral discussion on the issue.

Banning killer robots

With so much effort focused on creating a ban, and with the interest of major institutions and policy makers, a ban on LAWS seems to be the likely path of this issue. International law could potentially already prohibit the application of LAWS in war situations. However, legal experts consider it preferable to strengthen existing law through a new international legal instrument to ensure that LAWS are not developed and used. Under Article 36 of the 1977 Additional Protocol I of the Geneva Conventions, States Parties are required to review all new weapons systems to make sure that they abide by the rules of warfare. However, international law does not make any particular reference to autonomous weapons and their place in war.

Verifying compliance

Any ban or other legal restriction on the development and deployment of LAWS must, therefore, include rigorous verification measures to build confidence in compliance. There are two ways in which the international community could restrict LAWS: through regulating their development and operation; or by establishing a total ban either through a protocol to the CCW.

Compliance with a regulation of LAWS would be harder to verify than a blanket prohibition, especially if developers were reluctant to be transparent in their research. While a total ban would be easier to verify, it may not be practicable to include certain research and certain development activities given the verification challenges.

If a ban is established under the CCW, States Parties will need to consider whether the Convention's current confidence- and transparency-building measures would provide sufficient confidence in compliance with rules on LAWS. More stringent verification measures could include monitoring intent and transparency of autonomous weapons development and open-source information, such as media and press releases. This information could be added to the formal declarations that are shared with other signatories. Challenge or routine inspections could also be utilised as well as weapons reviews. If it is not possible to implement these measure under the CCW, a new stand-alone convention may need to be created.

All eyes will be on the CCW's Fifth Review Conference from 12-16 December in Geneva to see what recommendations from the meeting on LAWS earlier this year will be implemented.

The Final Report of the UN-OPCW Joint Investigative Mechanism in Syria

By Simeon Dukic

The Syrian government—with assistance from the international community—claims to have removed all stockpiles of chemical weapons it declared after it ratified the Chemical Weapons Convention (CWC) on 12 September 2013 (see Trust & Verify no. 145). Despite this, chemical weapon attacks continue to occur on Syrian territory (see Trust & Verify no. 146, 151 and 152). In response, the UN Security Council, in its resolution 2235, ordered the creation of an 'OPCW-United Nations Joint Investigative Mechanism to identify to the greatest extent feasible individuals, entities, groups, or governments who were perpetrators, organizers, sponsors or otherwise involved in the use of chemicals as weapons.' The mechanism (abbreviated 'JIM') represented the first ever attempt to identify the perpetrators of chemical weapons use.

What did the Joint Investigative Mission do?

The JIM's work included only incidents identified by the OPCW fact-finding mission between 2014 and 2015, which investigated 29 out of 116 alleged uses of chemical weapons in Syria. Of these, the JIM investigated nine of the most severe and pressing cases, based on an evaluation of the chemicals used, the delivery mechanisms, the quality of available data, and the amount of forensically verified information.

The JIM divided up its work in two phases. The first focused on collecting information, analysing the data from the fact-finding mission, mapping the incidents, and establishing investigation methodologies, standards of evidence, and investigatory procedures. The second involved case investigation, coupled with on-site inspections, witness interviews and the collection of other information from relevant UN member states and third parties.

The JIM established that eight of the nine cases involved the use of chlorine, and one included the use of sulphur mustard. The JIM found in the chlorine-related cases that helicopter-released barrel bombs had likely been used. The group also noted that chlorine was easily obtainable in Syria, with the cylinders used being readily available and traded around the world.

Pointing fingers

The JIM was partially successful in determining who was responsible for the incidents. It was able to identify users in three cases. In two cases the JIM reported that the Syrian Armed Forces were responsible for the use of chlorine. The investigators observed, in their third report to the Security Council (S/2016/738), that, on 21 April 2014, a Syrian army helicopter had dropped a device that released a toxic chemical affecting civilians in Talmenes near Idlib. Similarly, the JIM found that on 16 March 2015, the armed forces dropped a chlorine-filled barrel bomb that killed six members of a single family in Sarmin. Chemical weapons are not exclusively used by the government, however. The JIM also held the so-called Islamic State in Iraq and the Levant accountable for a sulphur mustard gas attack against civilians in Marea, near Aleppo, on 21 August 2015. The JIM has asked for more time to investigate three other cases (namely those that occurred at Kafr Zita, Omenas, and Binnish), and concluded that there was insufficient evidence to determine culpability in the remaining three cases.

What next?

Although the investigators pointed out that allegations of chemical weapon use have decreased since its inception, they have not stopped. Between December 2015 and August 2016 there were over 100 reports of sarin, sulphur mustard, VX, chlorine, and other toxic agent uses on the territory of Syria.

The United Nations Security Council (UNSC) discussed the report on the 30 August 2016. Samantha Powers, the US ambassador to the UNSC, advocated for immediate actions against actors who use these 'barbaric tools.' The French and UK ambassadors also urged swift action, but the Russian delegate was unconvinced by the findings. He stated that even though there is evidence that chemical weapons were used, the lack of specific detail about the perpetrators and the events meant that the culpability of the Syrian government could

Quotes

"Certainly, the OPCW has a long history of close collaboration with science and industry – and for good reason. Such collaboration was instrumental in establishing the robust verification regime that allows us to ensure our Member States are in compliance with their obligations. But, twenty years on, it is time for us to make scientists, industry representatives and civil society more active partners in our collective endeavour to rid the world of chemical weapons." • **OPCW Director-General Ahmet Üzümcü in remarks delivered at the Korea National Diplomatic Academy on 9 September 2016.**

"In Berlin, a number of participants spoke out in favour of revitalising and broadening the discussion on strengthening arms control and CSBMs. At first sight prospects are discouraging but the case for rekindling dialogue to dispel misperceptions and misunderstandings is compelling. Establishing a neutral mechanism for military fact-finding, challenge inspections under an OSCE flag rather than by sending national inspectors or even a centralised and institutionalised OSCE verification/inspection mechanism are some of the suggestions that we may want to consider. The OSCE as the most inclusive platform for dialogue in our region should play a significant role. Rebuilding trust and confidence is a long-term process but we have no option but to keep trying." • **OSCE Secretary General Lamberto Zannier speaks at the 2016 Annual Security Review Conference in Vienna on 28 June 2016.**

"The true nuclear capability of the isolated and secretive state is impossible to verify." • **Al-Jazeera news item on North Korea, 14 September 2016.**

"Our collective ability to monitor and verify compliance with the CTBT is more robust than it has ever been. The International Monitoring System is nearly complete. The International Data Centre has demonstrated its ability to provide independent and reliable means to ensure compliance with the Treaty once it enters into force." • **Former US Under Secretary for Arms Control and International Security, Rose Gottemoeller, gives remarks to Friends of the Comprehensive Nuclear-Test-Ban Treaty Ministerial, 21 September 2016.**

"[...] there is no multilateral prevention and verification agency for biological weapons, as there is for nuclear and chemical threats and risks." • **Ban Ki Moon on the devastating threat of Biological Weapons, and the lack of adequate preparation to prevent their use.**

"We now have more than 75 countries that have deposited their instruments of ratification covering close to 60 per cent of global emissions and the Paris Agreement will now enter into force three days before COP 22 in Marrakech. Together with the Sustainable Development Goals, we now have a global framework for action. We have both momentum and a mandate." • **Keynote Address by Patricia Espinosa, Executive Secretary of the UN Framework Convention on Climate Change at Chatham House Climate Change Conference - London, 10 October 2016**

Implementation Watch

Threshold crossed for entry into force of Paris Agreement on climate change

By Larry MacFaul

To enter into force, the Paris Agreement on climate change required a dual threshold to be crossed: 55 countries responsible for at least 55% of global emissions would need to ratify it (or 'accept' or 'approve' it – depending on the nature of the national process for joining international agreements). That threshold was crossed on 5 October 2016 when the EU joined, and the status of ratification reached 74 parties representing 58.82% of global emissions.

191 countries have already signed the agreement since it was opened for signature in April of this year. As highlighted by Patricia Espinosa, Executive Secretary of the UN climate change secretariat, the subsequent speed of ratifications and entry into force is 'unprecedented in recent experience of international agreements'.

Indeed the threshold had almost been reached in early September when the leaders of the USA and China together announced that they would join the agreement imminently. This was significant because these countries are the world's two largest economies and emitters of greenhouse gases. Then, on 3 October, India joined as well. At that stage, it was likely that threshold would be crossed very soon because the EU had just come to the conclusion that it could ratify the Paris Agreement without waiting for individual governments (a decision process explained in a recent paper by Client Earth and Ecologic).

US President Obama and Ban Ki-moon, outgoing UN Secretary General, both welcomed news that threshold had been crossed. This high level of response is consistent with the type of attention and support given to the negotiations last year; some 150 heads of state attended in Paris and the political engagement was complemented by initiatives from many businesses and cities. The negotiations were also given a significant boost by the submission of national climate action plans by some 188 countries. The resultant agreement was considered a major step forward by many civil society organisations, businesses and governments alike—a consensus not often attained in environmental treaties.

The Paris agreement builds on mechanisms that have been developed, discussed and refined over the last 20 years of climate negotiations. It includes long-term mitigation goals (providing a level of clarity absent from previous agreements), a mitigation ambition-raising approach with five yearly cycles of action as well as a five-year global stocktake of progress. The issue of adaptation to climate change was given equal status to mitigation, and further steps were made on finance, investment and capacity building.

The fundamental role and importance of monitoring, reporting and verification was also recognised in the agreement. These elements provide a way of building confidence among countries in effort sharing, but such data will also enable countries to review and refine their actions taken towards the treaty goals. The agreement sets out a common system across countries including standardisation of metrics and procedures, regular comprehensive reporting and a verification mechanism including technical expert review and a 'multilateral, facilitative consideration of progress'.

To appreciate how the growing level of cooperation at the international governmental level is reflected across the energy, investment and business sectors, it is worth reading Jeremy Leggett's latest 'State of the Transition' thread on www.jeremyleggett.net. (Dr Leggett is also VERTIC's founder). He highlights, among other developments, a report from CDP (formerly Carbon Disclosure Project) that 'over 600 major international corporations with a combined market cap of US$12 trillion are already starting to factor the Paris Climate Change Agreement in their business plans', and news that the tech giant Apple signed up to a corporate 100% renewable power campaign.

September also saw climate developments at the UN General Assembly. President Obama signed a Presidential Memorandum on Climate Change and National Security 'establishing a policy that the impacts of climate change must be considered in the development of national security-related doctrine, policies, and plans.' In addition, a group of about 100 countries collectively called for an amendment to the Montreal Protocol on Ozone Depleting Substances to phase down HFCs—a particularly potent greenhouse gas.

Despite this groundswell, not all economic trends are favouring a clean energy path needed to tackle climate change (as highlighted in 'State of the Transition), and not all policy makers are convinced of the need or desirability of taking action. This was evident in the manner in which the USA joined the agreement, as reported by the Washington Post. President Obama moved ahead on the issue without the US Senate's 'advice and consent' (a treaty ratification process requiring a two-thirds vote in the Senate). The White House stated that the President has the legal authority to join (or 'accept' - to use the formal term noted above) in this case since the Paris accord is an 'executive agreement' and they pointed out that this process has been used many times before. President Obama's decision and overall stance on climate change has been hotly contested by some Republicans who do not support national action in this area. The attitude of US politicians in general (and the incoming president in particular) will have a significant impact on the direction of climate discussions in the coming years. Be that as it may, the next UN climate conference will take place in November in Morocco where many governments and civil society groups hope that a range of tracks and operational procedures established under the Paris Agreement will be further developed.

India's Quest for Membership of the Nuclear Suppliers Group

By Matteo Zerini

India has been burnishing its non-proliferation credentials this year, with an eye on membership of the Nuclear Suppliers Group (NSG). It began 2016 by underlining its efforts in strengthening its security culture at the Nuclear Security Summit in March, and by signing up to three of the fifteen informal groups tasked with sustaining the momentum resulting from the summit. During the summer, India formally became a member of the Missile Technology Control Regime and subscribed to the Hague Code of Conduct against Ballistic Missile Proliferation (a voluntary and legally non-binding set of confidence building measures).

However, while the summer of 2016 produced some significant steps forwards in India's drive to join the NSG, it also yielded some diplomatic setbacks. India's bid to become the 49th member of the NSG was not approved at the latest meeting, held in Seoul on 23 and 24 June 2016. Reportedly, about a quarter of the group's members raised issues about New Delhi's candidature.

Entry requirements

Admitting India (who is not a party to the Treaty on the Non-Proliferation of Nuclear Weapons, or NPT) to the club that sets the standards for governing trade in nuclear-related materials would represent a major precedent. The Group was created in response to India's 'Peaceful Nuclear Explosion', which drew on nuclear material diverted from a Canadian reactor originally supplied for peaceful purposes.

Since its formation, any new members of the NSG were required to prove their active promotion of global nuclear non-proliferation. The five 'factors' taken into account for participation are outlined in the IAEA document INFCIRC/539. As all members of the NSG are States Parties to the NPT, participation to the treaty has come to be viewed as a prerequisite to NSG membership. However, the IAEA document seems to suggest that just the adherence to the treaty or an 'equivalent international nuclear non-proliferation agreement' would suffice.

India has argued that current members should adopt a merit-based approach to membership, while China (opposing

India's bid) advocated for a criteria-based approach. It is not entirely clear how 'merit' could be evaluated without some form of 'criteria', or 'factors' to borrow the current wording of INFCIRC/539.

The dilemma of Indian membership

These semantic differences obscure a significant dilemma. On the one hand, it is necessary to strengthen the current non-proliferation regime by involving states that can supply sensitive nuclear technology, such as India. On the other, NSG members need to decide how the inclusion of a non-NPT state would affect the NSG's current practices and guidelines.

When members of the NSG exempted India from its requirement for full-scope safeguards in 2008, they implicitly acknowledged that India plays a major role in international nuclear trade. However, letting India join could give rise to several additional precedence questions, many of which has been raised by Mark Hibbs, a respected NSG-watcher, in an op-ed piece published on the website of the Carnegie Endowment for International Peace on 15 May 2016.

At the same time, there are also fears that if India became a member, it might block Pakistan's inclusion, despite the role it could conceivably play in future nuclear trade and non-proliferation. Furthermore, Pakistan might react to India's membership (in the face of its exclusion) in a manner that might run counter to the objectives of the NSG.

India's accession to the NSG would recognise by the international community of the role it could play in the global nuclear regime. However, its rejection in June shows that several countries are concerned that India's role inside the NSG would not be entirely positive. The key concern is the verifiability of India's contribution to non-proliferation efforts in the absence of a framework such as the one provided by the NPT and IAEA safeguards. As indicated above, India will have to do more than just burnish its non-proliferation credentials: their membership would raise many uncomfortable issues for the NSG. If progress were made on tackling some of these matters, the chair of the NSG might summon a new meeting to evaluate India's bid. Otherwise, India will have to wait until next year before its bid might be discussed again.

The destruction of Libya's last chemical stockpile

By Simeon Dukic

Under Colonel Gaddafi Libya developed an advanced chemical weapons programme, comprising of 25 tons of sulphur mustard, 1,400 tons of chemical ingredients, and 3,500 aerial bombs. Nevertheless, Libya was obliged to destroy its chemical weapons after it ratified the Chemical Weapons Convention (CWC) in 2004. Articles III and IV stipulate that State Parties shall declare and destroy, respectively, any chemical weapons in their possession and in the territory under their jurisdiction. The CWC mandates that a Member State must destroy all declared weapons and material regulated by the treaty within a time period of ten years following the process described in Annex II on verification.

Although Gaddafi gave up most of his chemical weapons, he retained stocks of chemicals necessary for the production of mustard gas. After the Arab Spring, the National Transitional Council, which succeed the Gaddafi's regime, discovered and reported to the Organization for the Prohibition of Chemical Weapon (OPCW) the undisclosed chemical weapons and precursors. With the help of the United States, Libya destroyed the remaining weaponised deadly agents using a special oven in the desert in January 2014.

Nevertheless, Libya was still in the possession of so called "Category 2" precursors and toxic chemicals under the CWC. Although the material can be used for industrial purposes, it is also designed to make chemical warfare agents. The OPCW stated that the chemical were stored safely and monitored constantly. It was anticipated that Libya would destroy them by 2016.

However, the country entered again into a period of high instability with extremist groups like the Islamic State in Iraq and the Levant (ISIL) taking control of some areas and cities. The Libyan stockpiles were stored in the Jafa area, around 120 miles south from ISIL's stronghold, the city of Sirte. Thus, the Libyan National Authority for the CWC requested support from the OPCW and other State Parties on 16 July, 2016, in destroying the remaining 850 tonnes of chemical material. On 20 July the OPCW approved the request for help and started developing a plan for the destruction of the chemical precursors.

The matter was also taken up by the United Nations Security Council (UNSC) as an issue affecting international peace and stability. As a response on 22 July, 2016, it issues Resolution 2298 under Chapter VII, which endorsed OPCW's decision to support Libya's chemical weapons destruction. Additionally, it authorized UN Member States to acquire, control, transport, transfer and destroy chemical stockpile identified by the OPCW. The Egyptian representative at the UNSC regarded the Resolution as an important unified step in preventing jihadi non-state groups from acquiring chemical weapons. The Russia ambassador emphasized the significance of this point by referring to rise of chemical terrorism in Syria and Iraq. Moreover, he argued that this was a substantial step in global chemical demilitarization.

On 30 August 2016 the OPCW organized and coordinated an international effort to obtain the chemical material from the Libyan authorities. A Danish cargo ship collected more than 500 tonnes of chemical weapon remnants at the port of Mistara under the supervision of UN. Ahmet Uzumcu, the OPCW Director General, stated that the removal of this material was only the first step in verifiably eliminating Libya's chemical stockpile. The Danish vessel, accompanied by UK and Danish Navy vessels, delivered the shipment to a plant in Munster, Germany, operated by GEKA, a publically owned specialist company, for destruction, according to the German Ministry of Defence on 8 September 2016. Boris Nannt, the spokesperson for the Ministry, stated that the destruction process is due to be completed by December. The OPCW will continue its verification activities until the final disposition of the chemical arms components at the plant.

Ten states participated in this international endeavour, namely: Canada, Denmark, Finland, France, Germany, Italy, Malta, Spain, United Kingdom and the United States. Their efforts guaranteed that the chemical weapons remnants will be disposed, never to be acquired and weaponized by ISIL, or any other extremist non-state party in Libya. Moreover, the OPCW demonstrated its capability to successfully manage the international operation and make a tangible contribution in prohibiting and destroying chemical weapons and material.

S&T Scan

Measuring greenhouse gas emissions from the ground using BEACO2N

By Simeon Dukic

The article 'Measuring greenhouse gas emissions from space with high resolution' (see Trust & Verify no. 153) examined Carbonsat, a project designed to measure greenhouse gases, namely carbon dioxide (CO2) and methane (CH4), in urban areas from satellites. Despite not being realised, the results presented by the researchers from the Institute of Environmental Physics at the University of Bremen showed that one could measure city emission trends based on already existing data from satellite missions.

The BErkeley Atmospheric CO2 Observation Network ('BEACO2N'), aims to measure the increasing amount of greenhouse gases generated by cities from equipment deployed on the ground surface. In contrast to CO2 monitoring networks which rely on a handful of instruments placed at distances between five and 35 km, the approach adopted by BEACO2N involves the use of a high-density network of nodes equipped with low-cost sensing gear, which aims to sense anthropogenic greenhouse gases.

BEACO2N has conducted research and monitoring exercises in terms sensing CO2, nitrous oxide (NO2), ozone (O3), and carbon monoxide (CO) around the city of Oakland, California. The network achieved a spatial resolution of 2 km. Thus, besides monitoring average regional and city concentrations of gases, BEACO2N can provide information on greenhouse gases on a neighbourhood level.

The nodes contain infrared sensors for CO2 detection, as well as metal oxide-based micro-sensors to monitor NO2, O3, and CO concentration. These sensors are placed in waterproof enclosures together with microprocessors for automated data collection. Data is then transmitted via an onsite Ethernet connection, Wi-Fi antenna, or mobile phone connection.

The study involved 28 nodes deployed two kilometres apart and placed six to 476 meters above sea level. The equipment was installed on the walls and roofs of public institutions, mostly schools and museums, where wireless and air exchange with the surrounding area is optimised, while the sampling of local emission sources is minimised. The two-kilometre distance between different instruments was used to ensure that all significant sources of greenhouse gases are taken into account, and at the same time avoiding overlap of information.

The BEACO2N team assessed the project on four levels: cost, reliability, precision and bias of data. According to the study, each node with sensors that could measure diffusion samples between 0 and 1,000 ppm cost approximately US$2.8k. Together with ancillary sensors and hardware, the price jumps to US$5.5k per node (or US$154k for the entire network). Although this is a large sum, the BEACO2N project argues that the prices for comparable monitoring instruments such as commercial 'cavity ring-down analysers' come in at US$60k, with annual maintenance costs exceeding US$85k. Over time, BEACO2N network is more efficient.

Data reliability also appears to be good. The study indicated that there were rarely any incidents with the transmission of data from the nodes, with the nine most stable nodes having an over 80% uptime. They had no hardware faults and noted that data disruptions were due to electricity and internet connection failures. Moving the nodes to areas with a more reliable wireless connection improved the uptime of the system as a whole.

The study demonstrated that the accuracy of the sensors used is adequate for high-density urban deployment. For example, it mentioned that two instruments in central San Francisco which were at different altitudes and various distances from pollution sources showed a significant agreement in their measurement, despite high fluctuations and wind speed changes. The emissions, generally in the entire Oakland metropolitan area, were estimated within 18% accuracy, which significantly limits uncertainty.

BEACO2N appears to be a successful system for ground based monitoring of greenhouse gas emissions. However, some kinks still need to be ironed out. For example, at certain nodes, the researchers discovered over and under estimations of CO2. Furthermore, there have been concentrations of gases from unknown origins. However, the BEACO2N team is confident that they have already developed a system that can help them identify the reasons for such anomalies and improve the network.

The work is based on a three years of research and provides a promising base for measuring CO2 emissions in an urban area using a ground-based network. Therefore, it can provide an efficient system for monitoring reductions in greenhouse gases, especially when combined with data from other means of collection, including space-based platforms.

An Information Barrier for the Comprehensive Nuclear-Test-Ban Treaty

By Hugh Chalmers

Verification always needs to strike a careful balance between scrutiny and confidentiality. A treaty's verification regime needs to be accurate without being overly sensitive to build confidence in its implementation. This balancing act is familiar to anyone considering how to verify the dismantlement of nuclear weapons without releasing proliferative or classified information. In this context, initiatives such as the so-called UK-Norway Initiative has reviewed the use of 'information barriers' capable of indicating to an inspector if an object is a nuclear explosive device without releasing sensitive spectral information.

Technical 'information barrier' solutions to the verification dilemma are also being developed for the Comprehensive Nuclear-Test-Ban Treaty (CTBT), where the risks of spreading sensitive or proliferative information could be equally severe. The On-Site Inspection Radio-Isotopic Spectroscopy (OSIRIS) software—developed collaboratively by three US National Laboratories—aims to identify spectral signatures of a nuclear weapon test without releasing any extraneous or sensitive information.

Verification restrictions in the CTBT

The CTBT, in its protocol, states that any State Party subject to an On-Site Inspection (OSI) has 'the right to take measures it deems necessary to protect national security interests and to prevent disclosure of confidential information not related to the purpose of the inspection.' It goes on to assert that such measures could include 'restricting measurements of radionuclide activity and nuclear radiation to determining the presence or absence of those types and energies of radiation relevant to the purpose of the inspection'.

Radioactive products of a nuclear explosion can tell an observer quite a lot about the device that was detonated. The ratios of specific radioactive products will be different depending on the fission fuel used in the charge, the energy of the neutrons generated by it, and the time since it was detonated. If certain rare radioactive products can be detected, an observer can even infer whether and to what extent the device exploited nuclear fusion (in addition to nuclear fission)—distinguishing between pure fission and 'thermonuclear' devices. According to Swedish researcher Lars-Erik De Geer, if these radioactive products can be detected accurately and quickly enough, an observer could even infer whether the nuclear explosive used a sophisticated 'two-stage' thermonuclear design.

These observations would go far beyond the purpose of an OSI, which (according to the treaty) is only to clarify whether a nuclear explosion had taken place and, where necessary, collect any evidence that might identify a culprit. As such, the specifications of any pre-approved OSI equipment must take both safety and confidentiality considerations in mind.

The OSIRIS software

The OSIRIS prototype software aims to respect confidentiality during OSIs by taking gamma ray spectra from an off-the-shelf hand-held detector and discarding all information other than that on 'CTBT-relevant radionuclides' and selected calibration radionuclides. While the former help determine whether a nuclear test has taken place, the latter provide some reassurance to the user that the machine is working correctly.

Importantly, OSIRIS is not programmed to report on the presence of xenon or neptunium isotopes that can help determine the presence and consumption of various fissile fuels, and therefore the rough composition and design of the tested device. Indeed, none of the isotopes that can be used to identify possible weapon components—such as cobalt, lead, and gallium isotopes (as described by Ferenc Dalnoki-Veress in a memo for the James Martin Center for Nonproliferation Studies)—are reported by the OSIRIS software.

The software, therefore, processes complex spectral information—that can indicate the presence of more than twenty different radioisotopes—to deliver a simplified bar chart of only seventeen radioisotopes. As the detector collects information, the OSIRIS software displays the evolution of this bar chart in real time, and users can see summary data for each displayed isotope by clicking on the bar. Once the full spectrum is acquired and processed, the processed summary is saved to a text file and the full spectrum is discarded.

The software has been tested on an array of relevant spectrum models - including a severe nuclear reactor accident and a vented underground nuclear explosion—which varied in age from one to 100 weeks after the event. On the whole, the software correctly represented the presence of treaty-relevant radioisotopes more than 98 percent of the time and represented their absence more than 96 percent of the time.

Ready for deployment?

The software developers have concluded that 'the initial OSIRIS results are encouraging'. In contrast to information barriers developed to verify nuclear warhead dismantlement, the OSIRIS software does not have to characterise an unexploded nuclear weapon without revealing classified or proliferative information. The act of detonating the weapon produces two sets of less sensitive signatures: a shock wave and a host of exotic (and relatively unrevealing) radioisotopes.

However, the developers acknowledge that 'other tests will need to be conducted before settling on this or any approach' for radioisotope detection during CTBT OSIs. In particular, it is unclear whether states parties will be satisfied that the OSIRIS software is trustworthy enough for deployment. The draft OSI inspection manual suggests that each party 'has the opportunity to access a sample of its choosing of each item of inspection equipment' to help it 'familiarize itself with the equipment, including associated software, and to provide confidence that the procedures for operation, calibration, maintenance and protection of approved equipment are adequate'. Given that it is notoriously hard to identify hidden backdoors or malicious code in software, this confidence might be hard to gain in the case of OSIRIS.

The Alchemy of Carbon Capture and Storage

By Matteo Zerini

This year has registered important news on the front of the world's struggle to contain the effects of climate change. The world's major polluters have rushed towards the ratification of the Paris Agreement, allowing it to enter into force in a strikingly short period after the signature by states. Achieving the goals set by the Convention requires that strong efforts be put into the development of green technologies, to ensure that anthropogenic factors are minimised, if not removed from the equation determining the evolution of Earth's climate. Carbon Capture and Storage (CCS) has received considerable attention in the past, but solutions based on the concept have proved elusive so far.

The findings of the CarbFix project, conducted at the Hellisheidi geothermal power plant in Iceland, were published in June this year and suggested that basaltic rocks might become the alchemists gold of today's scientists researching into new methods for CCS.

Phase I of the experiment injected 175 tonnes of pure CO2 in a layer of basaltic rocks at between 400 and 800 meters depth from January to March 2012. Phase II injected instead a total amount of 73 tonnes of CO2 mixed with hydrogen sulphide, to test the feasibility of mineralisation for unprocessed exhausts. The aim of the project was to test CCS through mineral sequestration, i.e. the permanent storage of carbon dioxide underground through its mineralisation. The scientists dissolved the CO2 in down-flowing water to solve the problem caused by the buoyancy of the gas (which could lead to leaks if not addressed), as well as facilitate its reaction with the basalt of the test site, which through its high reactivity aids the mineralisation process. Defying expectations, after just two years over 95 percent of the injected gases were mineralised.

The need for reliable accounting

Critical to the success of any CCS technique is the permanence of buried emissions in the storage site and leakage minimization. To this end, monitoring is of paramount importance. The challenge presented by mineral sequestration is that conventional methods, e.g. seismic imaging, cannot detect dissolved or mineralised CO2. CarbFix, therefore, resorted to a combination of nonreactive but volatile chemical and previously untested isotopic tracers. They were then able to monitor plume migration as it moved within the storage formation. The detection of peaks in pH and concentration of dissolved carbon by monitoring wells allowed to keep track of the injectate spread. To verify that mineralisation of CO2 was indeed taking place, the scientists calculated the difference in the concentration of dissolved carbon and of the isotope carbon dioxide was spiked with between mineral precipitates and water samples from the soil.

An innovative verification method

As mentioned, CarbFix used a previously untested method to verify the fate of the injected gases. This was the employment of an isotopic tracer that would allow a quick and incontrovertible detection of the CO2 position and potential leakages. The team opted for the use of carbon-14, a mildly radioactive isotope of carbon, which would not have altered the chemical and physical properties of the injectate, consequently exerting no influence on the mineralisation process. The injected carbon dioxide, therefore, came in the form of carbon-14, rather than the common carbon-12. As carbon-14 is present in nature only in traces, the scientists were thus able to differentiate the precipitates derived from the artificially added carbon dioxide. The added value of this isotope is that the instrumentation required for its measurement is suitable for real-time detection and less difficult to field as opposed to that available for other alternatives, such as carbon-13 and oxygen-17.

Centre News

Director's reflections

Andreas Persbo

You have just read the penultimate edition of Trust & Verify for 2016. The spring edition focussed on tritium production in North Korea as well as means through which the international community can monitor the use of space. The summer edition gave an update of what Britain's decision to leave the European Union may mean for the country's safeguards commitment, as well as an update on what's happening in the Open Skies treaty.

International dialogue on big guns stutters ...

We have focussed a great deal on conventional arms control over the spring and summer. It is evident to us at least that this field is in a perilous state. The landmark 1990 Treaty on Conventional Armed Forces in Europe (known as the CFE) is in a state of suspension. While the Vienna Document, reissued in 2011, remains adhered to, the 1992 Treaty on Open Skies faces unique challenges in the years ahead. Despite the gloomy atmosphere, there are attempts to revitalise the European arms control order.

In a late August 2016 opinion piece for the Frankfurter Allgemeine Zeitung, Germany's Foreign Minister, Frank-Walter Steinmeier, called for a renewed arms control dialogue with the Russian Federation. He noted the need for a resumption of the verification regime and wrote that it could be possible to discuss new weapons systems and military capabilities in such a context.

Without a doubt, transparency is urgently desired. At the Fifth Review Conference of the Treaty on Conventional Armed Forces in Europe, recently concluded in Vienna, Bruce I. Turner, a Deputy Assistant Secretary at the US State Department, noted how states 'have limited information on Russia's modernized forces and no ability to verify Russian equipment levels.' He continued to observe that 'this increases the risk of military misunderstanding as Russia conducts the largest exercises on European soil in well over 20 years.'

In a comment to RIA Novosti, Mikhail Ulyanov, the Director of the Russian Federation's Foreign Ministry Department for Non-Proliferation and Arms Control, said that the 'previous CFE is outdated and there can be no return to it, but talks on something new are possible.' He ruled out a Russian initiative, however, stating that 'previous attempts to end the crisis in the control mechanisms for conventional arms failed, and not because of Russia, I am certain. Considering this, we have given the NATO side the opportunity to initiate.'

The key takeaway is that neither Western Europe nor Russia appears to desire an unmonitored buildup of conventional forces. While, armament levels in Europe are much lower today than they were at the end of the cold war, conventional forces have been modernised, and new technologies have been added to the armouries. From that perspective, a fresh examination of transparency needs in Europe appears urgently needed. What is not clear, however, is how to start this review, and how to ensure that it results in a renewed, stronger, relationship between East and West. The emphasis on transparency, monitoring and verification appear to be shared, and perhaps a discussion on those matters could provide a much needed square one.

... while all agree on the need to tackle climate change

The Paris Agreement will enter into force on 4 November 2016. US President Barack Obama has called this 'a turning point for our planet.' The UN Secretary-General called the rapid adoption of the pact 'testament for the urgency of action.'

The treaty rests on three main aims: First, holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Second, increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and finally making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

Parties have pledged to achieve these goals through what's known as 'nationally determined contributions' (NDCs) that are meant to be 'ambitious'. These NDCs are publicly available statements. While these are not formally verified, they are subject to review. The treaty's Conference of the Parties are required to take stock of implementation on a periodic basis, and the first such review will be conducted in 2023, and then every five years after that.

The pact is not without its opponents. The 2016 US Republican Party platform rejects the treaty, and since President Obama has chosen to bind his country through 'executive agreement' it could be relatively easily be reversed by a Republican president. (This route is not uncommon: in 2009, the University of Michigan found that 94.3% of all agreements entered into by the US between 1939-1989 were sealed through such agreements).

In a statement published 5 October, the UN Secretary-General opined that 'what once seemed unthinkable is now unstoppable.' Whether this is true remains to be seen. However, the global sense of urgency to try to mitigate the effects of climate change represents a rare, and much needed, display of international consensus.

National Implementation

Scott Spence

During this quarter, programme staff prepared legislation surveys for the implementation of the Biological Weapons Convention (BWC) for two States, and for the implementation of the Chemical Weapons Convention (CWC) for one State.

On 7-8 July, Programme Director Scott Spence attended the Fifth Consultative Meeting of the EU Non-Proliferation Consortium in Brussels and delivered a statement during the second panel on the way forward with UN Security Council Resolution 1540.

On 25-29 July, he travelled to San Ignacio, Belize, to participate in the World Organization for Animal Health /Belize Veterinary Legislative Identification Mission, where he presented on the legislative frameworks for addressing biological threats to the food supply.

The following month, Scott gave VERTIC's statement to the Preparatory Committee for the Eighth BWC Review Conference and also attended the PrepCom meeting during 8-12 August in Geneva. On 23-24 August, again in Geneva, he participated in the Second Conference of the States Parties to the Arms Trade Treaty.

Deputy Executive Director, Angela Woodward, participated in the International School of Nuclear Law (ISNL) at the University of Montpellier, France during 22 August-4 September, with her costs paid by a grant from the New Zealand Peace and Disarmament Education Trust (PADET).

In September, the programme participated in a series of meetings to launch EU CBRN Centres of Excellence Project 53, for which VERTIC has joined a UK-led consortium of experts to strengthen the national legal frameworks and provide specialised training on biosafety and biosecurity in Central Asian countries. Scott attended the kick-off meeting for the project's implementers in Brussels on 1 September, while Angela took part in the meetings to introduce the project to Kyrgyzstan, Uzbekistan, Afghanistan and Tajikistan during 19-29 September.

Verification and Monitoring

Larry MacFaul

During the summer, the programme focused on an exciting and diverse range of new and ongoing activities. Outreach to governments and research began on our new project to facilitate nuclear security reporting by states. The project is run in collaboration with NTI and will explore states' experiences and views on reporting on the current assortment of nuclear security instruments. We also commenced discussions with stakeholders under a new project on the Open Skies Treaty. This agreement, developed in the early 1990's, established a regime of unarmed observation flights over the territories of parties.

The team completed survey work and provided assistance at the 'Additional Protocol and Safeguards Implementation Workshop for Sub-Saharan Africa' organised by the US International Nuclear Safeguards Engagement Program of the National Nuclear Security Administration. The workshop included representatives from Benin, Cameroon, Cote d'Ivoire, Senegal, Zambia and Zimbabwe. Officials from the International Atomic Energy Agency also participated.

Towards the end of the quarter, we began planning activities for a new project to examine the establishment of a Group of Scientific Experts for Nuclear Disarmament Verification. The project will consider how a network might foster a disarmament verification research community in and across developing and developed regions

From 25 to 30 September, VERTIC participated in the 60th IAEA General Conference in Vienna during which the team engaged in a wide range of bilateral meetings with stakeholders from government and international organisations across our new and ongoing projects.

Grants and administration

Katherine Tajer

In September, VERTIC sadly bid adieu to two members of staff, Hugh Chalmers and Alberto Muti. Hugh Chalmers, who worked for the VM Programme for two years, is now employed by the UK's Department for Business, Energy and Industrial Strategy. We thank him for his work as a Senior Researcher and frequent contributor to this publication. His work on disarmament verification, in particular, was invaluable. Alberto Muti left the organisation after three years of service as a Researcher in the VM programme, for King's College London. Alberto played a major role in developing VERTIC's safeguards work. We wish them every success in their new positions. The NIM programme has also had to say goodbye to a member of staff. Giuseppe Di Lucia, who joined VERTIC as an intern in November 2015 and was then promoted to Assistant Legal Officer, left VERTIC in August. He will now join NATO in Brussels as an intern. We wish him well.

Summer brought to a close a successful fundraising campaign. In July, the Nuclear Threat Initiative and the Dutch Ministry of Foreign Affairs co-funded a project on nuclear security. Separately, the Dutch approved a project on an online implementation tool and a report on the legislative implementation of the BWC. In August, the Centre joined a UK-led consortium to implement CBRN project 53 under a contract with the EU commission. In September, we agreed on projects with the Foreign & Commonwealth Office, the Norwegian Ministry of Foreign Affairs and the US State Department. These projects will support our work on IAEA safeguards, on nuclear disarmament, and on conventional arms control.

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building trust through verification

VERTIC is an independent, not-for-profit, nongovernmental organisation. Our mission is to support the development, implementation and effectiveness of international agreements and related regional and national initiatives, with particular attention to issues of monitoring, review, legislation and verification. We conduct research, analysis and provide expert advice and information to governments and other stakeholders. We also provide support for capacity building, training, legislative assistance and cooperation.

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EDITION 153
Editing and production by Andreas Persbo.

ORIGINAL DESIGN
Richard Jones

SUBSCRIPTION
Trust & Verify is a free publication. To subscribe, please enter your e-mail address in the subscription request box on the VERTIC website. Subscriptions can also be requested by contacting Katherine Tajer at katherine.tajer@vertic.org