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# CTBTO SPECTRUM

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CTBTO PREPARATORY COMMISSION

PUTTING AN END TO NUCLEAR EXPLOSIONS

COMMISSIONER, JAPAN ATOMIC ENERGY COMMISSION

**NOBUYASU ABE**

VICE CHAIRMAN, NUCLEAR THREAT INITIATIVE

**DES BROWNE**

FORMER UN HIGH REPRESENTATIVE FOR DISARMAMENT AFFAIRS

**SÉRGIO de QUEIROZ DUARTE**

CTBTO EXECUTIVE SECRETARY EMERITUS

**WOLFGANG HOFFMANN**

FORMER PRIME MINISTER OF AUSTRALIA

**KEVIN RUDD**

## The Comprehensive Nuclear-Test-Ban Treaty (CTBT) bans all nuclear explosions.

## It opened for signature on 24 September 1996 in New York.

As of April 2015, 183 countries had signed the Treaty and 164 had ratified it. Of the 44 nuclear capable States which must ratify the CTBT for it to enter into force (the Annex 2 countries), 36 have done so to date while eight have yet to ratify: China, the Democratic People's Republic of Korea, Egypt, India, Iran, Israel, Pakistan and the United States.

The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) consists of the States Signatories and the Provisional Technical Secretariat.

The main tasks of the CTBTO are to promote signatures and ratifications and to establish a global verification regime capable of detecting nuclear explosions underground, underwater and in the atmosphere.

The regime must be operational when the Treaty enters into force. It will consist of 337 monitoring facilities supported by an International Data Centre and on-site inspection measures. As of 17 April 2015 over 85 percent of the facilities at the International Monitoring System (IMS) were operational.

THIS ISSUE'S COVER

# Atomic Overlook

### by Clay Lipsky

**ABOUT THE ARTIST**

Clay Lipsky is a fine art photographer and Emmy Award winning graphic designer based in Los Angeles, California. His artwork has been published and exhibited internationally, most notably with Esquire Russia, Ballarat Foto Bienalle, Lishui China Photo Festival, The Annenberg Space for Photography and the Smithsonian's National Atomic Testing Museum. For more info visit http://ClayLipsky.com

I was raised during the height of the Cold War, when the threat of nuclear war loomed between two superpowers. The dramatized depictions in TV and film of such an apocalyptic demise both intrigued and scared me as a child, yet the actual historical record of the atomic age was full of antiquated, black and white images that seemed dated and a world away.

This series re-contextualizes a legacy of atomic bomb tests in order to keep the ongoing nuclear threat fresh and omnipresent. Imagine if the advent of the atomic era occurred during today's information age with tourists gathering to view bomb tests at the "safe" distances used in the 1950s and sharing the resulting cell phone photos online. Atomic Overlook also speaks to the current state of the world, a voyeuristic, tourist filled culture where catastrophe is viewed as entertainment by increasingly desensitized masses.

The iconic mushroom cloud, a loaded symbol burned into our collective subconscious, represents a triumph of science, apocalyptic destruction and even national pride but in this case can also serve as a metaphor for larger societal issues such as global warming, industrialization and pollution. Issues that seemingly breed an adopted apathy, where individuals can do little but stand by and watch.

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# EDITORIAL
## LASSINA ZERBO
### CTBTO EXECUTIVE SECRETARY

*I am pleased to welcome you to this issue of Spectrum which coincides with the 2015 Review Conference of the Nuclear Non-Proliferation Treaty (NPT), the Treaty which entrenches the promise of a universal nuclear test ban. This is also the year in which the Science and Technology 2015 Conference and two meetings of the Group of Eminent Persons (GEM) – generously hosted by the Republic of Korea and by Japan – will be held. It is a pleasure to introduce here a number of high-calibre contributors to show the breadth of our work in these diverse fora.*

*As we approach the 20th anniversary of the opening for signature of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), we must not lose the sense of urgency in bringing this Treaty into force – a point made clearly and forcefully in this issue by members of the Group of Eminent Persons.*

*In her article, the President-designate of the NPT Review Conference, Ambassador Taous Feroukhi, explains how the CTBT helps to bridge gaps between the diverging interests of NPT Member States. I share Ambassador Feroukhi's conviction that "the NPT and the CTBT are brothers that can only stand strong together."*

*The 2012 NPT Review Conference reaffirmed the "vital importance" of entry into force of the CTBT as a core element of the international nuclear disarmament and non-proliferation regime. It is indeed disheartening that while the importance of the Treaty's entry into force has been widely recognized by the international community, it is yet to be reached.*

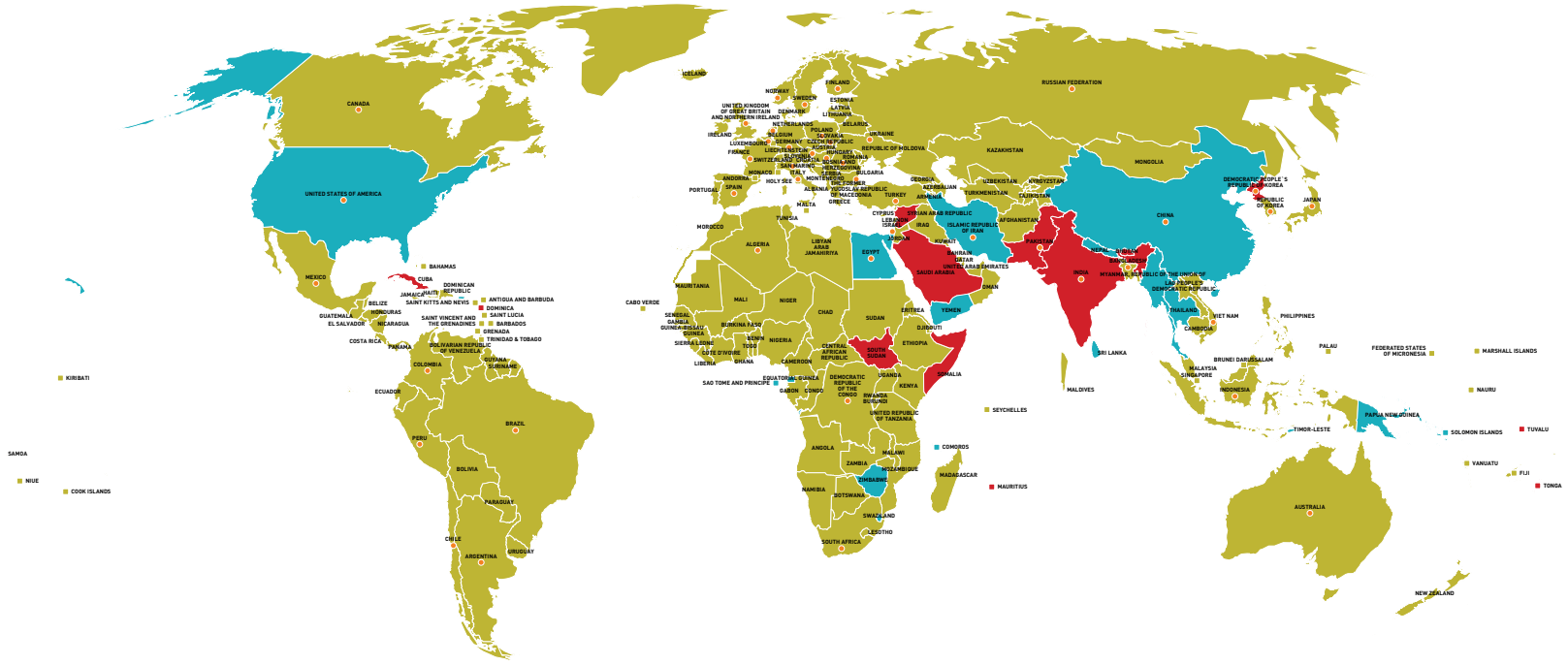
*But the news is not all bad. One reason for optimism is the close and fruitful cooperation of States within the framework of the CTBT, particularly in the Middle East, over recent months. The Integrated Field Exercise 2014 (IFE14) in Jordan in late 2014 was a milestone for the development of the CTBT's on-site inspection (OSI) regime. Once again, I wish to express my deep gratitude to the government of Jordan for its outstanding hospitality.*

*During the exercise, experts from all continents worked side by side for a common goal. IFE14 was thus an encouraging example of how the CTBT can foster cooperation amongst countries that do not usually see eye to eye on security issues. In this issue, you will find the personal reflections of several of the key protagonists involved in IFE14.*

*The significant progress made towards the completion of the International Monitoring System (IMS) network provides further grounds for optimism. This issue of Spectrum features contributions by our scientific colleagues and collaborators, including the CTBTO's new IMS Director Nurcan Meral Özel. Installing an IMS station in a remote location under difficult circumstances can prove extremely challenging. IMS engineer James Robertson chronicles the challenges he and his colleague and the Papuan officials encountered during the installation and certification of infrasound station IS40 in the tropical forests of Kerevat, Papua New Guinea.*

*As the CTBT verification regime approaches completion, Angola's ratification on 20 March 2015 has also moved the Treaty one step closer to universalization. The recently appointed co-chairs of the Article XIV process, Japan and Kazakhstan, are leading international efforts toward entry into force. With their dedication and wide-ranging experience, I am confident that members of the Group of Eminent Persons will continue to ensure that the CTBT's entry into force remains on the political agenda of the key States that must still ratify the Treaty. What the Treaty needs is leadership. Leadership from the remaining eight countries to ratify the CTBT, making entry into force a reality. The ball is in their court.*

# STATUS OF SIGNATURES AND RATIFICATIONS
## AS OF 17 APRIL 2015




| SIGNATORY STATES | RATIFYING STATES | NON-SIGNATORY STATES |
|---|---|---|
| 183 | 164 | 13 |
| 41 | 36 | 3 |

● ANNEX 2 STATES: 44

FOR MORE DETAILED INFORMATION ON SIGNATURES AND RATIFICATION VISIT CTBTO.ORG/MAP

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# The Group of Eminent Persons (GEM)

*Some of the participants at the meeting of the Group of Eminent Persons (GEM) in Stockholm, Sweden, April 2014.*

In September 2013, a group comprising global leaders, senior political figures and high-ranking diplomats from Member States was established at the United Nations Headquarters in New York. This Group of Eminent Persons – also known as the GEM – aims to ensure an innovative and focused approach to advance the ratification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) by the eight remaining Annex 2 States: China, the Democratic People's Republic of Korea, Egypt, India, Iran, Israel, Pakistan, and the United States. The Annex 2 States are the 44 countries that formally participated in the negotiations of the CTBT between 1994 and 1996, and possessed nuclear power or research reactors at the time. All of these States must ratify the Treaty for it to enter into force.

Through their expertise, experience and political standing, the Group supports and complements efforts to promote the Treaty's entry into force as well as reinvigorating international endeavours to achieve this goal.

In this issue of Spectrum, five members of the Group describe why they believe the CTBT's entry into force is so crucial and their personal efforts in helping to realize this objective.

*Left to right: Former Australian Prime Minister Kevin Rudd; former Director General of the IAEA Hans Blix; and CTBTO Executive Secretary Lassina Zerbo during a panel discussion, Stockholm, Sweden, April 2014.*

# Cementing the trend away from nuclear weapons

BY NOBUYASU ABE

It has been more than 18 years since I sat at a strategy session hosted by the then Australian UN Ambassador, Richard Butler, in New York in 1996 to move the draft Comprehensive Nuclear-Test-Ban Treaty (CTBT) for adoption in the General Assembly. Since then 183 countries have signed and 164 have ratified the CTBT but it has yet to enter into force because eight countries whose ratification is required have not yet done so. We need to bring the Treaty into force as soon as possible to put the world firmly on the road towards the elimination of nuclear weapons, to prevent the proliferation of such weapons until then, and to drastically inhibit the upgrading of nuclear weapons by those who already have them. The Treaty is a very good instrument for these purposes and that's exactly the reason why the remaining countries have not ratified.

Some analysts argue that these eight countries, i.e. China, the Democratic People's Republic of Korea (North Korea), Egypt, India, Iran, Israel, Pakistan and the United States, are an intransigent group and that it is virtually impossible to convince them to ratify. But in fact, none of them, except North Korea, has objected to the Treaty outright. All but India, Pakistan and North Korea have signed the CTBT, theoretically expressing their intention to become parties to the Treaty. India has stated that it would not stand in the way of the entry into force of the Treaty. Pakistan has even indicated it is ready to join the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) if India does. If so, why not the CTBT?

While we work on the non-ratifiers, there are many things that can be done.

1. Complete the International Monitoring System (IMS), composed of 337 seismic, infrasound, hydroacoustic and radionuclide monitoring facilities, of which around 85% are already operational. And ensure that on-site inspection capabilities are fully developed upon entry into force. With the verification regime fully established, this will help mount the pressure on anybody who might try to conduct a clandestine nuclear test as it will definitely be detected and condemned.
2. Ensure that the declared moratoria on nuclear testing remain in place until the CTBT enters into force. The U.S., Russia, Britain, France, China, India, and Pakistan have declared moratoria on nuclear testing in varying degrees. It is only North Korea that has tested since 1998, for which it has been condemned by the UN Security Council through resolutions which have imposed sanctions on the country. The resolutions must be enforced.
3. CTBTO Member States should make their assessed contributions in full, even before the CTBT has entered into force.[1] Any additional voluntary contributions would also be greatly welcomed.
4. Make use of the data available from the IMS for civil and scientific purposes such as for human welfare. While carrying out the difficult task of detecting remote clandestine nuclear tests, IMS stations also produce high quality precision data about the Earth's activities, for example. The CTBTO has already started making its seismic data available to international tsunami warning networks. Radionuclide data from the Takasaki monitoring station in Japan provided to people in and around Japan after the Fukushima nuclear accident in March 2011 proved to be both reliable and of high quality. These activities will help win the support of people around the world for the maintenance of the IMS.
5. Member States might also consider establishing additional monitoring stations in low-latitude areas where the mandated monitoring stations are sparse.[2] Traditionally, countries conducted tests in their own territories or outside under certain international arrangements. In the future, rogue States or non-State actors might conduct tests in failing States or in areas where there are fewer monitoring stations.

[1] The Resolution establishing the Preparatory Commission states in paragraph 5(a) that the costs of the CTBTO and its activities shall be met annually by all States Signatories, in accordance with the UN scale of assessment.

[2] Paragraphs 27 and 28 of Article IV of the CTBT foresee the establishment of cooperating national facilities (CNFs) for this very purpose. Since CNFs could be formally established only after entry into force of the Treaty, the CTBTO has envisaged during the preparatory phase, that prototype CNFs participate in cooperative experiments prior to entry into force (see CTBT/PC/III/1/Add.2, 19 September 1997, Appendix XVIII).

BIOGRAPHICAL NOTES

NOBUYASU ABE

is currently a Commissioner at the Japan Atomic Energy Commission. He served as the United Nations Under-Secretary-General for Disarmament Affairs from 2003 to 2006. He was the Ambassador of Japan to the International Atomic Energy Agency and other international organizations in Vienna from 1999 to 2001, and Director-General for Arms Control and Science at the Japanese Ministry of Foreign Affairs from 1997 to 1999.

# Verifying the nuclear test-ban: A regime that works

BY DES BROWNE

*There is hereby established the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization for the purpose of carrying out the necessary preparations for the effective implementation of the Comprehensive Nuclear-Test-Ban Treaty, and for preparing for the first session of the Conference of the States Parties to that Treaty.*
– Adopted by CTBT signatory States at the United Nations, 19 November 1996

Nearly two decades ago, signatory States to the Comprehensive Nuclear-Test-Ban Treaty (CTBT) voted to establish a Preparatory Commission to pave the way for implementation of a fully ratified treaty. By any measure, the new Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) was given a monumental task: to build a global verification regime to monitor compliance with the Treaty once it entered into force.

The CTBTO was given hundreds of complex and discrete assignments for creating this new regime, including developing operating instructions for seismological, radionuclide, hydroacoustic and infrasound monitoring; establishing an International Data Centre and global communications systems for reporting and analyzing information; and adopting procedures for on-site inspections.

Around the same time, another preparatory committee, formed in 1993 when the Chemical Weapons Convention (CWC) was adopted, was winding up its work. It would go out of business four years after its creation, when the CWC entered into force in April 1997.

Signatories to the CTBT may not have anticipated the creation of a global verification regime and full ratification in a similar time frame, but surely they didn't imagine there would still be need for a so-called "Preparatory" Commission well into the 21st century.

And there isn't. Today, the CTBTO Preparatory Commission has achieved all it was called upon to do and more. Not only is it setting up a global surveillance system with 337 monitoring facilities (of which 281 have already been certified) that is supported by global communications infrastructure, it has done the delicate and no less important work of building relationships among the countries that make up the system. Although Member States clearly own the stations that make up the CTBTO's International Monitoring System and the information they provide, States ensure that the stations transmit vast amounts of data every day to the CTBTO's headquarters in Vienna for analysis. As a result, the world now has the technical ability to identify any activity that would be a breach of the Treaty – and to get there, the CTBTO has built a network of unheralded and enviable engagement among countries.

The verification system also comes with a tremendous side benefit for humanity. Data generated by the CTBTO's monitoring stations offer a host of civil and scientific applications, such as contributing to disaster mitigation. For example, the CTBTO shares data with a number of tsunami warning centres and also tracked the dispersal of radioactive emissions after the Fukushima Daiichi nuclear power plant accident in March 2011.

With all of that work done, the idea that the CTBTO is still in the "preparatory" stage is absurd. Nearly two decades after it was created, the CTBTO today is managing the system it has built and awaiting the Treaty's entry into force. It is no longer paving the way. As CTBTO Executive Secretary Lassina Zerbo said in 2014 in a speech to mark the International Day against Nuclear Testing, "Although still labelled as a 'preparatory' organization, we are anything but preparatory in our work." The CTBTO has proven the concept that a system of verification could be built and that it could work – the basis upon which many countries signed onto the Treaty in the first place. Those who haven't ratified should no longer be given the cover offered by the suggestion that preparatory work is still underway. The CTBTO has fulfilled its task and built a remarkable verification regime. It's time to be honest about that and remove the word "preparatory" from its name.

**BIOGRAPHICAL NOTES**

## DES BROWNE

Lord Browne of Ladyton is a British Labour Party politician and a former Member of Parliament who now serves as the Vice Chairman of the Nuclear Threat Initiative, Convenor of the Top Level Group of UK Parliamentarians for Nuclear Disarmament and Non-Proliferation, and Chair of the Executive Board of the European Leadership Network. He served as the UK's Secretary of State for Defence from 2006 to 2008 and as Secretary of State for Scotland from 2007 to 2008. He has been a member of the House of Lords since 2010.

# The nuclear test-ban and international law

BY SÉRGIO de QUEIROZ DUARTE

Since the first nuclear test in 1945, public opinion worldwide has been concerned with their harmful consequences. During the second half of the 20th century more than 2,000 nuclear weapon tests were carried out both in the atmosphere and underground. The escalation of the nuclear arms race, together with the risk of further proliferation of atomic weapons, helped provide impetus for the negotiation of agreements aimed at curbing such test explosions as an effective non-proliferation tool and as a step toward achieving the goal of nuclear disarmament. The Partial Test Ban Treaty (PTBT) concluded between the United States, the Soviet Union and the United Kingdom in 1963 was the starting point for subsequent efforts to extend the prohibition to all environments.

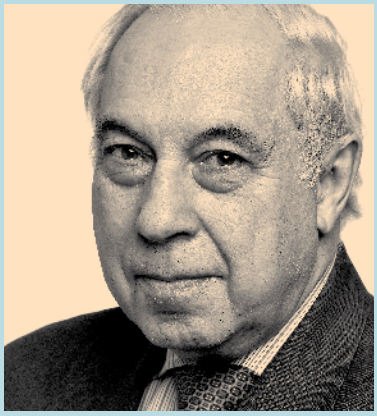
Thirty-six years later, the United Nations General Assembly adopted the Comprehensive Nuclear-Test-Ban Treaty (CTBT), a longstanding priority objective of the international community. To date, 183 States have signed and 164 have ratified it. The Treaty instituted an International Monitoring System (IMS) with 321 monitoring stations and 16 radionuclide laboratories worldwide, supported by an International Data Centre. The IMS is nearing completion and at the entry into force of the CTBT the verification regime will be able to meet its verification requirements. The IMS has already proven its practical worth in detecting the three nuclear explosions conducted by the Democratic People's Republic of Korea (DPRK), and in providing data to a number of tsunami warning centres, thus increasing their ability to issue rapid tsunami warnings.

However, despite its importance, the CTBT is not yet formally in effect. Ratification by eight States – China, the DPRK, Egypt, India, Iran, Israel, Pakistan and the United States of America – a necessary condition for its entry into force – is still pending. A group of international personalities experienced in disarmament issues – the Group of Eminent Persons (GEM) – set up by the Executive Secretary of the CTBTO in September 2013, is working with governments and non-governmental organizations directly concerned in order to promote the universalization of the Treaty. In their individual capacity, the members of this group participate in seminars and international conferences and avail themselves of every opportunity to explain to specialized audiences and the public at large the significance of the Treaty and the need for its full entry into force.

With the exception of the DPRK, all States possessing nuclear weapons have observed a voluntary moratorium on test explosions since the mid-1990s. This is an encouraging sign, but not enough. The international community needs to do more. The carrying out of a nuclear test by any State would entail the end of the current situation and would represent a serious challenge to international peace and security. The worldwide concern with the catastrophic consequences of any nuclear explosion expressed at the 2010 Review Conference of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), as well as the results of three important international meetings held since then, underscore the urgent need to make the prohibition mandatory under international law. Progress toward the entry into force of the Treaty would also be a factor for the success of the 2015 NPT Review Conference.

Completion of internal legal procedures for the ratification of the CTBT by the eight States mentioned above is in the security interests of all States, as well as that of humanity as a whole. The Treaty has already set a strong standard, but only by becoming part of positive international law will it be able to provide a powerful, verifiable legal barrier against proliferation and strengthen efforts toward nuclear disarmament.

**BIOGRAPHICAL NOTES**



## SÉRGIO de QUEIROZ DUARTE

was the UN High Representative for Disarmament Affairs from 2007 to 2012. In 2005, Duarte presided over the NPT Review Conference. From 2003 to 2004, he served as Brazil's Roving Ambassador for Disarmament Affairs. Prior to this, he was Brazil's Permanent Representative to the UN at Vienna and Chairman of the International Atomic Energy Agency Board of Governors. He also served as Ambassador to Nicaragua, Canada and China.

# A view on the Comprehensive Nuclear-Test-Ban Treaty (CTBT)

BY WOLFGANG HOFFMANN

I have seen the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) grow from the very beginning because I had the privilege to represent Germany when the CTBT was being negotiated in Geneva from 1994 to 1996. I was subsequently elected the first Executive Secretary of the new organization. I therefore follow with great interest and empathy the CTBTO's development under my successors, Tibor Tóth and Lassina Zerbo.

We began in 1997 with a handful of people and technical assistance provided by other international organizations at the Vienna International Centre. The preparatory work and help from the scientific community helped us make quick progress. From the beginning we tried to be modest in terms of personnel and financial resources. Member States gave us all the necessary political and financial support which meant that we were recognized as a legitimate partner by States and international organizations.

Since its inception, the CTBTO has established a rapidly growing network of monitoring stations, as foreseen in the Treaty. It was already possible in 1998 to monitor the nuclear explosions in India and Pakistan. The more recent explosions in North Korea were detected with reliability and precision. The verification system has now developed in such a way that nobody could detonate a nuclear device and evade detection. We owe this success to a competent and highly motivated staff who work for an organization that has a higher percentage of women than most of its international counterparts.

While the system's primary purpose is to detect nuclear explosions, the monitoring data – which belong to Member States – can also offer civil and scientific benefits such as providing valuable information for tsunami warnings. Even some countries that haven't yet signed the Treaty benefit from CTBTO data through their cooperation with other organizations on tsunami warnings. And monitoring the atmosphere can, for example, help warn air traffic controllers of ash from volcanic eruptions.

Under the able leadership of Lassina Zerbo, the development of the verification regime has reached its final stage. Even on-site inspection capabilities[1] have been fully developed and were tested successfully during the Integrated Field Exercise 2014 in Jordan.

The status of signatures and ratifications indicates the worldwide support for an end to nuclear testing: with 183 signatures, there are only 13 States which have not yet signed. And 164 States have ratified. The problem is that the Treaty has not yet entered into force. The reason for this is a rather complicated formula we agreed on during the final phase of CTBT negotiations. Generally, a certain number of ratifications are sufficient for entry into force. In the case of the CTBT, however, 44 States with nuclear capabilities must ratify. Of these, 36 have already ratified but eight have not; three of them have not even signed.

When Lassina Zerbo was elected Executive Secretary he proposed the creation of a Group of Eminent Persons to help solve this problem. States agreed and a group of around 20 personalities from politics, science, diplomacy and administration came together. The first meeting took place in September 2013. Work was divided into three groups of countries. Members developed different methods to influence the governments of the eight remaining countries. Articles and letters have been written, and meetings have been held with governments, politicians and members of civil society. Recently, I've been able to talk to governments and civil society in India and Pakistan with the financial and logistical assistance of the German Foreign Ministry. This endeavour must go on and it will go on.

[1] An on-site inspection can only be launched after the CTBT's entry into force.

**BIOGRAPHICAL NOTES**

## WOLFGANG HOFFMANN

served as the first Executive Secretary of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization from March 1997 until August 2005. Prior to this he was the German Ambassador to the Conference on Disarmament in Geneva from 1993 to 1997, where negotiations for the Comprehensive Nuclear-Test-Ban Treaty took place between 1994 and 1996. A lawyer by profession, He entered the German Foreign Service in 1965 where he held different positions, especially in the multilateral field.

# A U.S.-China roadmap for CTBT ratification

BY KEVIN RUDD

Nearly two decades after Australia introduced the text of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) to the UN General Assembly, we find ourselves at a crossroads. Only three P-5 countries – Russia, France and the UK – have ratified the CTBT. The U.S. and China have not, and show no signs of doing so.

Why does the CTBT's entry into force seem more remote than it was in 1996? There are two reasons: the U.S. Senate, and China's position that its ratification is conditional on U.S. ratification.

Australians are no newcomers to the global fight against nuclear proliferation. In 1952, Great Britain carried out its first nuclear test on Australian soil. Safety protocols for observers included placing their hands over their eyes. Today, numerous Aboriginal inhabitants of the Maralinga test site report chronic illnesses related to radiological contamination.

From the 1970s on, we also campaigned for decades to bring about a cessation of French nuclear testing in the South Pacific. Since then, Australia has enjoyed the benefit of bipartisan support on the CTBT. When talks on the CTBT stalled in Geneva in the 1990s, Australia, backed by 127 co-sponsors, introduced the text and saw it pass overwhelmingly.

As Prime Minister and Foreign Minister, I too pushed for ratification by the remaining Annex 2 States. At the 2011 CTBT Article XIV conference[1] in New York, I argued such action represented a significant confidence-building measure, especially in regions where tensions – and the potential for costly and dangerous arms races – are high.

[1] Named after the CTBT's article XIV, these conferences take place every two years and aim to promote the CTBT's entry into force.

Last year, during the Group of Eminent Persons meeting in Sweden, I argued that movement by the United States and China is not only central to advancing the CTBT's entry into force, it would also constitute a major confidence and security building measure between Beijing and Washington at a time when U.S.-China relations are entering a new phase.

Here the Obama-Xi relationship is central. Xi calls for a "new type of great power relationship" with the U.S. Joint ratification of the CTBT could make up one key element of this. It would also deliver to President Obama a critical legacy. Furthermore, given changing power relativities between China and the U.S. over time, it makes sense for the U.S. to see Chinese ratification sooner rather than later.

I am not naive concerning the entrenched opposition from some in the U.S. Senate. But the argument needs to be put to the treaty's opponents as to why it is in U.S. strategic interests to ratify now, rather than sometime in the "sweet bye and bye," if indeed ever. Furthermore, does the U.S. wish to risk its continuing non-ratification becoming a pretext for Russia to reconsider its commitment to the Treaty?

U.S.-China action on the CTBT would not make the Treaty's ratification by holdout States inevitable. But the momentum it creates would make it much harder for remaining Annex 2 states to resist. Some suggest that India has linked its potential ratification to China's. Pakistan, similarly, has pegged its ratification to India's own. North Korea, however, represents an entirely different world of pain.

The benefits of a U.S.-China approach are two-fold. Firstly, the momentum this partnership would bring about could see all P-5 members of the Security Council united on a crucial issue. The Council could become the cockpit of ratification, holding regular meetings to elevate the urgency of the CTBT's entry into force, and to keep the diplomatic spotlight on the remaining holdout States. Secondly, joint action of this nature also presents a tangible opportunity to build broader habits of cooperation between the U.S. and China – a bilateral relationship which will increasingly shape the global order in years to come.

I acknowledge it will take great determination, diplomatic imagination and good will to keep the CTBT ratification process in motion in years to come. A common U.S.-China effort on this front may be the CTBT's only real hope. The next Article XIV conference is likely to take place in September 2015. The time is ripe for the U.S. and China to seize this opportunity to act.

**BIOGRAPHICAL NOTES**

KEVIN RUDD joined the Asia Society Policy Institute as its inaugural President in January 2015. He served as Australia's 26th and 28th Prime Minister (2007-2010, 2013) and as Foreign Minister (2010-2012). He recently led a major research project on U.S.-China relations at the Harvard Kennedy School, where he is a Senior Fellow. As Chair of the Independent Commission on Multilateralism, he is also leading a review of the UN system over the 2015-16 period.

*Photo courtesy of IAEA/Dean Calma*

VOICES

# Two treaties closely intertwined

BY TAOUS FEROUKHI
SENIOR ADVISOR TO
THE FOREIGN MINISTER,
ALGERIAN MINISTRY
OF FOREIGN AFFAIRS

»As an inhomogeneous group with a wide range of diverging interests, NPT Member States as a group have much to gain from embracing the CTBT.«

On the eve of the 2015 Review Conference for the Nuclear Non-Proliferation Treaty (NPT), which I shall have the honour to preside over, it is timely to recall the close relationship between the 1968 NPT and its younger sibling, the 1996 Comprehensive Nuclear-Test-Ban Treaty (CTBT). The fate of these two treaties is closely intertwined.

The NPT makes reference to nuclear testing in its preamble,in which it enunciates the very essence of the CTBT long before it was adopted, namely: to "seek to achieve the discontinuance of all test explosions of nuclear weapons for all time. "In its Article IX, the NPT defines a nuclear weapon State as one that has"manufactured and exploded a nuclear weapon or other nuclear explosive device prior to 1 January 1967."

This two-tier system, along with the strong differences in emphasis that Member States place on the NPT's three pillars – nuclear non-proliferation, nuclear disarmament and the peaceful use of nuclear energy – is the root cause for the inherent tensions that have complicated and in some cases even prevented agreement on a final document during previous NPT Review Conferences. A most formidable challenge for any chairperson's negotiating skills!

The CTBT, on the other hand, knows no such distinction between Member States. It imposes the same obligation on all: to refrain from all forms of nuclear explosive testing, in all environments.

In spite of this obvious merit, though, the CTBT has the dubious distinction of featuring one of the most demanding entry-into-force clauses ever negotiated in treaty history. With ratifications still required by eight of the 44 Annex 2 States – the countries defined as nuclear technology holders when the CTBT was negotiated and which must all ratify – the Treaty's entry into force unfortunately remains unlikely in the short to medium term.

I am proud to say that my home country, Algeria, which also features


*General Assembly Hall, UN Headquarters in New York, Venue of the 2010 High-level Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).*

amongst the Annex 2 States, was one of the first countries to sign the CTBT, subsequently ratifying it in 2003. Given my country's painful experience with nuclear tests that were conducted on our own territory and without our consent, embracing the CTBT came naturally.

## A FORMIDABLE VERIFICATION REGIME

Despite not having entered into force, the CTBT has already by and large succeeded in stopping nuclear testing. The only country to have tested this century is North Korea. Moreover, the CTBT's formidable verification regime, while it is still officially in provisional operational mode, has demonstrated its capabilities to detect even small underground nuclear tests both impressively and repeatedly.

The CTBT enjoys strong support from the vast majority of NPT Member States. This support even predates the adoption of the CTBT, and has played a central role in virtually every one of the more recent NPT Review Conferences:

- In 1990 the failure to agree upon a final declaration was the result of a disagreement between the nuclear weapon States and the Non-Aligned Movement over the lack of progress in concluding a CTBT and the implementation of the nuclear weapon States' disarmament obligations enshrined in Article VI of the NPT;
- In 1995 the CTBT, which was already being negotiated in parallel at the Conference on Disarmament in Geneva, played a key role in achieving the NPT's landmark indefinite extension. The completion of the CTBT's negotiations in September 1996 was the implementation of the first element of the three-point programme of action plan;
- At the 2000 NPT Review Conference, steps 1 and 2 of the famous "13 practical steps" highlighted the "importance and urgency" of early entry into force of the CTBT as well as the moratorium on testing, pending the Treaty's entry into force;
- In 2005 the NPT Review Conference again failed to agree on a single document or proposal. This was in part due to the refusal by one State to recognize the importance of the CTBT as one of the 13 steps agreed on in 2000;
- The 2010 Final Document, negotiated under the able chairmanship of Ambassador Libran N. Cabactulan of the Philippines, confirms the "vital importance" of the CTBT's entry into force as a "core element" of the international nuclear disarmament and non-proliferation regime. The agreed programme of action even includes a number of operative points aimed at promoting the CTBT's entry into force.

This consistent support is also likely to be evident during the upcoming NPT Review Conference. As an inhomogeneous group with a wide range of diverging interests, NPT Member States as a group have much to gain from embracing the CTBT.

## BRIDGING THE GAPS BETWEEN THE HAVES AND THE HAVE-NOTS

By imposing the same no-test obligation on all, the CTBT's no-test norm bridges the gaps between the non-nuclear weapon States and the nuclear-weapon States. The former are barred from the first-time development of nuclear weapons, while the latter cannot resort to explosive testing to further enhance their arsenals. Instead, nuclear weapon States are obliged to resort to expensive simulation and other programmes to maintain the status quo, adding pressure to defence budgets.

The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) goes even further in levelling the playing field by assuring that all its monitoring

*United Nations Secretary-General (UNSG) Ban Ki-moon speaking at the 2010 High-Level Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The UNSG urged nations to make nuclear disarmament targets a reality.*

data – currently 15 gigabytes of data generated daily by some 300 International Monitoring System (IMS) stations around the globe – are equally available to all Member States.

I would like to compliment the CTBTO for its ambitious programmes aimed at building capacities in developing countries to enable them to make better use of CTBTO data and thus to participate proactively in CTBT verification. Experts from my home country, Algeria, have participated in such training activities on several occasions.

## BUILDING CONFIDENCE IN THE MIDDLE EAST

The CTBT can serve as a backbone and a starting point for creating a nuclear-weapon-free zone in the Middle East – a vital step toward increasing regional stability and global security. For example, it was encouraging to see participants from Egypt, Iran, Israel, and other Middle East countries participate in the recent on-site inspection exercise in Jordan, the Integrated Field Exercise 2014 (IFE14). This successful exercise has also helped to demonstrate that it is virtually impossible to hide a nuclear explosion from an on-site inspection. Unfortunately, this verification instrument will only be available to the international community once the CTBT has entered into force.

One of the determinants for the successful conclusion of the 2015 NPT Review Conference will be a balanced outcome in the three pillars of the treaty, including the implementation of the 1995 Middle East Resolution for the establishment of a zone free of nuclear and other weapons of mass destruction, as well as the ongoing negotiations on the Iranian nuclear programme between the "P5+1" and Iran. In this context, ratification of the CTBT by Middle East countries listed in Annex 2 provides a golden opportunity for an increased trust in their peaceful nuclear programmes. The CTBT's scope extends to nuclear explosions and does not impose restrictions on civilian nuclear programmes.

As a first step, the States of the region that have not yet ratified the Treaty, could consider working towards the completion of all IMS monitoring facilities by sending data to the CTBTO's headquarters in Vienna while cooperating at the technical and scientific level.

An Arabic proverb says: "*You need a brother, without one you're like a person rushing to battle without a weapon.*" It is my conviction that the NPT and the CTBT are brothers that can only stand strong together.


**BIOGRAPHICAL NOTE**

**TAOUS FEROUKHI**
was appointed as Senior Advisor to the Foreign Minister at the Algerian Ministry of Foreign Affairs in February 2015, having served as Director-General for Political Affairs and International Security from 2012 to February 2015. She was Permanent Representative of Algeria to Austria and to the UN Office at Vienna from 2001-2011, during which time she was Chair of the Board of Governors of the IAEA and Chair of the Preparatory Commission for the CTBTO.

## INTERVIEW

WITH ELLEN WILLIAMS
DIRECTOR OF THE U.S.
DEPARTMENT OF ENERGY'S
ADVANCED RESEARCH PROJECTS
AGENCY – ENERGY (ARPA-E)

# Assessing the Treaty's verifiability

**THREE YEARS AGO, THE U.S. NATIONAL ACADEMY OF SCIENCES (NAS) RELEASED A SEMINAL REPORT ON TECHNICAL ISSUES RELATED TO THE COMPREHENSIVE TEST BAN TREATY (CTBT). THE INDEPENDENT PANEL OF SENIOR SCIENTIFIC AND MILITARY EXPERTS WAS TASKED WITH REVIEWING TECHNICAL DEVELOPMENTS RELATED TO THE U.S. NUCLEAR STOCKPILE AND TO NUCLEAR EXPLOSION TEST MONITORING SINCE THE 2002 NAS REPORT ON THE CTBT. THE 2012 REPORT CONCLUDED THAT THE UNITED STATES DOES NOT NEED TO RESUME NUCLEAR TESTING TO MAINTAIN ITS SECURITY OR THE RELIABILITY OF ITS NUCLEAR WEAPONS.**

**ELLEN WILLIAMS, DIRECTOR OF THE U.S. DEPARTMENT OF ENERGY'S ADVANCED RESEARCH PROJECTS AGENCY – ENERGY, SERVED AS CHAIR OF THE PANEL. IN THIS INTERVIEW WITH THE CTBTO SHE REFLECTS ON THE MAIN ISSUES THE REPORT ADDRESSED AND ITS SIGNIFICANCE.**

I was born in 1953 so when I was growing up, my strongest early memories are from the early sixties as a child. At that time, people in the United States were very worried about the possibility of a nuclear attack and nuclear war. So in our schools we had drills to learn what to do in case there was a nuclear attack. Many people in my neighbourhood had built shelters in their basements where they could go after a nuclear attack and presumably be safe. I clearly remember the Cuban Missile Crisis and seeing the maps in the newspaper that showed how far into the United States the nuclear missiles might reach. This was very frightening for a small child, but of course very frightening for adults as well.

*When were you first involved at a professional or academic level with issues of nuclear disarmament?*

I became engaged with issues of nuclear disarmament when I was looking at problems in the United States after we had agreed to stop testing nuclear weapons. There were serious concerns about whether it was possible to maintain the safety and security of those weapons without testing. So beginning in the 1990s, I was closely engaged with learning about issues of nuclear policy and nuclear disarmament and testing.

*The certification of the noble gas monitoring system at radionuclide station RN38 in Takasaki, Japan, in December 2014 brought the total number of fully certified IMS facilities to 281. A further 19 stations have already been installed.*

*As Chair of the Panel that reviewed and updated technical issues related to the CTBT, what impact do you think the report has had on public debate in the United States and worldwide?*

During the previous debate in 1999 when the United States last discussed ratification of the CTBT, there was a great deal of confusion about technical issues and it clouded the debate. It was difficult for people to judge the issues because there were many conflicting points of view. I believe that one of the big impacts of the report has been in reconciling the earlier conflicting points of view. The report clarified the issue of different detectability levels depending, among other things, on the type of nuclear device that might be tested. This clearer perspective has resolved some previous differences, and allows discussion of the issue of detectability to be placed in the context of the sorts of nuclear threats that can be avoided under a continuing test ban.

*What were the reasons for the National Research Council report on the CTBT and the main issues it addressed?*

The CTBT study carried out by the National Research Council was requested by the United States Office of Science and Technology Policy. It was also supported by the Department of Energy, the State Department, the Carnegie Corporation, and the National Research Centre. The request for the study had to do with updating our understanding of the technical issues involved in nuclear monitoring and nuclear security. The National Research Council had conducted a study ten years earlier and policy makers wanted to know what had changed in the intervening decade.

We were specifically asked four questions. Firstly, what was the status of the United States' capability of maintaining its nuclear stockpile safely and securely in the absence of nuclear testing. Secondly, what was the status of the world's ability to monitor for nuclear tests, especially those that might be carried out evasively. Thirdly, what commitments did we as a society have to make to be able to maintain the security and stability of our monitoring system. And fourthly, what sorts of nuclear threats might be avoided under a continuing nuclear weapons test ban.

*How did the report evaluate the progress achieved in setting up the CTBTO's International Monitoring System between 2002 and 2012?*

That was one of the most pleasant and outstanding parts of the work that we saw. When the first report was being developed in 2000, the monitoring system under the CTBTO was notional. It had been planned, but little was in place. What we saw between then and 2012 was amazing progress, with the system set up to 80% completion. And by 2015 it is over 85% complete. It has achieved a truly outstanding ability to monitor – achieving much beyond the specifications and the capabilities that might have been possible in 1990. So we now see that it is possible with the CTBTO to monitor worldwide with better than one kiloton sensitivity for a normal nuclear test underground.

## NATIONAL TECHNICAL MEANS

**Satellites, aircraft, and electronic and seismic monitoring devices used by Member States to survey the activities of other States, including military movements and treaty compliance with regard to possible nuclear testing activities.**

*How did the report assess the quality of the data gathered and analysed by the CTBTO?*

The quality of the data gathered by the CTBTO is judged as very high quality. We see both the type of data that was possible in 2002, which is tele-seismic data and the new developments in regional seismic imaging. This allows us to understand much better the signatures of the explosion or the event that we see and be better able to distinguish nuclear events from things like earthquakes or mining explosions.

*What was the assessment of the overall nuclear-test-ban verification regime?*

We believe the overall package of detection methods is valuable. The national technical means (see information box) of course allow individual countries to monitor in addition to the CTBTO and they look at points of interest that are of specific concern to them. So in combination, any country can use its own networks of sensing and monitoring in combination with the CTBTO and get extremely fine coverage. We judged it as a very good combination with the CTBTO adding a lot of value to what the United States has in terms of its national technical means.

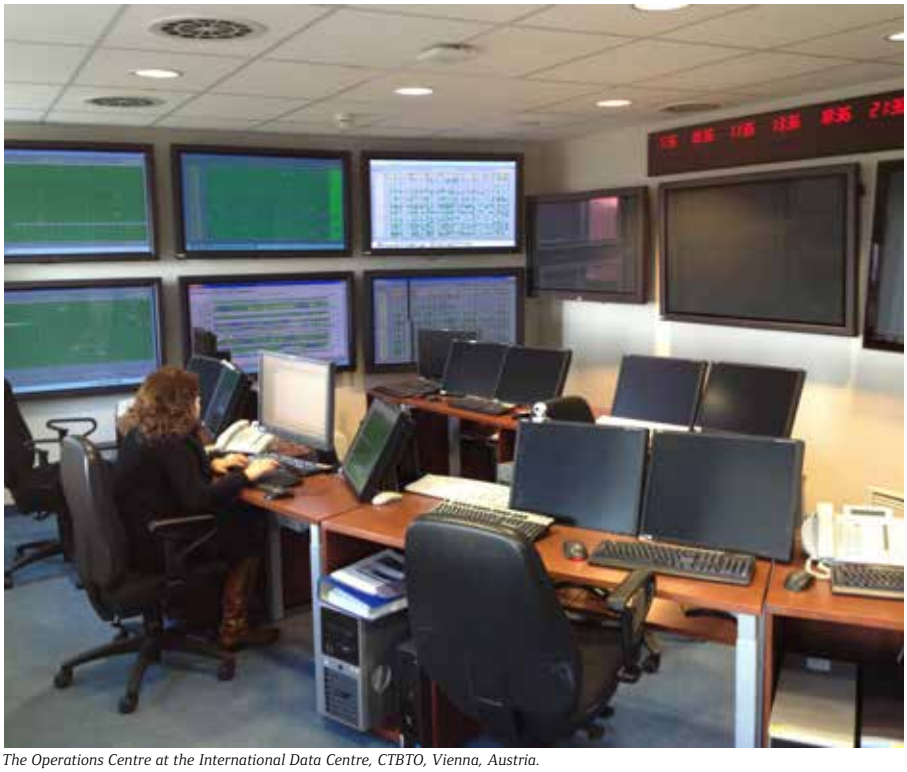
*Which parts of the report were most challenging for the Committee members and which were easy?*

In preparing the report we were specifically asked to address technical issues. Our goal was to provide clarity and understanding of the technical issues so that policymakers could have the information that they needed to make decisions. As we were writing the report, one of the things we were most concerned about was not to allow our own conclusions, deductions, or personal preferences to enter into the report. We had many long discussions to make sure that we had cleansed the report of personal opinion and kept it on a clear, sound technical level.

*How was the report received by scientists and policymakers in the United States?*

We believe it was well received. There were over one hundred newspaper articles which were generally favourable in terms of describing the report. We received feedback from scientists who were very pleased by the quality and depth of the technical information and again, we hope that as policymakers engage with more discussions about the CTBT that they have been using the report extensively to help them with their discussions.

Based on an interview conducted in Vienna in July 2012.



*The Operations Centre at the International Data Centre, CTBTO, Vienna, Austria.*

### BIOGRAPHICAL NOTE

**ELLEN WILLIAMS**
is Director of the U.S. Department of Energy's Advanced Research Projects Agency – Energy. From 2010 to 2014, she was the Chief Scientist for BP. She also served as Chair of the U.S. National Research Council Committee responsible for reviewing and updating the report on 'The Comprehensive Nuclear Test Ban Treaty: Technical Issues for the United States', released in 2012. Dr Williams is currently on a leave of absence from the University of Maryland where she has served as a Distinguished University Professor in the Department of Physics since 2000.

VOICES

# Banning nuclear explosions and the quest for nuclear disarmament

BY REBECCA JOHNSON,
DIRECTOR OF THE ACRONYM INSTITUTE
FOR DISARMAMENT DIPLOMACY

»As we saw in the final, successful push for the CTBT, partnerships between governments and civil society are necessary.«

When governments met in New York for the 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), two key developments laid the groundwork for a constructive outcome. These were: Comprehensive Nuclear-Test-Ban Treaty (CTBT) negotiations, which opened in the Conference on Disarmament (CD) in January 1994; and the ending of the Cold War, which shifted geostrategic relations and encouraged deep cuts in nuclear arsenals. Because of these developments, the nuclear-weapon States were able to argue that NPT extension was warranted because progress was finally being made on the treaty's Article VI disarmament obligations.

The CTBT was promoted for humanitarian and environmental reasons as well as disarmament and non-proliferation. Looking forward to the 2015 NPT Review Conference now, we again see deep concerns being expressed about the lack of progress on disarmament and the Middle East. As a further humanitarian disarmament approach puts the prospect of a broader nuclear ban treaty on the agenda, consideration of the intertwined histories of the NPT and the CTBT can teach us important lessons for the future.

Public and political calls for an international CTBT were made by civil society and various governments from at least 1954. After settling for a Partial Test Ban Treaty (PTBT) in 1963, Washington, Moscow and London diverted further test ban demands into efforts to stem proliferation, resulting in the adoption of the NPT in 1968. While signing up to commitments to "seek to achieve the discontinuance of all test explosions of nuclear weapons" in the NPT's preamble, they dismissed the CTBT as a long term or "ultimate" objective. They also proclaimed the CTBT "unverifiable" and tried to shift responsibility onto hold-out States, notably China and France, which were not Parties to either the NPT or PTBT during the 1970s and '80s.

When the 1990 NPT Review Conference foundered over opposition in the USA and the UK to a paragraph

»Even with the CTBT's Article XIV Achilles' heel blocking entry into force, the CTBT has proved its worth many times, turning nuclear testing from a high status demonstration of nuclear prowess into a pariah activity that responsible States must not pursue.«

on the CTBT in the draft final document text, despite agreement by all other NPT States Parties, it acted as a wake-up call. Though Washington and London accused CTBT advocates of undermining the NPT, it was clear to all that the 1995 Review and Extension Conference risked failure unless CTBT negotiations were underway by then.

## RENEWED DEBATE ON THE CONSEQUENCES OF NUCLEAR WEAPONS AND TESTING

Doctors and activists, including the Women's International League for Peace and Freedom, the Greenham Common Women's Peace Movement, the International Physicians for the Prevention of Nuclear War, and Women Working for a Nuclear Free and Independent Pacific, reinvigorated debate on the health, environmental and humanitarian consequences of nuclear weapons and testing. Encouraging and working with non-nuclear nations to renew pressure for the Treaty, NGOs took forward strategies to get the nuclear-armed States to halt their warhead testing programmes. In addition, parliamentarians and CTBT supporters in the United States, Japan and Europe argued that a CTBT was a necessary measure to strengthen and extend the NPT.

Under pressure from regional and environmental campaigns spearheaded by Greenpeace and the Nevada-Semipalatinsk Movement in Kazakhstan, the Soviet Union declared the first moratorium in 1991. France followed in April 1992, caught in an environmental-political pincer strategy from Greenpeace campaigns with a new Rainbow Warrior boat in the Pacific, and the French Green Party, which was riding high at that time, as well as parliamentarians and advisors who were pushing for France to join the NPT. The U.S. followed in 1992 in a successful legislative strategy taken forward by American NGOs, working closely with Congressional representatives. This committed the U.S. government to a nine-month testing moratorium and the target date of 30 September 1996 for CTBT conclusion.

The moratoria played an important part in 'pausing' testing by all except China, creating positive conditions for negotiations to go ahead. Though the CD achieved a negotiating mandate in 1993, it was clear from the beginning that none of the nuclear-armed States saw this as committing them to a genuinely comprehensive treaty. As described in my book "Unfinished Business"[1],Russia and the United States worked very constructively for most of the negotiations, even though they disagreed about some technical, verification and organizational issues. French and British diplomats dragged their heels as much as they could for the first 18 months. Together with China, however, they became drawn more closely in as the test ban negotiations progressed. India started constructively, but pulled away during negotiations, especially after the NPT was indefinitely extended.

Prior to May 1995, multilateral negotiations focussed mainly on institutional questions and getting agreement for the verification regime. Meanwhile, minilateral wrangling in private meetings among the P5 nuclear weapon States prioritized their own interests in what they called 'activities not prohibited' – from low-yield nuclear tests to 'safety and reliability' testing and so-called 'peaceful nuclear explosions'. Such 'exemptions' were not at all what the non-nuclear nations wanted, but they were excluded from the P5 minilaterals and were expected to go along with whatever the nuclear weapon States agreed amongst themselves.

## 1995: CTBT NEGOTIATIONS ENCOUNTER DIFFICULTIES

Though the CTBT's timely conclusion was given priority along with the NPT's extension in the package of decisions adopted by States Parties on 11 May 1995, negotiations ran into serious difficulties. China exploded a further nuclear test just days after the 1995 NPT Review and Extension Conference ended, and then a couple of months later France broke its moratorium in order to conduct six more tests in the Pacific, provoking international condemnation. India's position hardened as it tried unsuccessfully to insert commitments to time-bound nuclear disarmament into the CTBT.

Working constructively with civil society representatives in Geneva and elsewhere, the non-nuclear delegations sought to keep negotiations on track, with Mexico, Germany, Netherlands, Australia, Iran, Indonesia, Egypt, Japan, Sweden, Canada, and South Africa playing especially important roles. Presidents Clinton and Chirac helped to break the deadlock over scope in August 1995 by announcing that they would accept a "zero yield" understanding as

[1] Rebecca Johnson, *Unfinished Business: The negotiation of the CTBT and end of nuclear testing,* (United Nations, Geneva, 2009).

the CTBT's basic obligation. Though it took some months for some of the others to agree, this decision ended P5 wrangling over 'activities not prohibited' and exemptions, making the Treaty genuinely comprehensive as far as nuclear explosions were covered.

Technology, however, has continued to advance, enabling nuclear warheads to be updated and refined with in-lab testing. Concerns about this have been raised at every NPT meeting since 1995. Added to this is mounting frustration about the rivalries between nuclear-armed States inside and outside the NPT that have stymied CTBT entry into force and continued to block negotiations on interim non-proliferation steps such as a fissile materials treaty. While each NPT conference since 1995 has underlined support for the CTBT and a fissile materials treaty, pressure for a universally-applicable nuclear ban treaty has been growing since the 2010 Review Conference expressed concerns about the grave humanitarian consequences of nuclear weapons and use. As we saw in the final, successful push for the CTBT, partnerships between governments and civil society are necessary. From 2010, the International Campaign to Abolish Nuclear Weapons (ICAN) has undertaken this partnership role to carry forward the objective of a nuclear ban treaty, engaging constructively with international agencies as well as governments.

## HIGHLIGHTING THE RISKS AND CONSEQUENCES OF NUCLEAR DETONATIONS

A series of international conferences in Oslo, Norway (March 2013), Nayarit, Mexico (February 2014) and Vienna, Austria (December 2014), have highlighted the risks and consequences of nuclear detonations, whether occurring through intentional use or by accident or miscalculation. These conferences and associated joint statements in NPT meetings and the UN First Committee have underscored that the humanitarian risks are high and the consequences global, making it the business of all governments to ensure that their countries and people are protected.

The Chair of the Nayarit Conference concluded that the "broad-based and comprehensive discussions on the humanitarian impact of nuclear weapons should lead to the commitment of States and civil society to reach new international standards and norms, through a legally binding instrument". The 2014 Vienna Conference included consideration of nuclear testing, with sessions with downwinders from nuclear test sites as well as "Hibakusha" survivors from Hiroshima and Nagasaki. The powerful testimonies as well as scientific data reminded the 158 participating governments how seriously they should take the health, environmental and human impacts of nuclear weapons.

Building on this, Austria pledged to bring these important issues to the NPT in 2015 and called on governments "to identify and pursue effective measures to fill the legal gap for the prohibition and elimination of nuclear weapons". ICAN, with a broad network of over 400 humanitarian and disarmament organizations in 95 countries, argues that the time has come to "fill the legal gap" with an international nuclear ban treaty that would provide prohibitions, obligations and requirements on all States, whether or not they are NPT Parties.

## LESSONS LEARNED FROM CTBT NEGOTIATIONS

Treaties are products of their time and political conditions. Looking at how the world has changed since 1995, it is clear that demands for a universally-applicable, non-discriminatory nuclear ban treaty are going to intensify from now on. The challenge is not whether, but when. Learning lessons from the CTBT and other significant agreements, negotiations need to be initiated by a cross-regional group of States, in accordance with the principles that the forum must be open to all States and blockable by none, with inclusive mechanisms for civil society and international agencies to participate as appropriate.

As with most if not all international processes, some States will be reluctant or opposed, and may try to obstruct negotiations and dismiss the outcome. That is to be expected in multilateral diplomacy, as illustrated by the NPT and the CTBT. That doesn't mean those processes and treaties are invalid. Even with the CTBT's Article XIV[2] Achilles' heel blocking entry into force, the CTBT has proved its worth many times, turning nuclear testing from a high status demonstration of nuclear prowess into a pariah activity that responsible States must not pursue.

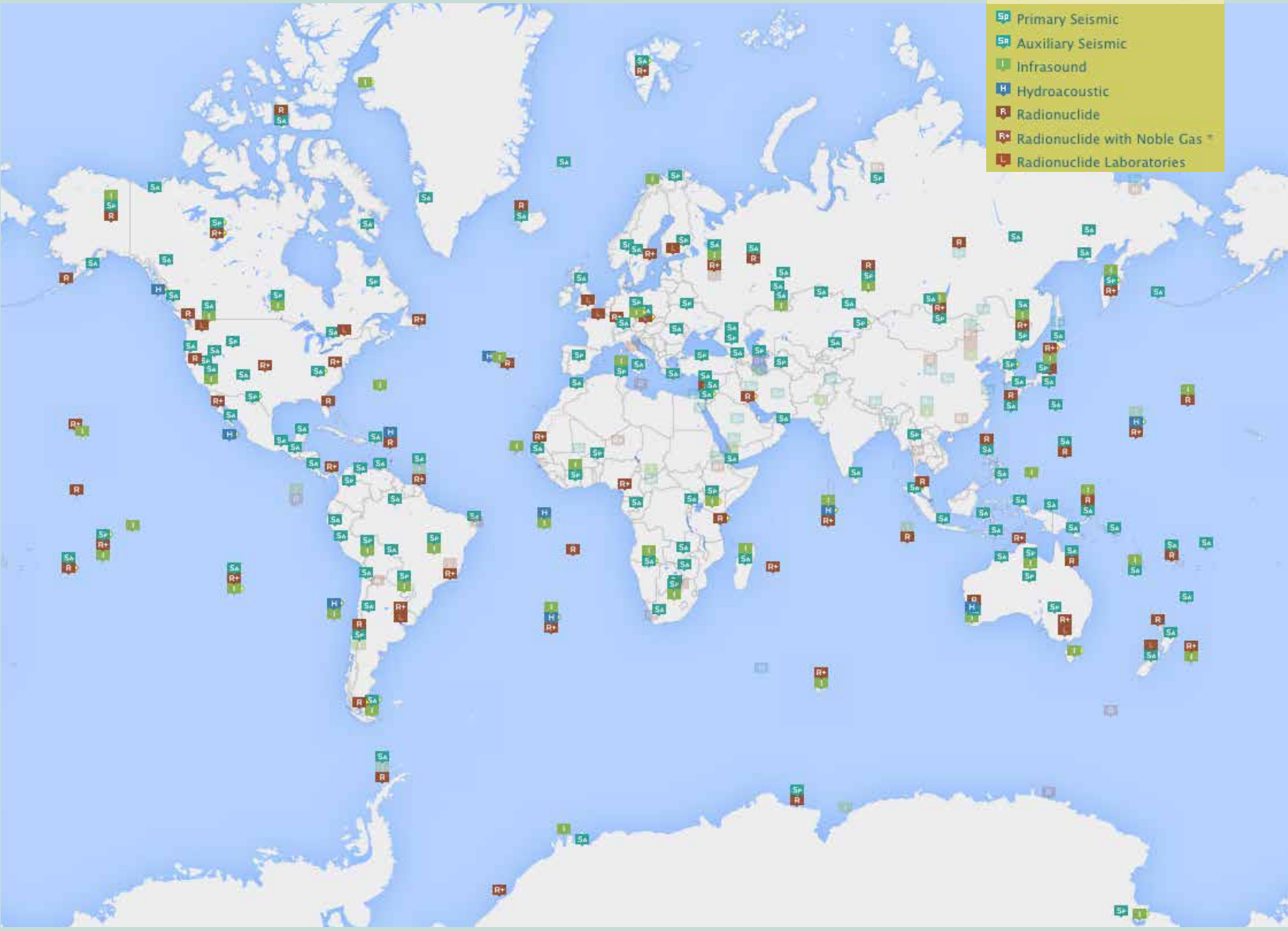
The CTBT is an important beacon in history. Driven by disarmament, humanitarian and non-proliferation objectives, this Treaty was a vital step towards nuclear abolition, and still contributes greatly to global security through its normative and political establishment.

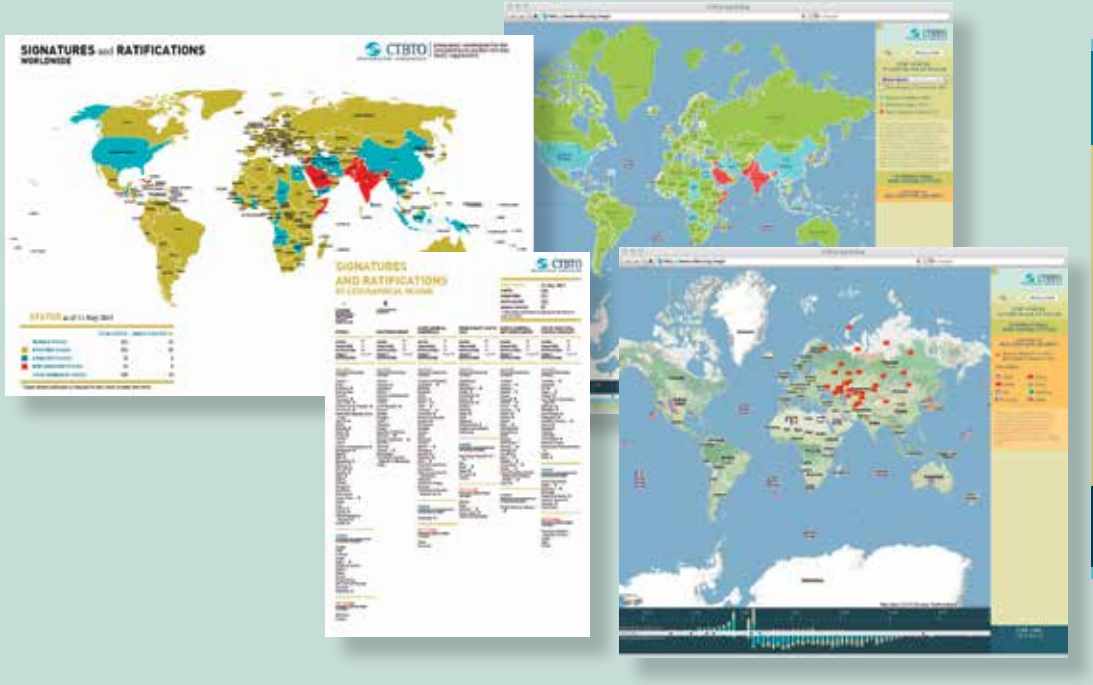
[2] Article XIV states that the CTBT 'shall enter into force 180 days after the date of deposit of the instruments of ratification by all States listed in Annex 2 to this Treaty'. The 44 States listed in Annex 2 formally participated in the 1996 session of the Conference on Disarmament and possessed nuclear power or research reactors at the time.


BIOGRAPHICAL NOTE

**REBECCA JOHNSON**
is Director of the London-based Acronym Institute for Disarmament Diplomacy and a steering group member (former Chair) of the International Campaign to Abolish Nuclear Weapons (ICAN). Dr Johnson has over 35 years' experience in working for disarmament and security, and has authored numerous articles, reports and books on multilateral diplomacy, international security, women's participation in political change, as well as British politics and nuclear decision-making.

# STATUS OF CERTIFIED IMS FACILITIES
## AS OF 17 APRIL 2015

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VERIFICATION HIGHLIGHT

# A successful conclusion to the Integrated Field Exercise 2014:

## The CTBTO's largest ever on-site inspection exercise

### A note of gratitude to the Jordanian government from CTBTO Executive Secretary Lassina Zerbo

*The Integrated Field Exercise 2014 (IFE14) was by far the most sophisticated exercise the CTBTO has ever conducted. The five-week exercise, which started on 3 November 2014, involved four years of preparation, 150 tonnes of specialized equipment including through in-kind contributions amounting to U.S.$ 10 million, and over 250 international experts.*

*IFE14 illustrated that we have mastered all components of the verification regime, and brought our on-site inspection capabilities to the same high level as the other two components: the network of monitoring stations, which is over 85% complete and the International Data Centre.*

*I would like to express my deep appreciation to the Jordanian government for its generous support. By hosting IFE14, Jordan underscored its role as an anchor of stability in the region and sent a positive political signal for international nuclear disarmament and non-proliferation efforts. I am inspired by the fact that His Majesty King Abdullah II of Jordan generously placed the exercise under his royal patronage and grateful for the outstanding cooperation and hospitality from all branches of the Jordanian government.*

*Prince Feisal Bin Al Hussein of Jordan (right) with CTBTO Executive Lassina Zerbo during IFE14, November 2014.*

Photo courtesy of Matjaz Prah, CTBTO

# Reflections on IFE14

BY OLEG ROZKHOV
DIRECTOR OF THE ON-SITE INSPECTION DIVISION

The Integrated Field Exercise 2014 (IFE14) in Jordan made history not only for the CTBTO, but for the Treaty as a whole. IFE14 was unprecedented in a number of ways. Firstly, it was the largest field exercise since the inception of the organization. Almost 150 tonnes of equipment were shipped to Jordan and used in the exercise. More than 250 experts from all over the globe participated in IFE14 in various capacities. And secondly, the exercise also drew significant attention from the international community. More than 80 VIPs from 28 Member States, various international organizations, NGOs and senior representatives from the host country visited the IFE14 exercise, thereby underlining its political importance.

IFE14 served as the true litmus test for showing that significant progress had been made in developing OSI capabilities since the previous integrated exercise in Kazakhstan in 2008. It also clearly demonstrated that we have the core capabilities necessary to conduct and achieve the primary objective of an on-site inspection, as provided for by the CTBT.

The exercise could not have been conducted with such success without the tremendous concerted efforts of the entire organization and its Member States, or without the substantial political, financial, expert and other forms of support provided by Member States. We would also like to pay tribute to the crucial role that Jordan played in both IFE14 preparations and as the host of this exercise. IFE14 received the highest political support in Jordan – it took place under the patronage of the Jordanian Royal Family.

While participating in the exercise in various capacities, I was both surprised and pleased to witness the highest level of enthusiasm, dedication and team work demonstrated by all IFE14 participants. It was evident that they were distinctly aware of the important work they were doing and felt privileged to contribute to promoting the CTBT and to strengthening international security.

# Did Maridia conduct a clandestine nuclear test?

## The Integrated Field Exercise 2014 from the perspective of the inspected State Party

BY MALCOLM COXHEAD

No country would welcome claims that it had breached the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Receiving an on-site inspection (OSI) to clarify whether a nuclear explosion had taken place might not be a comfortable experience either. But the arrival of inspectors would represent the opportunity for an inspected State Party to clarify concerns that had been raised about its actions.

Facilitating an OSI would also represent a significant practical challenge for an inspected State Party. Liaison with the inspection team and logistical support for its activities would need to be established quickly, and maintained for weeks to months. This is more than just booking a hotel and arranging a few rental vehicles. It requires the commitment of liaison and support staff, as well as the practical support of local authorities to facilitate inspection access. An inspected State Party that wishes to actively exercise its rights under the CTBT, to manage the access of inspectors and protect any information from sensitive sites, must promptly assemble the expertise that will allow it to follow the work of the inspection team, to analyse for itself the data the team collects, and to clarify any ambiguities that might arise about the meaning of that data.

For me, as the senior representative of the inspected State Party, and for my 35 colleagues playing the role of inspected State Party representatives, our task in the Integrated Field Exercise 2014 (IFE14) was made a lot easier by the very considerable preparatory work carried out by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) before we set foot in Jordan – also known for the purposes of the exercise as the fictitious state of Maridia. This was good as the intention for IFE14 was that Maridia would actively use CTBT provisions to protect its interests, and offer a realistic test for the inspectors, their equipment and OSI procedures.

### DIFFICULT TIMES FOR MARIDIAN REPRESENTATIVES

The exercise scenario for IFE14 created a fictitious backdrop that put Maridian representatives in a difficult position. Evidence of a possible nuclear explosion collected through the International Monitoring System (IMS), while not fully clear, was consistent with a nuclear explosion. Maridia's representatives were instructed to present an alternative explanation for the IMS detections. The 1,000 $km^2$ of the inspection area included some populated areas and some difficult to reach areas. Access to military sites and some industrial activities (such as quarrying) needed to be carefully managed. The presence of roaming tribespeople, and some sharp-teethed fauna posed a risk for the security of inspection equipment left unattended in the field.

Negotiating support and access for the inspection team played a big role in IFE14, as it could in any future OSI. This proved to be tough from the start of the exercise, and whether the inspection would begin on the night the inspectors arrived or the next morning led to midnight talks and a few frayed tempers. Working relations between Maridia's representatives and the inspection team were maintained but were tested several times as access to the inspection area was negotiated.

Each day multiple convoys of vehicles set out from the inspection team's base of operations, initially to search the inspection area and identify locations that might require closer examination. Inspectors traversed many thousands of kilometres of roads and trails to conduct visual reconnaissance, to take radiation measurements and samples and to install aftershock seismic monitoring arrays. Each convoy, or field team, included Maridian drivers and escorts whose job it was to facilitate and manage access for inspectors, and to help ensure the safety of all involved. These included negotiations for inspection equipment to be installed on private land, and secured against any interference. Perhaps inevitably, Maridia's technical people also wanted to offer their own expert advice to inspectors on the best way to make various measurements. This is possibly outside the scope of the OSI mechanism, and I discouraged it.

### A PUNISHING SCHEDULE

Days began around 7am with the assembly of teams to go to the field, and ended around 10pm following an evening wrap up meeting for Maridian personnel. The planning cycle was relentless, with missions for the following and subsequent day proposed, discussed, planned and coordinated with Jordanian agencies. Even with the excellent support provided by Jordan, some interesting real-world problems

had to be overcome to arrange access for the inspection team at some places.

The punishing schedule eased one day a week as field missions were not conducted on Fridays, respecting local custom. Planning had to go on even on Fridays but a couple of hours per week were thus left for the most favoured recreation of many IFE14 participants – floating in the Dead Sea.

A search of the inspection area was also conducted from the air, with inspectors recording dozens of photographs of installations that they thought worthy of investigation. Some photos were of buildings that turned out to be chicken coops, while others were of military sites. Maridia was able to satisfy the inspectors that those particular photos were not relevant to their task, and so they did not leave Maridian territory.

## MAINTAINING INTEREST FROM START TO FINISH

After two weeks of searching, the inspection team had narrowed its focus to a few areas, the main two being quarry locations. The inspection team thought that each might be the site of an underground nuclear explosion and was keen to apply a host of geophysical techniques and to sample for radiation. But arranging free access for inspectors to these areas of private land presented challenges for Maridia.

At one of the two sites, which came to be known as polygon 18, Maridia was eventually able to offer free rein to inspectors for inspection activities on the surface. Suspicions about the site waxed and waned as more and more of the investigations showed no evidence of a nuclear explosion. But the presence of what appeared to be a gated tunnel entrance, for which Maridia had inexplicably lost the key, kept interest alive.

The second of the two main sites, known as polygon 29, presented greater problems due to a local radiation hazard and what Maridia described to the inspectors as proprietary commercial interests. The inspection team's plans for geophysical investigation and for radiation measurements and sampling were carefully negotiated, including taking account of safety risks. Maridia offered its explanation for what inspectors saw at the site. But were they satisfied? Finally, the analysis of subsurface gas samples showed strong indications of a nuclear explosion. Maridia sought to explain these too – but would this be believed?

The fictional background to the IFE14 story was that yes, there had indeed been an underground nuclear explosion in the area known as polygon 29. However, Maridia's approach was to present itself as innocent and argue that the IMS detections, as well as any suspicious observations by the inspection team, had innocuous explanations. The Maridian team did not try to block or otherwise stymie the inspection, as to do so would be judged as guilty behaviour. Along the way, the checks and balances of the CTBT's OSI mechanism were put into play, and radioactive gases indicative of a nuclear explosion were ultimately found. No team likes to lose a game but satisfaction for the Maridian side came from playing hard to test the OSI mechanism – and helping to make it ready.

*The inspection team (left) hands over the preliminary findings document to the delegation of 'Maridia'.*

*Soil-gas sampling for noble gas detection.*

*The inspection team conducting electrical resistivity tomography.*

# Twenty-four hours in a day were not enough

## The Integrated Field Exercise 2014 from the perspective of the inspection team

BY GREGOR MALICH

Vienna, 3 November 2014: Not one of the designated core inspection team members who had just been informed of Alluvia's request for an on-site inspection (OSI) in Maridia was taken by surprise. This was the day when the OSI Integrated Field Exercise 2014 (IFE14) was scheduled to begin, the day when years of preparations came to an end and were finally put to the test – anticipation reached its climax.

The OSI regime foresees that once the CTBTO Executive Council has approved a pertinent request from a Member State, an OSI can proceed. This will involve the mobilization of inspectors from around the globe and their deployment to the inspected State Party. Once there, the inspection team will conduct and use permitted inspection activities and techniques for a duration of up to 130 days, enabling the team to collect facts that will allow clarification as to whether a nuclear test explosion has been carried out. This is, in a nutshell, what lay ahead of us – i.e. the surrogate inspection team that I was leading – along with many uncertainties, except for what had been made known about the constraints of IFE14 in the booklet for exercise participants. But there was also the belief that we truly formed a team and exercise preparations had come a long way.

### NUMEROUS TASKS TO BE ACCOMPLISHED PRIOR TO DEPARTURE

The launch phase of the inspection started with the activation of the Operations Support Centre in the morning of 4 November as soon as it was confirmed that the OSI request complied with Comprehensive Nuclear-Test-Ban Treaty requirements. As this phase was to lay the foundations for the initial inspection activities and confirm the availability of required resources including what we would need the inspected State Party to provide, the tasks to be accomplished were intricate and profuse. They ranged from a review of the OSI request and information on the triggering event and the inspection area, to initial inspection planning, inspection mandate preparation, logistics planning and arrangements, to the communication of requests for information and support from the inspection State Party, and ultimately to assembling the team. To put it mildly, these were harried times for everybody involved, not least because of the strict limits on daily working hours at the Operations Support Centre – not the only 'exercise artificiality' since such restrictions would not apply in a real OSI. Despite all of this, by the evening of 6 November the inspection team's "starting 40" had assembled in Vienna and had been briefed, planning was complete and the inspection mandate had been signed. All boxes on the to-do list had been ticked (some more confidently than others) so that we were ready to literally embark on our journey.

### TOUGH NEGOTIATIONS LATE INTO THE NIGHT

The following day provided a welcome first breather as travel to the point of entry in the inspected State Party, Maridia International Airport (also known as Queen Alia International Airport in Amman, Jordan), was on the agenda: time to reflect on open and closed issues, to prepare for the first meeting with the inspected State Party, and of course, a chance to get some rest. The team transitted in two travel groups via separate routes but arrived within 20 minutes of each other very much on schedule. Night had fallen in the meantime and what followed was a good illustration of the unexpected during an OSI: After welcoming us briefly and transferring the team to a nearby hotel, the inspected State Party initially refused to accept the inspection mandate, referring vaguely to some legal issues. This led to tough negotiations late into the night: our encounter with the inspected State Party had only just begun, with weeks full of discussions, more negotiations, misunderstandings and clarifications, disagreements and agreements ahead of us.

The base of operations was set up on the shores of the "Costa del Maridia" at a site inside the inspection area overlooking the Dead Sea, the scene of many beautiful sunsets during the exercise. We only had to make minor changes to the layout plans for the base and thanks to everybody working hard on their tasks and beyond, and not least because of the support we managed to negotiate from the inspected State Party, readiness for commencing inspection activities could be achieved within Treaty timelines. It took more time, however, until the inspection team became fully operational and before a routine was established at

the base. This did not happen until after three days of field deployments on Friday 14 November, when the inspection was limited to activities within the base in order to respect the Muslim traditions of Maridia. This 'exercise artificiality' applied on every Friday during IFE14 and turned out to be invaluable as it offered us time to consolidate team functionality and to organize and maintain the infrastructure and equipment accordingly. In this sense, even though there was little time to rest, this first Friday at the base provided the second breather as we were able to adjust our daily tasks and schedule, while allowing for subsequent reviews and amendments as necessary throughout the inspection.

## OPERATING AS A COHESIVE UNIT

With the routine, the team grew in both confidence and experience. It was clearly visible that we operated as a cohesive unit throughout the exercise and each rotation of team members revitalized the team, if within limits. The base of operations with all its components functioned effectively and it was particularly pleasing to see a number of inspection techniques being applied usefully for the first time in a realistic OSI context, including airborne multi-spectral imaging, noble gas laboratory operations and active seismic surveys. Deployments of field teams became smoother every day, as did the integration of collected information which ultimately pointed to one site within the inspection area where there were a number of findings consistent with an underground nuclear explosion. This achievement, however, was deeply etched on many inspectors' faces – no matter how enthusiastic everybody remained – as we grappled with inadequate rest until the end of the exercise. This was not helped by the fact that some critical functions were dependent on only one inspector; the lack of time, such as for proper field mission debriefings, could only be noted but not properly compensated for. Twenty-four hours in a day was not enough for the inspection team, at least not during IFE14.

*Pre-flight briefing with representatives of the inspected State Party ahead of an additional overflight.*

When we dismantled the base on 6 December as part of the IFE14 post-inspection activities, nearly five weeks had passed since the request for an OSI. With the CTBTO flag gleaming in the sun and Kraftwerk's "Radioactivity" from the IFE14 playlist sounding across the site, I could only see the smiling faces of both my fellow team members and the inspected State Party representatives. No doubt there was delight that the exercise had come to an end; but even more noticeable was the satisfaction that IFE14 had surely served its purpose by showing the world how much progress has been made in the development of OSI capabilities.

**BIOGRAPHICAL NOTE**


**OLEG ROZKHOV**
has served as Director of the On-Site Inspection Division since October 2010. Prior to this, he was a career diplomat with the Ministry of Foreign Affairs of the Russian Federation, holding the rank of Minister Counsellor Extraordinary and Plenipotentiary. He held a number of senior positions at the Ministry, including Deputy Director, Department for Disarmament and Security Affairs, and Deputy Head of the Delegation to the 2010 NPT Review Conference from 2005-2010. Earlier in his career, he was a member of the Russian delegation to the CTBT negotiations in Geneva.

**BIOGRAPHICAL NOTE**

**MALCOLM COXHEAD**
is Director of CTBT and Nuclear Disarmament at the Australian Safeguards and Non-Proliferation Office. Since 2004 he has served as the Task Leader for the elaboration of the draft on-site inspection Operational Manual in the CTBTO's working group that deals with verification issues. He led the team of experts assembled to play the role of inspected State Party representatives in the Integrated Field Exercise 2014 (IFE14) in late 2014.

**BIOGRAPHICAL NOTE**

**GREGOR MALICH**
has been the Chief of the Equipment and Implementation Section, OSI Division, since June 2014. Prior to this, he was the Head of the Operational Response Unit for Nuclear, Radiological, Biological and Chemical Events at the International Committee of the Red Cross. He has managed technical and development programmes in many geographical regions for the private sector and international organizations. Dr Malich also worked for the OSI Division from 2001 – 2008.

# CTBT: SCIENCE AND TECHNOLOGY 2015

**Randy Bell**
Project Executive of the CTBT: Science and Technology 2015 Conference and Director of the International Data Centre at the CTBTO.

**The International Data Centre (IDC) must partner with National Data Centres, academia, and industry to maintain technical credibility. We must stay abreast of scientific advances, take part in scientific discovery, even lead and motivate the direction of science to ensure our needs are being met.**

**We have to promote the use of International Monitoring System data and IDC analysis for civil, scientific, and even industrial applications because this will help ensure the future of our mission. Scientific partnerships lead to new methods to process our data and can help us see deeper into the noise to find smaller signals with greater confidence or with less effort. These partnerships familiarize new generations of potential staff with our mission and technologies.**

**More eyes on the data mean more quality checking. More applications of our data increase the value our Member States perceive from their investment in the monitoring system.**

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## THEMES

1. The Earth as a Complex System
2. Events and their Characterization
3. Advances in Sensors, Networks and Processing
4. Performance Optimization

**INTERVIEW** WITH NURCAN MERAL ÖZEL, DIRECTOR OF THE IMS DIVISION

# The International Monitoring System (IMS): A Globe-Spanning Construction Project

*You have served as Director of the International Monitoring System (IMS) since November 2014. How do you envisage the IMS evolving under your leadership?*

Under my leadership, I naturally want to move towards the completion of the IMS network. Currently, 88% of the IMS stations are installed, offering broad IMS coverage and certified stations are sending data around the clock to the International Data Centre in Vienna. As the current IMS Director, I commend this achievement. I will work with host countries and seize every opportunity in this regard. I want to make significant progress with the noble gas monitoring programme which plays an essential role in the verification system and proved to be crucial during the accident at the Fukushima Daiichi nuclear power plant in March 2011. For example, one of the earliest achievements under my leadership was the first certification of a noble gas system at an IMS radionuclide laboratory. I also want the IMS to continue benefitting from cutting edge scientific developments in all CTBT verification technologies; in this regard, I will engage vigorously with my team and with the scientific community. Data reliability and security, and more robust stations and equipment are at the top of my agenda.

*The IMS is one of the key components of the verification regime that monitors compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT). By the beginning of March 2015, 270 of the 321 stations that will make up the IMS network had already been certified and 11 of the planned 16 radionuclide laboratories had been integrated into the network. As the IMS approaches completion, what challenges do you foresee in terms of sustaining some of the earliest facilities, some of which are approaching their end-of-life cycle?*

The IMS is key to the CTBTO and is one of the most ambitious global projects ever undertaken. The build-up of the IMS means that the CTBTO has been involved in a globe-spanning construction project for over ten years. But we also know that the logistical challenges the IMS faces are enormous. As the build-up phase is completed, the focus has turned increasingly towards sustaining the IMS. Beyond straightforward maintenance of existing equipment, sustainment involves enhancement, improvement, and refinement, in some cases even the replacement of current equipment with newly evolved technologies. Since equipment does not last forever, all 337 facilities will eventually be in need of re-capitalization, which is another logistical challenge. Establishing and maintaining a treaty-based monitoring network in 89 different countries has also been an administrative challenge. I am convinced that by combining the efforts of all involved, Member States, station operators, equipment providers and the CTBTO, we will manage this obsolescence peak with great success, and not only protect the investment made in the IMS network but also maintain a very high level of performance.

*The construction of hydroacoustic station HA04, located in the Crozet Islands, will complete the IMS network of 11 hydroacoustic stations. These stations monitor the world's oceans to ensure that no nuclear test goes undetected. Considering the remote location of HA04 in the southern Indian Ocean, what kind of logistical and engineering challenges do you envisage?*

The IMS has considerable experience in establishing stations in remote locations that present logistical and environmental challenges. In a way, that is what makes this network quite extraordinary and this job quite exciting too! HA04 is indeed located in one of the most remote places on the globe, with no airport nearby and where the only human settlement is a scientific base. The approach to deal with these challenges is careful planning, risk awareness and mitigation as well as the use of state-of-the-art installation techniques. In this regard, the IMS has demonstrated its experience on numerous occasions and has many success stories. For example, the hydroacoustic station HA3 on Robinson


*The Crozet Islands. Map courtesy of Jean-Pierre Langer, Monaco. Featured in Discover France!*

Crusoe Island, Chile, was successfully installed in March 2014. Due to the remoteness of the site, the morphology of the bay, the weather conditions and the risk management measures, the degree of complexity of the HA4 project is expected to exceed the HA3 project. The contract for this station was awarded in December 2014 and a land site survey was conducted the same month. Installation of the station is planned for the 2016-2017 austral summer. This year, we will start on the assessment of the modular design developments for the next generation of IMS hydroacoustic equipment. The main objective of the project is to evaluate options for modular solutions to enhance the sustainability, cost effectiveness and maintainability of hydroacoustic stations.

*You were the Director of the Turkish National Data Centre when the Democratic People's Republic of Korea (DPRK) announced that it had conducted its second nuclear test on 25 May 2009. What role did the National Data Centre (NDC) play in evaluating the event?*

Our analysis was directly communicated to the Ministry of Foreign Affairs. During the preliminary analysis of the 25 May 2009 event in the DPRK by the Turkish NDC, we observed the arrival of a very clear P-wave – the first type of seismic wave to arrive at the seismograph – at the IMS primary seismic station in Keskin, Turkey. That arrival was missed by the IDC's final automatic bulletin (the bulletin that is used as a starting point by human analysts), then picked up and associated with the event by IDC analysts. Since we were familiar with the station at Keskin, we were able to choose a more appropriate frequency band for analysis, and obtain a better match to the expected travel time for a P-wave from the DPRK event to the station. I sincerely believe that our interaction with the IDC on this issue helped both sides.

*In March 2011, Turkey signed an agreement with the CTBTO to receive tsunami warning data. As the founding coordinator of the National Tsunami Warning Centre in Turkey which also provides services to the Eastern Mediterranean, the Aegean Sea and the Black Sea, how useful is CTBTO monitoring data for tsunami warning centres?*

IMS data in this context are used as a supplement to the existing networks of tsunami warning centres and help in many ways, such as providing a more uniform setting of the stations in the network, higher data availability and faster data transmission. And as discussed earlier, some IMS stations are in isolated places not populated by other networks. All of these factors help improve the accurate determination of earthquake parameters and hence contribute to the issuing of earlier tsunami alerts deriving from potentially tsunamigenic earthquakes.

*As the only female Director in an organization that is still quite heavily male, what advice would you give to young women scientists?*

In our professional lives, we should consider people's abilities and not their gender. But women's nature is more protective and I guess this allows them to be better managers. My main advice to women is to be brave both in their professional and private lives and discover their abilities. Be yourself, be factual, be intuitive, and most importantly, be confident. Organize your time, avoid taking comments personally, and don't be afraid to be assertive. Science is for everybody. In that respect, I am proud to serve an organization that gives special emphasis to the gender balance. Having said that, I believe that real actions are in the hands of institutions and policy makers. They have to ensure that institution-based support for women in the critical years – i.e. the first years of motherhood – should be provided and men should be empowered to take equal responsibility in family life.

**BIOGRAPHICAL NOTE**

**NURCAN MERAL ÖZEL**
has served as Director of the IMS Division since November 2014. Prior to this she was a faculty member and Vice-Director of the Bogazici University-Kandilli Observatory and Earthquake Research Institute (BU-KOERI) in Istanbul, Turkey. She was also responsible for all seismological operations at BU-KOERI, which hosts the National Earthquake Monitoring Centre and Istanbul Earthquake Early Warning and Rapid Response System. From 2006 to 2014 Professor Özel served as Director of the Turkish National Data Centre, during which time she participated in CTBTO meetings on verification issues as a Member State delegate.

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# OPERATION AND MAINTENANCE OF THE IMS

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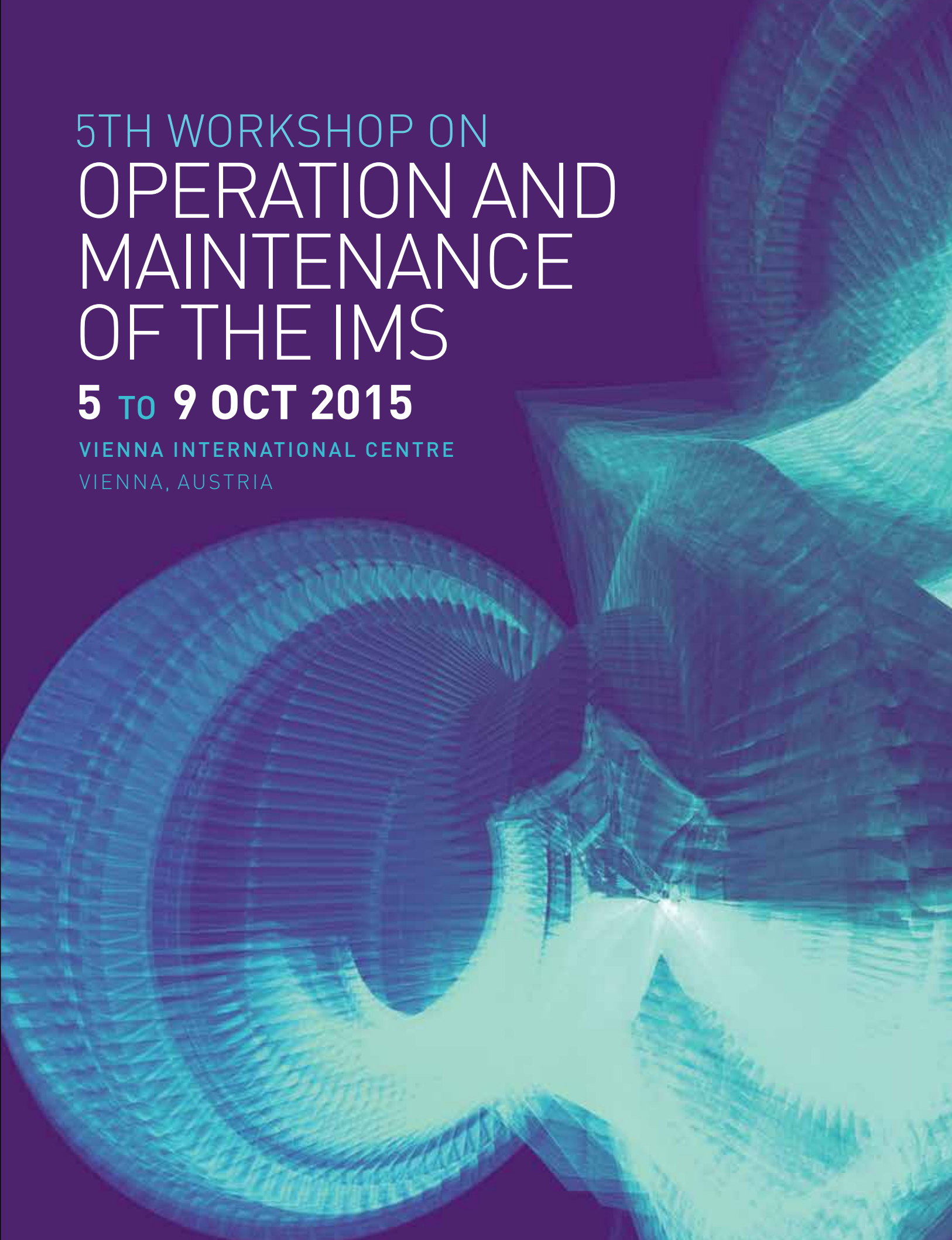
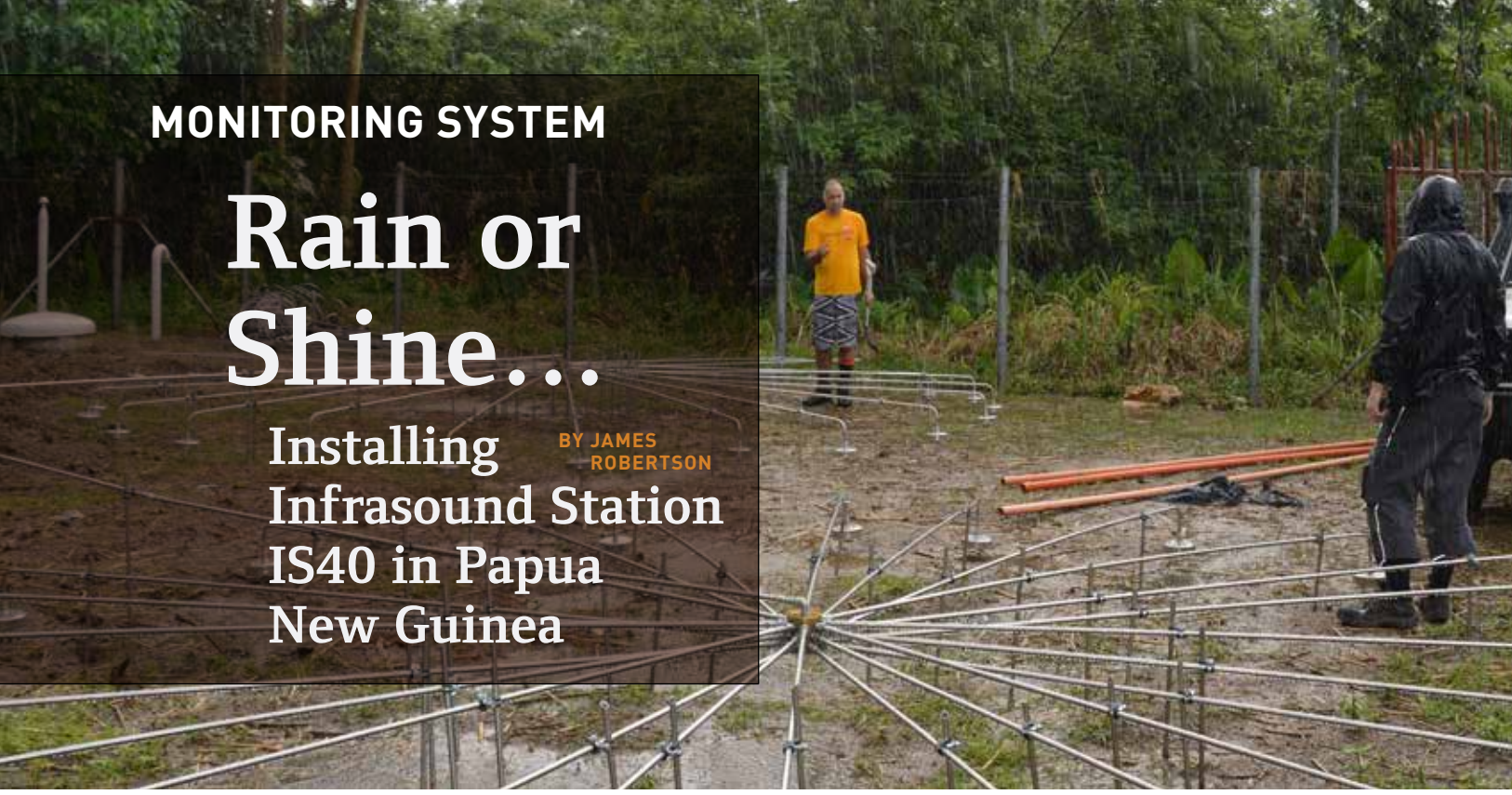




MONITORING SYSTEM

# Rain or Shine…

## Installing Infrasound Station IS40 in Papua New Guinea

BY JAMES ROBERTSON

Rain or shine: this was the motto during our installation and certification visits to the CTBTO's infrasound station, IS40, in Papua New Guinea last autumn. Those words, typically stamped on your summer rock concert ticket, meant the work was going to get done no matter what conditions were thrown at us. But in the case of Papua New Guinea during the north-westerly monsoon season, these words were more than an idiom; they had to be taken quite literally. It was either going to rain, or it was going to shine. Nothing in between.

IS40 – one of the stations making up the International Monitoring System (IMS) – is located in Kerevat, East New Britain, Papua New Guinea. The closest certified IMS infrasound stations to IS40 are IS39, Palau (2,370 km), IS22, New Caledonia (2400 km) and IS07, Australia (2600 km). The East New Britain province of Papua New Guinea is part of the north-eastern section of the island of New Britain and includes the Duke of York Islands. The capital of the province is Kokopo, several kilometres to the east of Rabaul, which was the provincial capital until it was largely destroyed by a volcanic eruption in 1994.

### AFTER 15 YEARS, THE FINISH LINE WAS FINALLY IN SIGHT

Efforts to build IS40 began in 2000 and since then, the CTBTO and the Rabaul Volcanological Observatory (RVO) have been working jointly to construct and certify the station. The RVO, established after the 1937 volcanic eruption in Rabaul, is responsible for monitoring the activity of volcanoes found throughout Papua New Guinea, where more than 150 eruptions have been recorded over the last 200 years.

As we reached the end of 2014, the finish line was finally in sight. The many hours of engineering, planning,


*Pacific Ocean IMS infrasound stations around IS40 (red star).*
*Green and white stars respectively represent certified and non-certified IMS infrasound stations.*

travel, procurement actions, site surveys, contract negotiations and meetings between Papuan officials – including the IS40 station operator, technicians and engineers – and the CTBTO were going to pay off.

All that was needed was one last visit to complete the installation and perform the final tests required to certify the station and officially bring it into the IMS infrasound network of 60 planned stations. So in early October, after six months of planning and coordination between the CTBTO and the RVO for the trip, Slava Bereza, a seismic technician with the CTBTO, and myself climbed aboard a plane and embarked on a 13,500 km journey from Vienna, Austria, to Rabaul, Papua New Guinea. After two and a half days involving frequent changes between planes, buses and cars, we finally arrived in the rich tropical forests of the East New Britain Province, where we met with Ima Itikarai, Assistant Director of the RVO and the station operator of IS40.

## EXTREME WEATHER CONDITIONS

Once in Rabaul, a typical morning started by coordinating the day ahead with the RVO crew, after which we would head off together to begin our work in the sun. A lot of sun! An intense solar radiation bath, to be exact. With the sweltering heat come the clouds, and then the rain: torrential downpours that flood everything in sight. Rivers running down every nook and cranny, filling every dry spot that could possibly be filled, and it all happens in a matter of seconds.

With 90% of the work to be performed taking place outside in the elements, it became a case of picking your poison. After five hours of working in the sun, all one could hope for was rain. After four hours of constant rain, you found yourself begging for the sun. When the rain finally stopped, out came the mosquitos, and with malaria posing a serious risk in this area, they become more than just a nuisance. With this in mind, we would arrive at the station as early as possible, when the sun was lowest in the sky.

As much field work as possible had to be completed before noon. After that it was a race against time to finish everything before the rain began. The installation of any outdoor equipment had to be done while it was dry. One of the main objectives during the installation was to relocate the sensors that measure infrasound (microbarometers) closer to the centre of each remote station site. This was necessary to optimize the measurement of infrasound signals. We achieved this by placing the instruments in weatherized cases and connecting them to existing underground instrument vaults close by.

*Ima Itikarai (right), Assistant Director of the Rabaul Volcano Observatory (RVO), and John Bosco (left), an engineer with the RVO, both played a key role in the installation of IS40. Rabaul's active volcano is visible in the background.*

*RVO workers relocating fibre optic cables to enable the eventual transmission of data all the way back to Austria.*

## BATTLING AGAINST THE ELEMENTS

With knee-deep holes having been pre-dug and concrete slabs poured, we began each morning by installing the case, conduit, instrumentation and then the cables, always with the weather conditions in mind. In addition to one engineer kneeling in mud, hunched over a case installing the instruments, another engineer had to be inside the underground vault rewiring cables. It was impossible to decide which task zapped more energy from the body. While outside, you had the luxury of any mild breeze that would blow across the field, though you were still being baked in the equatorial sun. If you chose to work in the underground vault, glorious shade was yours to be had, but the muggy heat was stifling, if not unbearable. In both cases, beading sweat, meant to cool us down, was now our enemy as it dripped onto sensitive electronics and made our grip on hand-tools all the more difficult.

We worked together as hard as we could to complete our planned tasks by mid-day, but would inevitably be reminded that time was running out by the claps of distant thunder. "One more test! One more screw! One more wire!"

*Stuck in the mud: even with the most capable 4x4s in Rabaul, it was always a risk.*

We would push the limits until the sky would open up and the rain would fall. If you weren't finished, it became a mad dash to make sure that the equipment remained dry. This was it, your trial by fire. Did I seal that connection correctly? Was the conduit glued together tightly enough? Was the instrument case anchored securely to the concrete base? Well, if they were not we would find out soon enough as the rain turned each work site into a mini duck pond.

In the end, all of the hard work paid off. No instruments floated away and only a few cars got stuck in the mud. Though the tasks were challenging, with the help of experienced staff in the field, remote monitoring from our offices in Vienna and the invaluable assistance from Ima and his colleagues at the RVO, we achieved our goal.

## ALL THE HARD WORK HAD BEEN WORTH IT

Looking back, one of the most rewarding things about a station installation, no matter where in the world, is returning back to our base camp and seeing all systems up and running with the correct waveforms scrolling across the computer screen. It is even more encouraging knowing the same information is being successfully received and analysed by our colleagues back in Vienna. And in the case of IS40, it meant that all our hard work was going to pay off, no matter what the weather conditions had been like, with the station one step closer to contributing to the IMS network by the time we headed back to Vienna.

The final CTBTO installation efforts were completed in mid-November and the station was officially certified in December after thorough review and confirmation that all official requirements for an IMS infrasound station had been met. With the certification of IS40 the total number of certified infrasound stations in the network reached 48.

### BIOGRAPHICAL NOTES

**JAMES ROBERTSON**
has been an Infrasound Engineering Officer with the Engineering and Developing section at the International Monitoring System since the summer of 2013. He first joined the CTBTO as a consultant earlier that year after working as a field engineer for over 17 years in optical radiation measurements and infrasound in the USA. Both fields have allowed him to gain invaluable installation experience in extreme environments from the South Pole to Papua New Guinea.

# Erratic Furnaces of Infrasound:
## Volcano Acoustics

BY MILTON GARCÉS

The sun rose over the desolate lava landscape, a study of red on black. The night had been rich in aural diversity: pops, jetting, small earthquakes, all intimately felt as we camped just a mile away from the Pu'u O'o crater complex and lava tube system of Hawaii's Kilauea Volcano.

The sound records and infrared images captured over the night revealed a new feature downslope of the main crater. We donned our gas masks, climbed the mountain, and confirmed that indeed a new small vent had grown atop the lava tube, and was radiating throbbing bass sounds. We named our acoustic discovery the 'Uber vent'. But, as most things volcanic, our find was transitory – the vent was eventually molten and recycled into the continuously changing landscape, as ephemeral as the sound that led us there in the first place.

### A MENACING INCANDESCENT SPECTACLE

Volcanoes are exceedingly expressive mountains. When quiescent they are pretty and fertile, often coyly cloud-shrouded, sometimes snow-capped. When stirring, they glow, swell and tremble, strongly-scented, exciting, unnerving. And in their full fury, they are a menacing incandescent spectacle. Excess gas pressure in the magma drives all eruptive activity, but that activity varies. Kilauea volcano in Hawaii has primordial, fluid magmas that degas well, so violent explosive activity is not as prominent as in volcanoes that have more evolved, viscous material.

Well-degassed volcanoes pave their slopes with fresh lava, but they seldom kill in violence. In contrast, the more explosive volcanoes demolish everything around them, including themselves; seppuku by fire. Such massive, disruptive eruptions often produce atmospheric sounds known as infrasound, an extreme basso profondo that can propagate for thousands of kilometres. Infrasound is usually inaudible, as it resides below the 20 Hz threshold of human hearing and tonality. However, when intense enough, we can perceive infrasound as beats or sensations.

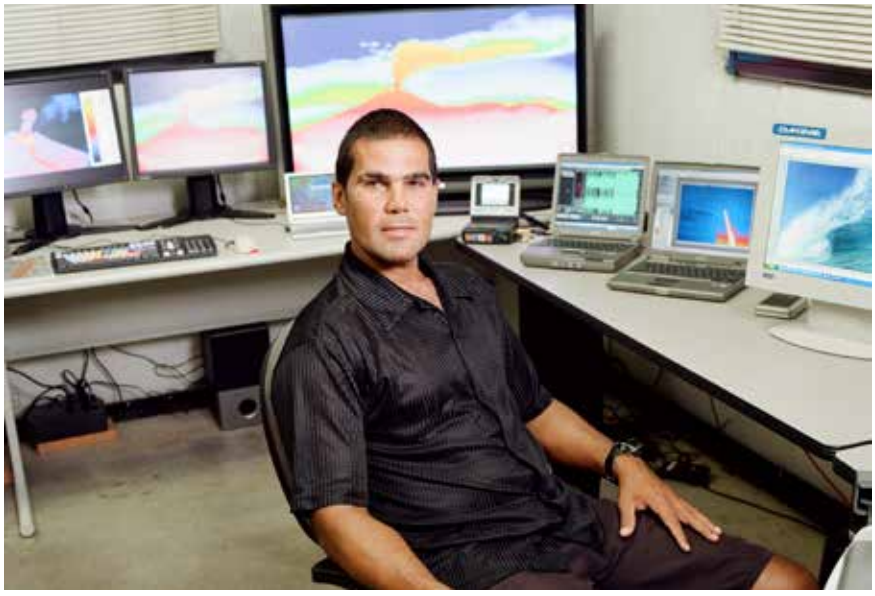
Like a large door slamming, the concussion of a volcanic explosion can be startling and terrifying. It immediately compels us to pay attention, and it's not something one gets used to. The roaring is also disconcerting, especially if one thinks of a volcano as an erratic furnace with homicidal tendencies. But occasionally, amidst the chaos and cacophony, repeatable sound patterns emerge, suggestive of a modicum of order within the complex volcanic system. These reproducible, recognizable patterns permit the identification of early warning signals, and keep us listening.

Each of us now has technology within close reach to capture and distribute Nature's silent warning signals, be they from volcanoes, tsunamis, meteors, or rogue nations testing nuclear weapons.

### ARENAL VOLCANO: COSTA RICA'S MOST ACTIVE VOLCANO UNTIL 2010

I first heard these volcanic sounds in the rain forests of Costa Rica. As a graduate student, I was drawn to Arenal Volcano by its infamous reputation as one of the most reliably

*Photo: Arenal, Costa Rica. Photographer: Daniel Vercelli*



explosive volcanoes in the Americas. Arenal was cloud-covered and invisible, but its roar was audible and palpable.

In that first visit to Arenal, I tried to reconstruct in my minds' eye what was going on at the vent from the diverse sounds emitted behind the cloud curtain. I thought I could blindly recognize rock-falls, blasts, pulsations, and ground vibrations, until the day the curtain lifted and I could confirm my aural reconstruction closely matched the visual scene. I had imagined a flashing arc from the shock wave as it compressed the steam plume, and by patient and careful observation I could see it, a rapid shimmer slashing through the vapour. The sound of rock-falls matched large glowing boulders bouncing down the volcano's slope. But there were also some surprises. Some visible eruptions were slow, so I could not hear them above the ambient noise. By comparing my notes to the infrasound records I realized these eruptions had left their deep acoustic mark, hidden in plain sight just below aural silence.

## EARLY WARNING OF HAZARDOUS ERUPTIONS

I then realized one could chronicle an eruption through its sounds, and recognize different types of activity that could be used for early warning of hazardous eruptions even under poor visibility. At the time, I had only thought of the impact and potential hazard mitigation value to nearby communities. This was in 1992, when there were only a handful of people on Earth who knew or cared about infrasound technology. With the cessation of atmospheric nuclear tests in 1980 and the promise of constant vigilance by satellites, infrasound was deemed redundant and had faded to near obscurity over two decades. Since there was little interest, we had scarce funding, and were easily ignored. The rest of the volcano community considered us a bit eccentric and off the main research streams, but patiently tolerated us. However, discussions with my few colleagues in the United States, Italy, France, and Japan were open, spirited, and full of potential.

## THE CTBTO'S ULTRA-SENSITIVE GLOBAL SENSOR NETWORK

Fast forward to the mid-1990s when a computer revolution took place. The global infrasound network of the International Monitoring System (IMS) began construction before the turn of the millennium in its full 24-bit broadband digital glory. Designed by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), the IMS infrasound stations detect minute pressure variations produced by clandestine nuclear tests at standoff distances of thousands of kilometres. This new, ultra-sensitive global sensor network and its cyberinfrastructure triggered an 'infrasound renaissance' and opened new opportunities in the study and operational use of volcano infrasound.

Suddenly endowed with super sensitive high-resolution systems, fast computing, fresh capital, and the glorious purpose of global monitoring for hazardous explosive events, our community grew rapidly and reconstructed fundamental paradigms early in the 21st century. The years 2005/6 brought regional acoustic monitoring networks in the USA, Europe, Southeast Asia, and South America, and helped validate infrasound as a robust monitoring technology for natural and man-made hazards. By 2010, infrasound was part of the accepted volcano monitoring toolkit. Today, large portions of the IMS infrasound network data, once

### TOWARDS A VOLCANIC NOTIFICATION SYSTEM WITH INFRASOUND DATA

**Powerful volcanic eruptions, such as those of Mt. Kelud in 2014 or Eyjafjallajökull in 2010, may cause disturbances in the different layers of the atmosphere. These fluctuations are measured by infrasound stations and analysed in order to extract parametric data that best characterize the volcanic source. The remote monitoring of volcanic activity with infrasound is of interest to the Volcanic Ash Advisory Centres (VAAC), which are responsible for coordinating and disseminating information on volcanic ash clouds that may endanger aviation. The synergy between the CTBTO and ARISE (Atmospheric dynamics Research Infrastructure in Europe) partners offers a unique opportunity for the establishment of a Volcanic Notification System (VNS) using infrasound data from a global station network. The VNS makes best use of the infrasound component of the IMS together with the operational capabilities of the International Data Centre. ARISE advanced products provide valuable parametric inputs on the atmosphere dynamics that drive the infrasound wave propagation. These results may serve as quality indicators, thus increasing the VAAC's confidence when receiving notification messages. The proposed approach is being tested with VAAC Toulouse, mandated by the International Civil Aviation Organization, and demonstrates the usefulness of infrasonic data to the International Airways Volcano Watch.**

exclusive, are publicly available through the IRIS Data Management Center[1] and the international infrasound community has grown to the hundreds, with rapid evolution as new generations of scientists join in.

In order to capture infrasound, either a microphone with a low frequency response or a barometer with a high frequency response is needed. The sensor data then need to be digitized for subsequent analysis. In the pre-millennium era, you would pay a few thousand dollars to get a single, basic data acquisition system. But, in the very near future, there will be an app for that. Once the sound is sampled, it looks much like your typical sound track, except you cannot hear it. A single sensor record is of limited use because it does not have enough information to determine the arrival direction of a signal unambiguously. So we use arrays and networks of sensors, using the time of flight of sound from one sensor to another to recognize the direction and speed of arrival of a signal. Once we associate a signal type to an event, we can start characterizing its signature.

## THE CHALLENGES OF CLASSIFYING VOLCANIC SOUNDS

As you might imagine, it is very hard to classify volcanic sounds. They are diverse, and often superposed on other competing sounds (often from wind or the ocean). As with human voices, each vent, volcano, and eruption type can have its own signature. Identifying transportable scaling relationships as well as constructing a clear notation for event identification and characterization remains one of the field's greatest challenges.

The infrasound community has had an easier time when it comes to the biggest and meanest eruptions, the kind that can inject ash to cruising altitudes and bring down aircraft.

Our data centre crew was at work when an acoustic signal from a huge volcanic eruption scrolled through the monitoring screens, arriving first at Riobamba in Ecuador, then at our station near the Colombian border. It was large in amplitude and just kept on going, with super heavy bass – and very recognizable. Such signals resemble jet noise — if a jet was designed by giants with stone tools. These sustained hazardous eruptions radiate infrasound below 0.02 Hz (50 second periods), so deep in pitch that it can propagate for thousands of kilometres to permit robust acoustic detection and early warning of hazardous eruptions.

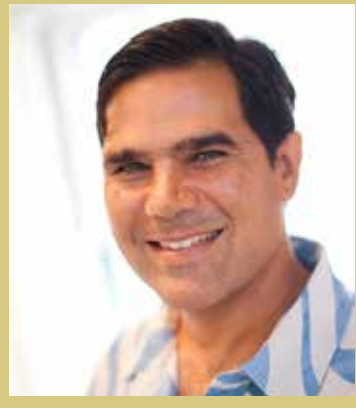
In collaboration with our colleagues in Singapore, Japan, Indonesia, and Palau, we will be focusing on the early detection of hazardous volcanic eruptions in Southeast Asia. One of the primary obstacles to technology evolution in infrasound has been the exorbitant cost of infrasound sensors and data acquisition systems, sometimes compounded by export restrictions. However, as everyday objects are increasingly vested with sentience under the Internet of Things, this technological barrier is rapidly collapsing. Today, one may readily download a free Infrasound Recorder App that turns your iPhone, iPod Touch, or iPad into an infrasound capture and analysis system. Instead, the questions of the decade are how to receive, organize, and distribute the wealth of information under our perception of sound so as to construct a better informed and safer world.

*This is an updated version of an article that was originally featured on the Sounding Out's series* 'Hearing the UnHeard' (soundstudiesblog.com/2014/10/02/hunting-monsters-volcano-infrasound/).

[1] http://ds.iris.edu/spud/infrasoundevent
http://www.iris.edu/bud_stuff/dmc/bud_monitor.ALL.html

*The "Cookie Monster" skylight on the southwest flank of Pu`u `O`o, Hawaii. Photo by J. Kauahikaua 27 September 2002*

### BIOGRAPHICAL NOTES



**MILTON GARCÉS**
is a geophysicist at the University of Hawaii at Manoa. He is also the founder of the Infrasound Laboratory in Kona and a collaborating scientist with the Earth Observatory of Singapore. Dr Garcés specializes in the study of global infrasound from man-made and geophysical sources in the atmosphere, ocean, and solid Earth. He operates the CTBTO's International Monitoring System stations in Hawaii and Palau, as well as regional stations in Hawaii.

*Colonel Mamadou Djerma, Grand Chancellor of the National Orders of Burkina Faso awards Lassina Zerbo with the country's highest honour, on behalf of the President of Burkina Faso.*

CTBTO Executive Secretary **Lassina Zerbo** was awarded the title of **Commander of the National Order of Burkina Faso**, the country's highest honour, in January 2015. He received the award for his work towards the preservation of peace and international security as head of the CTBTO and prior to this, as Director of the organization's International Data Centre Division. Zerbo received the award from the Grand Chancellor of the National Orders of Burkina Faso, Mamadou Djerma, in the name of the President of Burkina Faso.

Austria's Director for Arms Control, Nonproliferation, and Disarmament **Alexander Kmentt** was elected as the "**2014 Arms Control Person of the Year**" for his significant achievements and contributions to reducing the threats posed by the world's most dangerous weapons in the past year. This commendation has been issued by the Arms Control Association since 2007. Among the past winners are CTBTO Executive Secretary Lassina Zerbo (2013), Kazakhstan's Deputy Foreign Minister Kairat Umarov (2010), U.S. Senator Richard Lugar (2009), and former Norwegian Foreign Minister Jonas Gahr Støre (2008). Between 2006 and 2011 Kmentt served as the Special Assistant to the CTBTO's Executive Secretary.

**Thierry Dubourg** joined the CTBTO as Director of the Administration Division in early 2014. Previously Dubourg held positions in Budget, Finance and Internal Administration with the French Atomic Energy Commission (CEA). From 1997 to 2009, he was the first Chief of the Financial Services Section at the CTBTO, where he was responsible for setting up its structure, procedures and reporting tools. Among his successes was the implementation of a split currency system, which protected the organization against US Dollar/Euro fluctuations.

Former British Defence Secretary **Desmond Browne** (left) and former Russian Minister of Foreign Affairs **Igor S. Ivanov** (right), both members of the Group of Eminent Persons (GEM, see also page 4), are this year's recipients of the **Nunn-Lugar Award for Promoting Nuclear Security**.

The Nunn-Lugar Award was initiated in 2012 in honour of U.S. Senators Sam Nunn and Richard Lugar, who were also the award's first recipients. The Carnegie Endowment for International Peace and Carnegie Corporation of New York created the award to recognize an individual or institution whose work has helped strengthen global security and further peaceful co-existence among nations by preventing the proliferation of nuclear weapons and reducing the risk of their use.

Former United Nations Under-Secretary-General for Disarmament Affairs, **Jayantha Dhanapala,** received the **2014 Inter Press Service International Achievement Award for Nuclear Disarmament**.

The award for championing a world free of nuclear weapons is co-sponsored by the Tokyo-based Soka Gakkai International, which is leading a global campaign for the abolition of nuclear weapons. Dhanapala is currently the President of the Nobel Peace Prize-winning Pugwash Conferences on Science and World Affairs, Deputy Chairman of the Governing Board of the Stockholm International Peace Research Institute, a member of the GEM, and a member of several other advisory boards of international bodies.

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**PREPARED, COORDINATED AND EDITED BY:**
Denise Brettschneider

**CTBTO CONTRIBUTORS:**
Amina Daadouch, Dieter Eckhart,
Pierrick Mialle, Michelle Quevenco,
Amanda Szalczynski, Patricia Torruella

**LAYOUT AND DESIGN:**
Todd Vincent

**DISTRIBUTION:**
Pablo Mehlhorn

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Public Information
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Comprehensive Nuclear-Test-Ban
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Vienna International Centre
P.O. Box 1200
1400 Vienna, Austria
T +43 1 26030 6200
F +43 1 26030 5823
E info@ctbto.org
I www.ctbto.org

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