Observing missile launches using infrasound technology

The launch and flight of missiles can be observed using a number of different instrument types. Radar and satellite systems, for instance, can be used—by those countries that have access to them—as can infrasound sensors. As a complementary monitoring method, infrasound has the ability to detect a number of the aspects of a missile launch, such as location, trajectory and, to a limited extent, the type of missile used. Such recordings can be made even if the launch takes place hundreds of kilometres from an infrasound detector. In order to illustrate the potential of infrasound in this regard, this article examines data from an infrasound array used by the International Monitoring System (IMS) of the 1996 Comprehensive Test Ban Treaty (CTBT)—namely the I31KZ array in Aktyubinsk, Kazakhstan.

The IMS consists of a network of monitoring sensors designed to detect nuclear explosions and provide information on them to state parties as a means of verifying compliance with the CTBT. In addition to infrasound, the IMS operates three other types of technologies: seismological, radionuclide and hydroacoustic. Traditionally, it was the long observational range of infrasound that led to its adoption as the method of choice for the monitoring of nuclear and large chemical explosions during the 1950s and 1960s, before the advent of satellite monitoring systems. However, interest in infrasound diminished after the signing of the 1963 Partial Test Ban Treaty, which banned all but underground nuclear testing. The 1990s saw a re-birth in infrasound monitoring, now as a means of assisting verification of the CTBT.

Infrasound detection of rockets

Sound waves in the atmosphere become audible to humans if the frequency is in the range of 20-20,000Hz. Ultrasonic sound, which bats use for orientation, is inaudible to humans as it has frequencies higher than 20,000Hz. Likewise, sound lower than 20Hz cannot be heard; infrasound lies between 0.001-17Hz. A typical rocket infrasound signal is in the 0.1-1Hz frequency range. Infrasound frequencies have the advantage of lacking any significant attenuation in the Earth's atmosphere (i.e. loss in signal strength due to scattering and absorption of waves). Thus, infrasound waves can be observed even after travelling thousands of kilometres from their point of origin.

The ability to detect rocket-generated infrasound depends primarily on three factors. Firstly, local noise conditions at the receiver site determine the detection

In this issue ...

Bharath Gopalaswamy examines infrasound technology while Jasper Pandza discusses how Landsat 7 imagery can be used to monitor nuclear facilities. Plus Verification Watch, Verification Quotes, Science & Technology Scan and Centre News.

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threshold of a launch. This noise is correlated with local surface winds as well as with other background noise. Secondly, atmospheric conditions—such as temperature and wind structure between the source and the receiver—play a significant role in influencing infrasound propagation. Infrasound is also generated by natural phenomena such as wind, lightning and bolides and it is therefore important to be able to distinguish between their infrasound signatures and those caused by missiles. The third factor relates to source characterization. Most of the long-range infrasound is, it would seem, generated by the supersonic shock cone of a rocket at high altitude, as opposed to being generated at or near the launch site by plume exhaust or plume interaction with the ground.

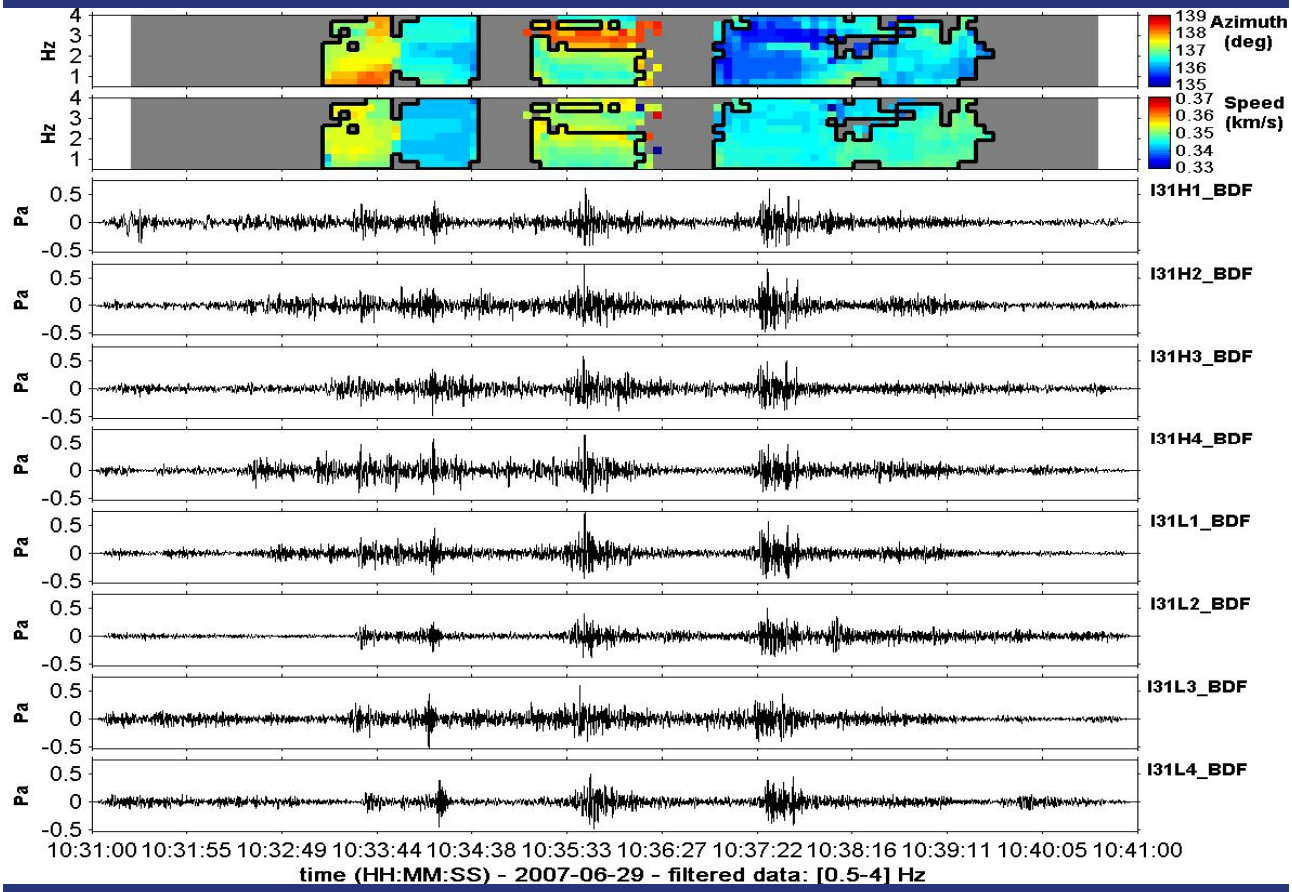
The I31KZ array in Kazakhstan

The I31KZ array in Aktyubinsk, north-west Kazakhstan, was built in 2001 as part of the IMS. Its construction was a joint effort between the Comprehensive Test Ban Treaty Organization (CTBTO) and the Kazakh Institute of Geophysical Research.

The array is an eight-element infrasound station employing MB2000 type microbarometers that can measure pressure fluctuations from 0.003-27Hz (with an electronic noise level of two millipascal/root mean squared in the 0.02-4Hz band). The data registered by the station is sent in near real time mode to the CTBTO's International Data Centre in Vienna, Austria.

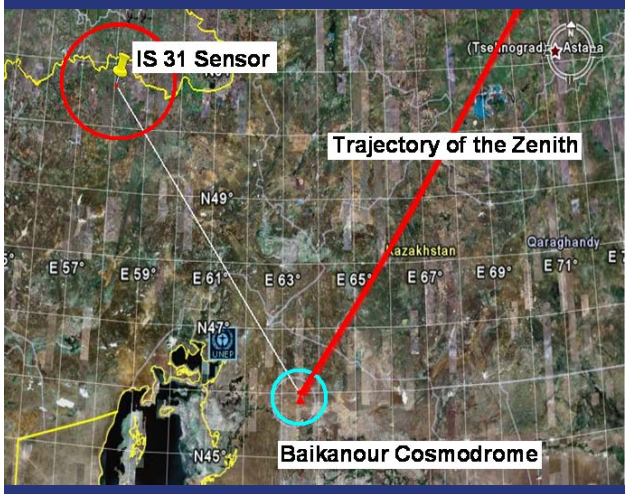
The array is located about 600 km away from the Baikanour Cosmodrome and consequently routinely observes missile launches from this site. Using a minimum of three microphones, spaced apart, these individual channels of the array are cross-correlated and spatially transformed over a finite window of time in order to calculate the direction from which the wave energy caused by a rocket launch arrives at the array. The optimal distance of the microphones from each other depends on the frequency character-

Figure 1: **The Zenith rocket launch**



Infrasound signal from the Zenith rocket launch recorded by the eight-element I31KZ array on 29 June 2007.

Figure 2: **Plotting trajectory**



The simulated trajectory of the rocket and the location of the I31KZ array.

istics of the waves of interest. By performing this procedure repeatedly over the length of a time-series that contains a signal, the back azimuth (the direction from the signal's source to the receiver) as well as the wave velocity can be computed.

An instance of launch detection—the Zenith rocket—observed at Aktyubinsk is shown in Figure 1. This was launched from the Baikanour Cosmodrome at 10:00 UTC on 29 June 2007. The sound waves arrive at the sensor approximately at 10:32 UTC. The direction from the signal's source to the receiver has been calculated to lie between 135 and 139 degrees. The arrival velocity of the waves are between 0.33 and 0.37 Km/s. This is characteristic of infrasound velocities. Figure 2 shows the trajectory of the rocket, plotted by freely available software.

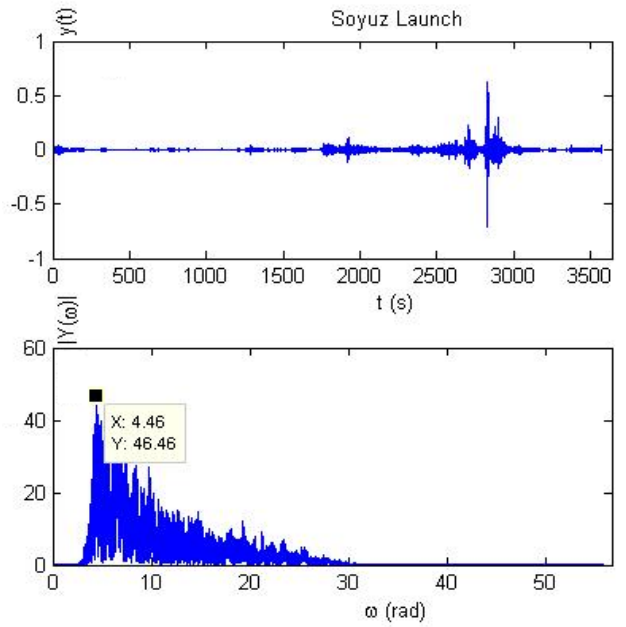
A simple pattern can be observed based on the signal processing analyses that have been carried out on the detections made by the Aktyubinsk array. In long range infrasound (500km-1500km), the dominant energy for liquid rockets lies between 0.1-1 Hz (Gopalaswamy, B. 'Role of Infrasound in Monitoring the Comprehensive Test Ban Treaty', *Journal of Sound and Vibration* (submitted)). This is represented in Figure 3, which shows the detection of a Soyuz launch and its dominant energy. Figure 3 also shows the dominant frequency at around 0.4Hz which is quite consistent with the literature (see Kashack, G. et. al, 'Long-range infrasound from Rockets', *Journal of the Acoustical Society of America*, Vol. 48, 12-20, 1970). Their study also reports that the dominant frequencies of solid fuel rockets are around 1-2Hz. However, it was not possible to validate information from events involving solid fuel rocket motors due to a lack of data.

Based on openly available data from launch detections at the I31KZ array, and in other stations, an empirical relation has been found that demonstrates the maximum distance at which certain classes of rockets can be detected, see Box 1 (overleaf). This finding was used to determine the maximum horizontal detection range of missiles. Table 1 (overleaf) shows the results.

Discussion

The above example demonstrates that infrasound stations such as those that form part of the CTBT IMS are, in principle, able to detect missile launches. Use of the IMS system itself for this purpose would likely be politically challenging, and it is also unclear at this stage how the CTBTO's International Data Centre would handle infrasound signals arising from

Figure 3: **Soyuz infrasound**



Top: Infrasound signal from a Soyuz launch.
Bottom: Signal transformed by Fourier analysis.

Table 1: **Detection ranges**

Rocket	Liftoff Thrust (kN)	Detection distance (km)
Proton	10,470	6,300
Ariane 5	6,470	4,500
Agni II	503	675
Scud-B	93	130

Maximum detection range for selected rockets.

missile launches. However any infrasound sensors that have similar specifications as those used by the CTBT IMS would be able to perform this function.

Infrasound sensors are inexpensive compared to other monitoring technologies. Ground-based radars and infrared monitoring satellites are likely to monitor missile launch and flight with much greater accuracy, but they cannot compare with the cost of obtaining an infrasound array, where one sensor costs as low as approximately US$2,500. Of course, infrasound could also be used as a complementary technology, alongside radar or satellites, and thereby potentially provide greater assurance or additional information for monitoring activities.

As the infrasound velocities shown above indicate, infrasound monitoring cannot provide 'early warning' alerts of missile launches—which could be used to prepare a response to an offensive missile strike. Infrasound takes too long to travel from the missile to the sensors to be used for this application. Rather, infrasound detection could potentially be used to assist with verifying compliance with the terms of a missile test agreement between two or more states.

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For further reading, see S. Aboul-Enein and B. Gopalaswamy, 'The Missile Regime: Verification, Test Bans and Free Zones', *Disarmament Forum* 4, UNIDIR, December 2009.

Box 1: **Determining maximum range**

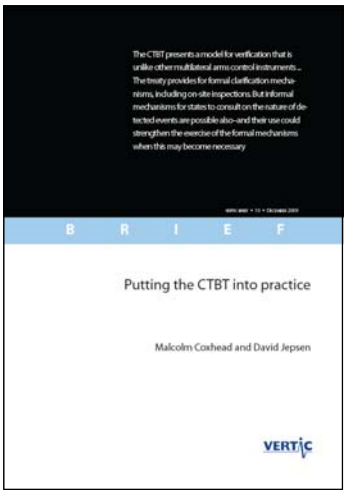
This relation is given as follows:

$$1.3\log10(R) = 2.759+\log10(NP)$$

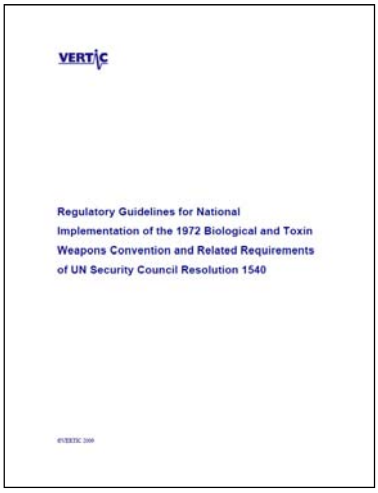
where R is the maximum range in kilometres and NP is the noise power of the rocket (the total amount of acoustical energy radiated per unit time).

Source: P. Brown et al (*'The Potential of the International Monitoring System Infrasound Network for the Detection of Rocket Launches'*, Prepared for the International Security Research and Outreach Programme, International Security Bureau, March 2007).

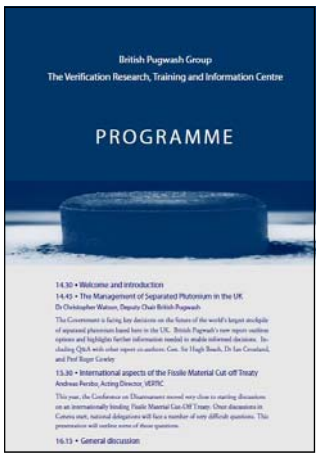
VERTIC publications and events October—December 2009



Our latest publications on the CTBT, generously sponsored by the Ploughshares Fund and the Norwegian Ministry of Foreign Affairs. Two of these reports have launched our new series 'Occasional Papers'.



In October, VERTIC distributed an internal 31-page report on the UK-Norway Initiative. VERTIC also released 27 pages of regulatory guidelines for national implementation of the BWC...



...and in November, VERTIC held a well-attended event on national and international aspects of fissile material control.

Challenges in identifying the operational status of nuclear facilities using Landsat 7

In April 2008, it was announced that the archives of the world's longest running satellite imagery acquisition programme, the United States Landsat programme, are to be made available free of charge. Since January 2009, all scenes dating back to 1972 and new acquisitions by the Landsat 5 and Landsat 7 satellites can be downloaded from the US Geological Survey (USGS) website. Using Landsat imagery could be of interest for NGOs and members of civil society who are working on nuclear non-proliferation and arms control issues, as under certain circumstances Landsat imagery can produce a preliminary indication of the operational status of key proliferation-relevant nuclear facilities. Gaseous diffusion enrichment, plutonium production, fuel reprocessing and nuclear power generation often produce large amounts of waste heat that must be discharged, usually via cooling towers or a cooling lake. This waste heat can often be seen on thermal satellite imagery that Landsat satellites are able to generate.

Several previous studies concluded that thermal Landsat imagery can be used for determining the operational status of nuclear facilities, particularly those that discharge their used cooling water into reservoirs. The aim of this article is to explore a rudimentary method for making this determination, without having to rely on professional analysis software or imagery experts. The proposed technique could appeal to organisations that want to produce visual evidence of a state's proliferation activities, but which cannot regularly afford expert knowledge, professional software or commercially available high-resolution imagery that usually costs more than US$1,500 per scene. It has been found, however, that the results obtained with the method suggested here must be treated with caution, in particular when looking at smaller nuclear facilities with cooling towers. This is because the method predominantly relies on eye judgement and requires certain atmospheric conditions to be present when an image is acquired.

After a brief introduction to Landsat 7 imagery, this article outlines the method for analysing imagery with the commercial off-the-shelf graphics editing program Adobe Photoshop. Then, for a small case study, several Landsat 7 scenes of the 5 MWe plutonium production plant in Yongbyon, North Korea (Figure 1) have been obtained and the resulting conclusions on the plant's operational status have been compared to data provided by the International Atomic Energy Agency (IAEA) and other high-resolution imagery that give a more reliable indication of the plant's operational status. Finally, the advantages and limitations of using Landsat imagery are discussed and some conclusions are made.

Figure 1: **Yongbyon 5MWe**

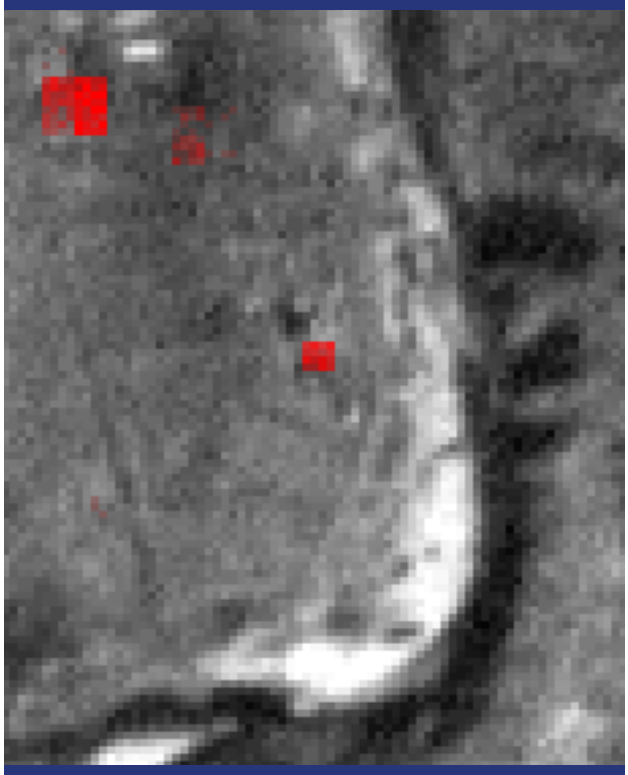
Close-up of the 5MWe reactor. The steam plume reveals that it is operational on 18 February 2007, the date this image was taken. Source: Google Earth, 39°47'48.74"N, 125°45'12.33"E.

Satellites for arms control

In Cold War times, satellite imagery capabilities fell under the rubric of National Technical Means, meaning that satellite imagery was used for military reconnaissance and outside the provisions of any international arms control verification regime. Over time, it became tacitly accepted that space can be used for reconnaissance purposes, leading each superpower to gather information about the other's strategic nuclear programmes. The 1967 Outer Space Treaty formalised the peaceful use of space, which led many other states to develop their own space technologies for remote sensing.

As with other arms control regimes, satellite imagery also had a difficult start in multilateral nuclear nonproliferation verification. Its use in IAEA safeguards was suggested to the Agency as early as the mid-1980s. But only after various independent feasibility studies and the conclusion of the Model Additional Protocol in 1997 did it become routinely used. Today, the Agency has its own satellite image interpretation department and actively supplements its verification efforts with satellite imagery.

Figure 2: **Yongbyon thermal image**



The 5 MWe reactor with a fair temperature signature on 19 February 2007, one day after the imagery in Figure 1 was taken. Source: USGS.

Landsat 7

To reveal the operational status of nuclear facilities, a satellite must be equipped with sensors capable of detecting light in the thermal range. Only a few satellites operating under civil programmes have such sensors. These include Landsat 5, Landsat 7 and the Terra satellite with its ASTER sensor. Since its start in 1972, the Landsat programme was meant to meet the needs of its civilian and scientific users, rather than making profit by selling imagery or by generating information for national intelligence services. Landsat imagery has therefore been cheaper to obtain compared to commercial high-resolution imagery, even before the imagery was made available free of charge. The Landsat satellites are developed by NASA and their data is managed by the US Geological Survey (USGS).

Landsat 7 has been operating since 1999 and has a revisit time of 16 days. Of its eight spectral bands, band 8 and band 6 are useful when examining the operational status of nuclear facilities. The panchromatic band 8 offers a 15m resolution, which is poor compared to the commercially available 0.5m imagery but sufficient to identify large structures. Band 6 shows thermal radiation with a wavelength of 10.40µm to 12.50µm. Even though the resolution of this band is 60m, differences in surface temperatures of objects smaller than 60m can still be observed as long as these temperature differences are large enough. Landsat 7 is also well suited for environmental applications such as monitoring deforestation and agricultural change. Bands 4, 5 and 7 detect light in the near-infrared and mid-infrared (with a 30m resolution), which is the spectral region in which vegetation strongly reflects sunlight.

Apart from the fact that Landsat 7 cannot penetrate clouds which reduces the usefulness of many acquired scenes, a serious drawback of using Landsat 7 imagery is that the satellite's 'Scan Line Correc-

tor' (SLC) failed in May 2003. This instrument compensated for the forward motion of the satellite when recording imagery and hence scenes after this date have data gaps that grow towards the scenes' edges and that make up about 22% of a scene. USGS suggests combining two images acquired soon after one another to fill the gaps, but this may not always be feasible as the key thermal information in a scene is sometimes made up of just a few pixels. However, the Yongbyon facilities considered further below always lie within the centre of Landsat 7 scenes and consequently the failure of the SLC has no negative effect on these examples.

Method and examples

The following method requires little more than a computer with internet connection and a graphics editing program such as Adobe Photoshop. Landsat 7 scenes can be chosen and downloaded with USGS GloVis (http://glovis.usgs.gov/) or the USGS EarthExplorer (http://earthexplorer.usgs.gov). Every scene comes in eight separate bands in the GeoTIFF format which can be opened and edited by the graphics editor.

The analysis process is not much more difficult than carrying out an advanced edit of digital photographs. In a nutshell, the tonal information of thermal band 6 must be converted from a range of dark to bright pixels into a range of transparent to red pixels, which is done by putting band 6 into the mask of a solid colour adjustment layer, with the solid colour chosen as red. Band 6 is then placed over the panchromatic band 8. Next, the tonal range of the thermal band must be adjusted with the levels toolbox to cut out the part of the tonal range that corresponds to colder temperature. What remains is only the tonal information corresponding to high temperature, displayed at the highest contrast. This allows for identifying temperature hotspots, such as one would expect to see at cooling towers (Figure 2).

When looking for warm water plumes, the tonal range of the thermal band must be adjusted to the temperature range of the water. In addition to cutting out tonal information that corresponds to cold temperature, it also helps to cut tonal information corresponding to the warmest temperature. Plumes such as those shown in Figure 3 can thus be made visible.

Analysing imagery with this method is based on eye judgement, which makes it a rather inaccurate process and comes with a range of limitations, as discussed below.

Case Study: Yongbyon

To test the above method of revealing the operational status of a proliferation-relevant facility, several scenes of the 5MWe plutonium production reactor in Yongbyon, North Korea, have been obtained and processed.

North Korea has long been of proliferation concern to the international community, and with the state's second nuclear test occurring in May this year, tensions are at another high. Considering that there is reprocessing plant very close to the 5MWe reactor, it is very likely that plutonium from this reactor was used for its two nuclear tests. As a result of multilateral negotiations in 2007, North Korea allowed the IAEA to verify the reactor's shutdown in July that year and even destroyed the reactor's cooling tower in July 2008. However, rebuilding a comparatively small cooling tower is within North Korea's capabilities and, noting the ongoing proliferation concerns, it is worthwhile to continue monitoring the Yongbyon facilities in the future.

The conclusions on the Yongbyon plant's operational status, based on the thermal imagery obtained, have been compared to data provided by the IAEA and open-source high-resolution imagery. The IAEA provides a concise summary on its safeguard activities at Yongbyon on its website from which a rough operational history can be inferred (http://www.iaea.org/NewsCenter/Focus/IaeaDprk/fact_sheet_may2003.shtml). Additionally, many high-resolution scenes that are able to reveal a steam plume have either been obtained and published by other institutions or are available through free web

applications such as Google Maps. The presence of a steam plume provides a much better indication of the reactor's operational status than thermal imagery can give. However, the visibility of steam plumes on satellite images can be reduced by certain atmospheric conditions such as strong winds or high temperatures.

As an example, the Google Earth satellite image in Figure 1, which shows a plume coming from the cooling tower, can be compared to the thermal image taken a day later which displays a temperature hotspot at the reactor complex (Figure 2). Both images suggest that the reactor was operational at this time.

Yet it should be kept in mind that plutonium production reactors operate at low fuel burn-ups which means they start up and shut down much more frequently than nuclear power plants which are generally kept operating for many months. It is therefore important to observe a longer trend over several months rather than focusing on individual correlations between thermal and visible imagery. And it can indeed be observed with Landsat 7 scenes obtained over a longer period that for several years the reactor was operated frequently for short periods before IAEA inspectors verified its shutdown in July 2007, and since then the reactor remained switched off.

Even though the conclusions made from the thermal imagery largely seem to agree with the reference data, it was generally difficult to clearly identify temperature hotspots at the Yongbyon reactor site. The hotspots only became more noticeable when looking at multiple scenes taken over a long period, which shows that the limitations discussed below play a large role in what can be seen in thermal imagery.

A further point suggests that this method should be applied with caution to other reactors. Experts have commented that this 5 MWe reactor is an exceptional case, as it produces a surprisingly large amount of thermal power (about 25 MWth) for a small nuclear facility. It is likely that it is only because of this reason that its operational status can be monitored with thermal satellite imagery and care should be taken if this method is applied to other small facilities. One can conclude that this method is more suited for larger facilities. If, however, this method were to be applied to smaller facilities, it would be useful to establish where the minimum thermal power output of nuclear facilities lies for this technique to be used.

Limitations

Although this method produced some positive results, these were constrained by several inherent inaccuracies that come with thermal Landsat imagery and by using such a rudimentary method. First, adjusting the thermal tonal information with the levels dialogue box is solely based on eye judgement which means that there is the risk of increasing the contrast of a particular part of the tonal range too much, leading to an exaggerated and misleading representation of what may be very small temperature differences.

The use of eye judgement therefore leads to some subjectivity in the analysis. It is important to highlight this point when considering the implications that may result from drawing conclusions about nuclear facilities that are of proliferation concern. Yet if this is kept in mind and in the absence of professional software, this method could be useful in obtaining some preliminary indications. It should be noted that professional remote sensing analysis does not rely on eye judgement and hence is not subject to this limitation.

Second, the vast majority of Landsat 7 scenes available to download were acquired at day time, as all its bands (with the exception of the thermal band 6) measure the reflected sunlight in a particular spectral window. Night time acquisition would have led to more accurate results as one would find it easier to distinguish between temperature hotspots caused by industrial activities and the facilities' surroundings. This is because the sun can warm up buildings and other structures which consequently emit thermal

radiation themselves and this is registered by thermal imagery and can potentially lead to misinterpretation.

Third, overlaying the thermal band onto the panchromatic band is in principle a straightforward process with Landsat imagery, as the resolution of one band is exactly four times smaller than the other. With Photoshop however, it is unclear whether the thermal band is placed over the panchromatic band accurately. Dedicated remote sensing software would be able to make sure that a pixel in the thermal band is placed over the correct pixels in the panchromatic band. This is particularly important when looking at temperature hotspots.

Further advantages and limitations of using thermal imagery depend on whether one is looking for temperature signatures from cooling towers or from water reservoirs: with regard to cooling towers, atmospheric conditions, such as winds and air temperature, can adversely influence the discernability of temperature hotspots at these structures. Because the resolution of Landsat 7's thermal band is rather small, this problem is much larger compared to the problems that atmospheric conditions cause to imagery of visible light mentioned above. Consequently, it would be better to use high-resolution imagery of visible light, where available (and affordable), when observing cooling towers.

This preference for high-resolution imagery over thermal imagery is reversed when searching for warm

Figure 3: **Novouralsk enrichment plants**

The cooling lakes of the Russian Novouralsk enrichment plants on 22 June 2002. Source: USGS.

water plumes in reservoirs, because visible light simply cannot reveal differences of water temperature in a cooling lake. Warm water plumes are much larger than steam plumes and when using thermal imagery they are registered over a wider tonal range, making them straightforward to spot on thermal imagery. Furthermore, because the emissivity (that is the material's specific ability to radiate heat) of water is roughly equal to 1, it is possible to estimate the absolute water temperature from thermal imagery.

As mentioned above, the 15m panchromatic resolution is quite low compared to the best resolution available commercially (0.5-1m). But this should not be a significant problem as free high-resolution services such as Google Earth can be used to establish what to focus on with Landsat 7 imagery. It is generally of advantage to complement Landsat imagery with other open-source information and many previous studies have demonstrated that a good mixture of open source information can lead to groundbreaking insights in nuclear non-proliferation issues.

Conclusions

Due to the limitations discussed in this paper, it is clear that this kind of rudimentary analysis, based on Landsat 7 imagery, is not likely to produce consistently accurate results. It has also become clear that small facilities with cooling towers are much harder to observe with thermal imagery than those discharging their used cooling water into lakes. However, the key advantages in using Landsat 7 images remain: their use is cost free, they can be acquired almost instantly and analysing them does not require expert knowledge.

Having said this, even professional analysts may not be able to rely exclusively on thermal and even high-resolution imagery of visible light when observing facilities with cooling towers, because the discernability of hotspots or steam plumes is heavily dependent on atmospheric conditions. It is also worthwhile to note that amounts of heat or water vapour sufficient to appear on satellite imagery can be generated without running a nuclear reactor—and perhaps certain states may want to give the impression that their facilities are operational to gain a bargaining chip in multilateral negotiations.

For whom might Landsat 7 imagery be useful? Ultimately, the production of fissile materials remains the highest technological hurdle on the way to a nuclear weapon. Unless a facility is rather small, most of the industrial processes required to overcome this hurdle produce significant amounts of excess thermal energy and this creates at least some potential for NGOs or, indeed anyone else who is interested, to identify key proliferation steps when they occur. NGOs working towards greater openness and accountability in the nuclear non-proliferation community often find they have potentially inconsistent and unreliable information available, and because of its inherent inaccuracy the use of thermal Landsat 7 imagery is no great exception here. Yet such organisations have the advantage of being able to disseminate information very quickly, outside political and bureaucratic constraints. From their perspective, low cost or free satellite imagery together with inexpensive software and simple analytical methods removes financial and technical constraints in conducting research. This would allow preliminary findings to be made and acted on, though hopefully bearing in mind the inconclusive nature of such results.

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VERTIC Consultant

Jasper Pandza completed an internship at VERTIC in the summer of 2009 and continues to work on various projects as a consultant. Recently he started a PhD project entitled 'Deterring Radiological and Nuclear Terrorism' at the Centre for Science & Security Studies, Department of War Studies, King's College London.

Verification Watch

START treaty expires with no successor pact agreed

On 5 December, the 1991 Strategic Arms Reduction Treaty (START) between the US and Russia expired with no replacement deal having been agreed on to take its place, despite strenuous—and ongoing—negotiations between the two sides in Geneva, Switzerland. The main features of the START successor are already well known: Presidents Barack Obama and Dmitry Medvedev agreed in July to cut the number of strategic nuclear warheads in their possession to between 1,500 and 1,675 (down from a maximum of 2,200 agreed in 2002), and to reduce strategic delivery vehicles to between 500 and 1,100 each. But differences have arisen over matters of verification and monitoring, with Russia pushing for a less intrusive system than before. 'Control measures must be adequate to a new treaty, not the old one,' argued the Russian foreign minister, Sergei Lavrov, on 17 December. It was, he said, 'time to get rid of excessive suspiciousness, especially as both presidents have said repeatedly they want to see a new level of US-Russian relations based on trust, mutual respect and equality.'

As the 1991 pact expired, US inspectors left Russia's main ballistic missile factory at Votkinsk, 600 miles east of Moscow, bringing to an end the permanent American presence at the plant that the treaty authorized. With Russia resistant to continued monitoring at Votkinsk, it is highly unlikely that they will return. The Russian military has long been opposed to the presence of US observers in the heart of Russia. For the moment, despite this major change, the old treaty otherwise remains in effect. A joint statement released by the US and Russian leaders on 5 December declared that, in the interests of 'strategic stability', the two countries would continue to 'work together in the spirit of the START treaty' and ensure that a new agreement enters into force 'at the earliest possible date.' A new deal—which few analysts on either side doubt will be signed at some stage—is seen by many as critical to restoring confidence in the non-proliferation regime ahead of the Nuclear Non-Proliferation Treaty review conference next May. As this edition of *Trust & Verify* went to press, the latest indications were that no deal would be signed before early 2010.

In further START-related news, the *New York Times* revealed in December that next year, once the new deal is done, the presidents of both countries plan to send their negotiators back to the table 'to pursue a far more ambitious agreement tackling whole categories of nuclear weapons never before subject to international limits.' In addition to further reducing their levels of deployed strategic warheads (perhaps down to 1,000 each), the envisioned talks will address levels of stored strategic warheads and numbers of tactical weapons, neither of which have ever been limited by treaty. According to the *NYT*, the US has around 3,000 strategic warheads in storage, and Russia around 1,000. In terms of tactical warheads (here understood as those with ranges below 300 to 400 miles), Russia is thought to have between 3,000 and 8,000, while estimates of the US stockpile range from 500 to 1,200—with some still deployed in Europe. Earlier this year, Mr Obama abandoned the George W. Bush administration's plans for a missile-defence shield in Eastern Europe as part of efforts to 'reset' the fraught state of relations between the US and Russia and improve the chances of securing a new arms treaty. The 1991 treaty was signed by US President George H. W. Bush and the Soviet leader Mikhail Gorbachev after nearly a decade of negotiating—and just five months before the collapse of the Soviet Union. It forced massive cuts in Cold War nuclear stockpiles, down to no more than 6,000 warheads and 1,600 delivery platforms each. It entered into force on 5 December 1994.

David Cliff and Matthew McGinn, London

OPCW elects new director general

On 2 December, the Organisation for the Prohibition of Chemical Weapons (OPCW) unanimously elected Ahmet Üzümcü of Turkey as the organization's next director general. His election took place at the fourteenth Conference of States Parties, held between 30 November and 4 December in The Hague, The Netherlands. Mr Üzümcü will begin his four-year term in July 2010, replacing Rogelio Pfirter who has served in the role since 2002.

Mr Üzümcü currently serves as Turkey's permanent representative to the United Nations Office in Geneva. He was nominated in October over six other candidates from Algeria, Finland, Germany, Indonesia, Switzerland and the United Kingdom. Mr Üzümcü has an extensive background in international security and non-proliferation affairs, including posts as Turkey's representative to NATO and to the UN Conference on Disarmament. Commenting on Mr Üzümcü's selection, Mr Pfirter said that he was 'a candidate of sterling personal and professional qualities' to lead the organization into the future.

Mr Üzümcü will be the first Turkish head of a major international organization. According to Paul Walker, head of security and sustainability of Global Green USA, the award of this post 'has some meaning not just for the OPCW but for Turkey in its role in the world.' The director general-elect has said that he will continue efforts directed toward universalization of the convention.

Matthew McGinn, London

Ghana signs logging agreement with EU

On 20 November, Ghana signed a Voluntary Partnership Agreement (VPA) with the European Union under the EU Action Plan for Forest Law Enforcement Governance and Trade (FLEGT)—the first country to do so. The VPA will include a licensing scheme aimed at combating the export of illegal timber to the EU.

In response to the problems created by illegal logging and deforestation, the European Commission adopted FLEGT in 2003. The ultimate goal of the plan is to encourage the sustainable management of forests, especially in key targeted countries and regions. The plan emphasizes the need to carry out governance reform and capacity building to ensure that timber exported to the EU is produced through legitimate forestry operations. Targeted countries are expected to voluntarily enter into a bilateral FLEGT-VPA with the EU. Under the plan, the European Commission, in conjunction with EU member states, is to assist with capacity building in FLEGT partner countries (including by providing support to NGOs and private sector actors).

Critics of VPA's have argued that the voluntary nature of the agreements and the lack of universal application make them vulnerable to circumvention as illegal timber could still be imported into the EU from countries that do not have a VPA. As a result, further measures are needed. To reinforce the system, the commission proposed a timber 'due diligence' regulation, which requires companies to ensure that only legally harvested timber is placed on the market.

Anthony Adisianya , London

London newspaper publishes 'evidence' of secret Iranian nuclear weapons work...

According to a confidential Iranian document published in December by the *Times*, the Islamic Republic may be presently testing a neutron initiator—the trigger for a nuclear weapon. The document, originally written in Farsi and thought to date from early 2007 (in the assessment of unspecified 'foreign intelligence agencies'), describes a plan to test an initiator over a period of four years. It refers to the neutron source uranium deuteride, or UD3, a substance that independent experts contacted by the *Times* confirmed as having 'no possible civilian or military use other than in a nuclear weapon.' Iran insists that its controversial nuclear activities are only for peaceful purposes, but if genuine, this document—headed 'Outlook for Special Neutron-Related Activities Over the Next Four Years'—proves otherwise. 'Although Iran might claim that this work is for civil purposes, there is no civil application,' the newspaper quoted David Albright, president of the Washington-based Institute for Science and International Security, as saying. 'This is a very strong indicator of weapons work.' The Foreign and Commonwealth Office in London said that the new revelation raised 'serious questions about Iran's intentions.' In response to the accusations, the Iranian president, Mahmoud Ahmadinejad, claimed that the document in question was a forgery by the US government and that its content was 'fundamentally not true'.

Whilst it is generally accepted that Iran has, in the past, conducted research into the design of a nuclear weapon, Western governments differ as to whether that work was ever actually abandoned and, if so, when. A US National Intelligence Estimate released in December 2007 judged 'with high confidence' that Iran's nuclear weapons programme was halted in 2003 in response to international pressure, and that the country was 'less determined to develop nuclear weapons than we have been judging since 2005.' The assessment, representing the consensus view of America's 16 intelligence agencies, further judged 'with moderate confidence' that Iran had not restarted its nuclear weapons program as of mid-2007—a finding that has now been thrown into serious doubt. Crucially, and in defiance of several United Nations resolutions, Iran has not suspended its uranium enrichment work (enrichment being one of the most difficult and time-consuming aspects of nuclear bomb-making). In September 2009, Iran was forced to admit the existence of a secret nuclear facility near the holy city of Qom—a facility of a size and configuration 'inconsistent with a peaceful program,' in the words of President Obama. The discovery of this plant, which followed a long intelligence-gathering effort by American and allied agencies, presented clear evidence of Iran's 'serial deception of many years,' British Prime Minister Gordon Brown declared. Following that revelation, the *Times'* more recent (and arguably more damaging) disclosure of Iran's apparent experimentation with uranium deuteride is certain to further strengthen the case for additional sanctions ahead of an end-of-year deadline for diplomatic progress on the nuclear issue set by Mr Obama.

Moreover, the news that Iran may be currently working on an initiator highlights enduring limitations in the verification regime of the International Atomic Energy Agency (IAEA)—a system that relies heavily on states' declared nuclear material and activities under their individual non-proliferation safeguards agreements and, if party to a supplementary 'Additional Protocol', their declarations of 'nuclear fuel cycle-related research and development activities not involving nuclear material.' Unearthing clandestine weapons work is, as a result, particularly difficult. As James Acton and Carter Newman noted in a 2006 VERTIC report on IAEA verification of military research and development (R&D), 'no state is likely to declare its weaponization activities and states' reports on their fuel cycle activities are unlikely to be of much help in verifying military R&D...Since the IAEA is lacking an important component of the verification regime (i.e. information submitted from member states), verification activities would have to commence on vague, often incorrect and most definitely incomplete information.'

David Cliff, London

...while Iran claims CTBT monitoring station is to be used for spying

Iran has claimed that a recently constructed seismic monitoring station just over the border in neighbouring Turkmenistan was built to enable world powers to spy on Iranian activities. The station forms part of the global network of seismic, infrasound, hydroacoustic and radionuclide stations designed to detect and pinpoint nuclear explosions anywhere on the planet—to be banned once the 1996 Comprehensive Nuclear Test Ban Treaty (CTBT) receives the outstanding ratifications necessary for its entry into force. In remarks that underscore the deteriorating state of relations between Iran and the West, Abolfazl Zohrehvand—a senior Iranian diplomat involved in Iran's nuclear negotiations—attacked the CTBT as an 'espionage treaty' that 'contradicts countries' national sovereignty.'

In response, the preparatory commission charged with establishing the treaty's extensive verification regime insisted that the new facility (which is currently undergoing testing) was unconnected to concerns over Iran's nuclear program, and that the placement of a particular station was, in any case, unrelated to the location of a test it detects, citing North Korea's nuclear tests in May 2009 and in October 2006 as evidence. In the 2006 test, '23 stations worldwide, among them a station as far away as La Paz, Bolivia, picked up the signals loud and clear,' said Annika Thunborg, a spokeswoman for the commission. 'In May 2009,' she said 'when the DPRK declared another nuclear test, 61 seismic stations picked up the event—from Ussuriysk, Russia, to Texas.' According to the commission, there are already three similar seismic monitoring stations inside Iran itself, including one in Tehran. Furthermore, Ms Thunborg added, the decision to build the station in Turkmenistan was taken back in the mid-1990s, with Iranian involvement.

The CTBT—the prospective successor to the 1963 Partial Test Ban Treaty, which outlawed all but underground nuclear testing—has at present 182 signatory states, and 151 ratifications. To enter into force, however, it must be ratified by the 44 'Annex 2' states that participated in the negotiations of the treaty from 1994-1996 and that possessed nuclear power or research reactors at that time. Nine of these countries have yet to do so, including, problematically, Iran and North Korea. For its part, America remains only a signatory to the treaty after the US Senate rejected ratification in 1999 (though President Obama wants a second vote in the hope of reversing this decision). The six other Annex 2 hold-outs comprise of China, Egypt, India, Indonesia, Israel and Pakistan. Many believe that US ratification of the CTBT would see a number of these other countries follow suit, although prospects for Iranian and North Korean ratification appear, for the moment at least, bleak.

David Cliff, London

Verification Quotes

'*We don't intend to cut our relationship or cooperation with the [International Atomic Energy] Agency. We are set to build the new enrichment facilities under the supervision of the IAEA as we believe it is part of our rights,*' Iranian Foreign Ministry Spokesman Ramin Mehmanparast on IAEA monitoring in Iran.

'*Only recently has verification gotten the attention it deserved all along,*' US Senator Jon Kyl, long-time opponent of CTBT verification, while discussing negations on a new START, makes a sudden reversal on the value of verification.

'*The meeting has had a positive result, everyone should be happy,*' Xie Zhenhua, lead Chinese climate negotiator, on the outcome of the UN climate conference in Copenhagen.

Yukiya Amano takes charge at the IAEA

On 1 December 2009, Yukiya Amano of Japan succeeded Mohammed ElBaradei as director general of the International Atomic Energy Agency (IAEA). Mr Amano is the fifth head of the IAEA since the UN-backed organization's founding in 1957, and takes on the role at one of the most difficult periods in its 52-year history—at a time of pressing non-proliferation crises with both Iran and North Korea.

A graduate of the Tokyo University Faculty of Law, Mr Amano—who formerly served as Japan's official representative to the agency and who brings considerable experience in disarmament, non-proliferation and nuclear energy issues to the post—was selected by the IAEA board of governors to take over from Mr ElBaradei in July. Born in 1947, he is not only the first Asian to head the agency, but also from the only country ever to be attacked with nuclear weapons. Addressing staff members on his first day at the helm, he spoke of the 'stormy' situation in which the IAEA currently stands, promising to fight the proliferation of nuclear weapons, enhance nuclear security and address the global energy need in an 'impartial, reliable and professional' manner.

Shortly prior to his departure, Mr ElBaradei told IAEA governors that investigations into Iran's ostensibly civilian nuclear programme had 'effectively reached a dead end' due to the lack of Iranian cooperation. 'There has been no movement on remaining issues of concern which need to be clarified for the agency to verify the exclusively peaceful nature of Iran's nuclear program,' Mr ElBaradei said. Iran's rejection of an IAEA-brokered plan to ship some three-quarters of its low-enriched uranium abroad for processing (proposed in October), and, subsequently, its declared intention to build ten new enrichment facilities, ensure that this issue—now in its eighth year—is likely to remain a top priority of Mr Amano for some time, as will managing the ongoing tension with North Korea over its continued refusal to abandon its nuclear weapons programme. Since its 2003 withdrawal from the Nuclear Non-Proliferation Treaty (which Mr Amano, incidentally, helped to extend indefinitely in 1995), North Korea has successfully tested two nuclear devices and come under suspicion of helping to build a nuclear plant, now destroyed, in the Syrian desert. North Korea expelled IAEA inspectors in April 2009.

Whether Mr Amano will be able to reverse these trends remains to be seen, but given the largely fruitless efforts of Mr ElBaradei, room for optimism is slight. Mr Amano has, in any case, indicated that he will maintain a more technocratic, less politically involved, profile than his often outspoken predecessor. 'The IAEA's basic function is not political negotiation but implementing already agreed safeguards,' he said in February 2009. 'Remarks by the director have political implications which, if made without properly assessing these implications, can be very dangerous.' Mr Amano will now hold the top job until 2013 at the earliest; Mr ElBaradei was twice reinstated after his initial appointment in 1997, despite courting controversy in the US by publicly opposing the 2003 invasion of Iraq.

David Cliff, London

US unveils new bioweapons strategy but rules out verification

President Obama has decided not to support a global monitoring system for the 1972 Biological Weapons Convention (BWC). The announcement was made by US Under Secretary of State Ellen Tauscher in an address to the convention's annual conference in Geneva, held this December, where the new American strategy for countering biological threats was unveiled. 'The Obama administration will not seek to revive negotiations on a verification protocol to the convention,' Ms Tauscher declared. 'We have carefully reviewed previous efforts to develop a verification protocol and have determined that a legally binding protocol would not achieve meaningful verification or greater security.' Instead, compliance with the BWC 'should be promoted by enhanced transparency about activities and pursuing compliance diplomacy to ad-

dress concerns.'

A multi-year effort to construct a system of verification for the BWC ended in failure in 2001, when the Bush administration rejected the draft plan, claiming that it would not work and that intrusive inspections could expose American businesses to industrial espionage. The Obama administration appears principally concerned with the first of these two objections. 'Things that were breakthroughs ten years ago are now something you can do in your garage,' said a senior White House official ahead of Ms Tauscher's remarks, speaking on condition of anonymity. 'That's not a context in which verification is going to be very realistic or effective.' Ms Tauscher herself argued that it was 'extraordinarily difficult to verify compliance' with the BWC, noting that 'the ease with which a biological weapons program could be disguised within legitimate activities and the rapid advances in biological research make it very difficult to detect violations,' or indeed construct a system of verification able to 'keep pace with the rapidly changing nature of the biological weapons threat.'

The newly released strategy has seven major goals: to promote global health security; to establish and reinforce norms against the misuse of the life sciences; to obtain information on current and emerging risks; to take steps to reduce the potential for exploitation of dangerous biological materials (such as ensuring the security of high-risk pathogens and toxins in laboratories); to expand America's capability to prevent and disrupt biological attacks; to communicate effectively with its domestic and international stakeholders; and to foster a common international dialogue on biological threats. At the Geneva meeting, Ms Tauscher spoke of America's determination to 'reinvigorate the Biological Weapons Convention as the premier forum for global outreach and coordination,' and the importance of efforts to promote universal membership. The BWC currently has 163 states parties and 13 signatories. Nineteen states have neither signed nor ratified the convention.

David Cliff, London

Climate deal 'noted' in Copenhagen

After two weeks of intensive negotiations, and two years of preparation, the UN climate change conference in Copenhagen (7-19 December) ended without a legally binding agreement to reduce greenhouse gas emissions. Instead, the participants agreed only to 'take note' of a nonbinding agreement—the 'Copenhagen Accord', which states the international community's intent to limit temperature rises to less than 2C—that President Obama brokered with the leaders of China, India, Brazil and South Africa. The accord sets no timetable for it to be transformed into a binding pact, nor does it specify the size of emissions reductions needed to achieve the 2C goal—only that 'deep cuts in global emissions' were necessary. It does, however, include a promise of US$30 billion in climate aid to developing countries over the next three years, and a commitment by developed countries to jointly mobilise US$100 billion a year by 2020.

Regarding arrangements for the measurement, reporting and verification (MRV) of developing countries' mitigation actions, one obstacle to a binding deal at the conference, the accord asks these nations to monitor their own unsupported activities (those actions not given international financial assistance) and submit to the UN 'national communications' reports every two years. But the text also refers to undefined 'provisions for international consultations and analysis' of mitigation, reportedly a compromise between the US and China. Those 'nationally appropriate mitigation actions' that are supported by international finance will be subject to international MRV, and recorded in a registry along with the matching support. Developed countries' emissions reductions and financing 'will be measured, reported and verified in accordance with existing and any further guidelines'.

Although some diplomats and leaders from the developed world talked up the accord as an 'important beginning' (UN Secretary General Ban Ki-moon) and a generator of 'momentum' (Mr Obama), it falls far short of the hopes held by many in the lead-up to the conference.

David Cliff and Larry MacFaul, London

Science & Technology Scan

US laboratory develops new landmine locator device...

A team of engineers at the Lawrence Livermore National Laboratory in California have developed an aerial land mine location system, as a means of making de-mining safer, cheaper and quicker. Traditional (and trusted) de-mining methods involve the use of metal detectors and the manual prodding of soil, but these methods are inefficient and can result in death or serious injury to de-mining personnel. False positives are a particular problem. Often when using metal detectors, de-miners are unable to tell apart metallic mines from other pieces of metal, and because some antipersonnel mines are made predominantly of plastic, detecting their small metal components requires the detector's sensitivity to be turned up—which, in turn, leads to an even greater number of false positives.

Science & Technology Review, Livermore's own publication, reports that the laboratory's land mine locator is equipped with its unique LANDMARC (land mine detection advanced radar concept) system, 'which features an ultrawide radar-sensing technology called iRadar and tomographic algorithms that provide three-dimensional subsurface images.' The iRadar sensor sends out short electromagnetic pulses over a very wide frequency range and, by so doing, enables 'much finer resolution of materials than other sensing systems.' LANDMARC is deployed on a remotely operated, and highly manoeuvrable, helium-filled aerial platform: a 12-metre wide unit that can cruise at over 40 miles an hour and rotate 360 degrees while doing so (or while hovering). A telescoping mast lowers a sensor bar mounted with individual iRadar units from the platform; they then generally hover 1-2 metres above the ground.

Matthew McGinn, London

...and a handheld gamma-ray detector

Scientists and engineers at Livermore , working alongside the US Defence Threat Reduction Agency and the National Nuclear Security Administration, have also developed a portable detection device that significantly enhances the field of gamma-ray spectroscopy—a key means of locating radioactive materials at ports and border crossings. The device is known as GeMini, and utilises the element germanium (hence the 'Ge' in GeMini) to accurately detect and identify nuclear materials. The high energy resolution of germanium enables GeMini to differentiate between legitimate and illegal sources of gamma rays, which is of benefit for national security. GeMini's design also incorporates a novel ultra-miniature electromechanical cooling system (hence the 'Mini') with an infrared shielding mechanism developed at Livermore. Previous germanium-based spectrometers have been confined to laboratories where liquid nitrogen is available to cool them, as germanium only achieves its useful high resolution at extremely low temperatures. GeMini's cooling system does away with the need for liquid nitrogen, thus making the instrument portable. Easily portable in fact: a key aspect of this device is its size—small enough to fit in the palm of a hand. According to *Science & Technology Review*, when compared to other instruments, 'GeMini identifies nuclear materials with a higher level of certainty and at considerable cost savings.' The handheld design of the device allows for ease of use by first responders in the event of a nuclear incident, and for security personnel on alert for the smuggling of nuclear materials. Currently, a version of GeMini is being developed to enhance international safeguards agreements by allowing the device to be used for inspections of nuclear facilities.

Matthew McGinn, London

Gas study conducted on Boston subway

Between 5-11 December, the US Department of Homeland Security released harmless gases and dye tracers into the Boston subway system in an experiment designed to study how smoke and other airborne contaminants move through public transport networks. The study is part of US efforts to prepare for a possible chemical or biological attack along the lines of the 1995 Tokyo subway sarin incident. 'Proactively studying and preparing for possible threats is one of our most effective strategies for fortifying our critical infrastructure,' said America's homeland security secretary, Janet Napolitano ahead of the gases' release. 'This study is one of many efforts the department is undertaking across the country to inform our emergency response planning in preparation for chemical or biological terrorist attacks.'

The research team included scientists from American laboratories in California, Illinois and Virginia, as well as from Australia and the UK. According to a press release issued by Ms Napolitano's department, the data produced by the study 'will help guide the design of next generation detection systems and enable transportation systems to strengthen evacuation, ventilation and other incident response strategies.' Measurements were taken at over 20 stations, as well as in subway carriages across the underground portion of the Boston network. In March 1995, members of the apocalyptic Japanese cult Aum Shinrikyo released the highly toxic nerve agent sarin onto five of Tokyo's metro trains, killing 12 people and causing thousands more to seek medical attention.

David Cliff, London

VERTIC News & Events

National Implementation

On 20-21 October, VERTIC staff participated in a workshop on the Biological Weapons Convention (BWC) held in Riyadh and sponsored by the Government of Saudi Arabia, along with senior officials from the BWC Implementation Support Unit. The event covered the current biological weapons threat; overlaps between the BWC and UN Security Council Resolution 1540; national implementation; assistance, cooperation and coordination; confidence-building measures; scientific and technological developments; as well as regional and national perspectives and activities.

During 30 November-4 December, VERTIC participated in the Chemical Weapons Convention (CWC) Conference of States Parties in The Hague and gave a presentation on the National Implementation Measures Programme at the "Open Forum" civil society side event on 2 December, which was open to all delegations at the Conference. In the margins of this Conference VERTIC collaborated with Dr Paul Walker of Global Green, the US affiliate of Green Cross International, in the launch of Chemical Weapons Convention Coalition (CWCC). The CWCC is 'an independent, international body whose mission is to support the aims of the Chemical Weapons Convention and to supplement the efforts of the member states of the Organisation for the Prohibition of Chemical Weapons with focused civil society action aimed at achieving full membership of the Convention, the safe and timely elimination of all chemical weapons, preventing the misuse of chemicals for hostile purposes and promoting their peaceful use'.

During the 2009 BWC Meeting of States Parties, held from 7-11 December in Geneva, VERTIC delivered a statement during the NGO session encouraging States Parties to take action on national implementation, the submission of the Confidence Building Measures and on universality of the Convention. VERTIC hosted a lunchtime side event on 10 December to launch its new BWC Regulatory Guidelines, with additional presentations from Bob Mathews (member of VERTIC's International Verification Consultants Network) who spoke on the regulatory regime for the BWC in Australia, along with building a culture of responsibility among life scientists through codes of workplace conduct; and from Nicholas Sims (member of VERTIC's Board of Trustees) who spoke on the development of an 'accountability mechanism' for the BWC. VERTIC staff also had several successful bilateral discussions with delegations in the margins of the meeting.

VERTIC has now published its new 'Regulatory Guidelines for National Implementation of the 1972 Biological and Toxin Weapons Convention and Related Requirements of UN Security Council Resolution 1540' which have been developed as guidance for States when they are engaged in the process of preparing any regulatory and administrative measures that may be necessary to supplement their primary legislation for national implementation of the 1972 Biological and Toxin Weapons Convention, as well as the biological weapons-related provisions of UN Security Council Resolution 1540. The Regulatory Guidelines are now available in five languages; VERTIC is grateful to the Global Partnership Program, Department of Foreign Affairs and International Trade Canada, for translating this document into French and Russian.

VERTIC's Factsheet number 10, providing guidance on the establishment or designation of a BWC National Authority, is now available in Arabic (in addition to existing versions in English, French, Russian and Spanish).

Angela Woodward, Scott Spence and Rocio Escauriaza-Leal

Arms Control and Disarmament

In October, programme staff attended the Pugwash Consultation on Issues Related to the NPT Review Conference, with a Special Focus on the Greater Middle East held in London and later a seminar on the Comprehensive Nuclear Test Ban Treaty held in New York. The programme also attended the Wilton Park Meeting on New Approaches to Penalizing Nuclear Smuggling. October ended with the presentation of the programme's evaluation of the second on-site inspection exercise of the UK-Norway Initiative at a workshop hosted by the UK Ministry of Defence.

In November, the programme attended an ESARDA working group meeting on verification technology. This served as a welcome reconnection with the ESARDA community, which VERTIC has been out of touch with for too long. The programme also visited the United Service Institution (USI) of India in New Delhi to learn more about Indian attitudes to arms control and disarmament. The meeting was very fruitful and carries with it great hopes for future collaboration between USI and VERTIC. On 26 November, VERTIC, together with British Pugwash held an event on national and international aspects of fissile material control. The centre was pleased to welcome some 30 representatives from all relevant branches of government in addition to guests from the BBC, CNN and the print media.

In December, programme staff met with the French Military Attaché to discuss issues relating to the 2010 NPT Review Conference. Most programme members attended the RUSI-UNAUK-BASIC conference on the review conference on 3 December 2009.

On 8 December, Andreas Persbo attended the Foreign Secretary's Christmas reception. He, and Meena Singelee then attended the annual Wilton Park Non-Proliferation Conference.

Andreas Persbo, Hassan Elbahtimy, Meena Singelee and Jasper Pandza

Environment

In October, VERTIC attended the second Chatham House-Rights and Resources Initiative Dialogue on Forests, Governance and Climate Change (co-organized with the World Resources Institute), in Washington DC. Prior to this, VERTIC participated in a meeting, also held in Washington, on Monitoring, Reporting and Verification (MRV) and Governance with several research institutes and other organizations working on projects that can inform and assist initiatives on Reducing Emissions from Deforestation and Degradation (REDD).

Between 14-17 December, VERTIC attended the 15th Conference of Parties to the UN Climate Change Convention, in Copenhagen. During the conference, VERTIC participated in a meeting on MRV, forest governance and REDD. VERTIC provided observations from experience with developing and implementing the Chatham House study 'Measuring the response to illegal logging'. VERTIC also participated in a workshop on setting up a research network on greenhouse reporting and monitoring. In addition, VERTIC conducted a series of bilateral meetings with several organizations during the conference to discuss working with them on upcoming projects in 2010, and to discuss funding for new work streams.

Between October and December, VERTIC continued its work on the Chatham House illegal logging project. This included carrying out research on target countries and the private sector, preparing survey results and starting to collate project partner work. Initial results of the full phase of the project, covering 12 countries (including producer, processing and consumer states) were discussed with the project working group in early December.

Larry MacFaul

Grants & Administration

In the quarter, the Ploughshares Fund awarded VERTIC a one year grant of US$37,782 to supplement funding already given by the Norwegian Ministry of Foreign Affairs on a publication series on the Comprehensive Nuclear Test Ban Treaty.

In December, David Cliff, a recent graduate of the University of Exeter, with an undergraduate degree in Geography and a postgraduate masters in International Affairs joined VERTIC as an intern. He is currently working in the Arms Control and Disarmament programme, and is responsible for the internal *VERTIC News Brief* series, as well as for contributions to *Trust & Verify*.

Also in December, VERTIC submitted its final report to the Ford Foundation. The Foundation has been a loyal ally of VERTIC over many years but is now moving out of the arms control and disarmament area. We wish to thank the Foundation and its staff for supporting VERTIC in a period of financial stress.

Finally, Matthew McGinn finished his internship with VERTIC, Matt has been an outstanding intern, with a certain appetite for numbers and spreadsheets, and we would like to thank him for his contribution to the organization.

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building trust through verification

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