Science and Technology: a key for verification sustainability

Excellencies, Ladies and Gentlemen,

It is a great honor for me to be here today and I thank Lassina Zerbo, the Incoming Executive Secretary, as well as the Organizing Committee for inviting me to the closing session of this Scientific and Technology 2013 conference.

The distinguished previous speaker, Dr Siegfried Hecker, has briefed us on the advantages of the CTBT for nuclear-armed states, in stopping a costly contest for sophistication, hence bringing more stability and, consequently, reducing the risk of an nuclear arm-race. This alone is an achievement for the benefit of mankind that worth supporting the CTBT and calling for its early entry-into-force.

There is no doubt that we have all benefited from the commitments that Signatory States have undertaken through the CTBT in terms of general security. But we should not forget that, in addition to the political will, negotiating a CTBT was possible because S&T allowed conceiving such a unique, global, reliable, efficient and continuously operating verification system. Today we have an Organization that, after a more than fifteen-year-long build-up period, delivers almost the best of what is possible today in terms of verification. I am optimistic on the fact that this will last and this is what I am going to share with you today.

The first part of my presentation will address key milestones regarding the achievements that CTBTO has offered to the international community, inside and alongside its mandate. Then, I will consider the role of Science and Technology in the make up of this unique mix of science, technology, and politics. Finally, I will consider ways to sustain this successful process and see whether lessons could be learned in other fields even if, as the danish physicist Niels Bohr said once, "*prediction is very difficult, especially about the future*".

So, firstly, <u>what have we achieved?</u>

Let's look at the facts. Being in front of so many scientists, there is no need to remind that experience is trustworthy. If today we look back at the build-up of the verification system we have to consider two hard facts. As a first point, this verification system is based on a twenty-year-old design that has indeed proven being adequate. The second point is that after 15 years it is almost completed. In my opinion, to give rough numbers, I would say that it is at more than 80% completed. In addition, and this is of utmost importance, this system is already operating, even if this is in a provisional mode and the OSI program is in good shape. And, not only is it operating, but it is delivering efficiently what it is meant for.

Let's consider some achievements and start with the *raison d'être* of the treaty. The PTS has been successful in fulfilling its mission on the occasion of this event that has been unanimously condemned by the international community: the nuclear-test conducted by North Korea last February. From that observation alone, we should ask ourselves whether it is worth considering an early entry-into-force even if the verification system is not completed at 100%. I will come back to this later.

If we now look to other events of global importance in a more chronological order, we must consider what happened after the deadly tsunami of 2004 in the Indian Ocean. The data of the International Monitoring System are now provided to tsunami warning centers that are recognized

as such by UNESCO. Why were the data repeatedly requested by the international community? Because of the quality and reliability of the data of the IMS stations. Because of their high level of availability in almost real-time, and because they are spread all over the world! Today more and more tsunami-warning centers are including those precious elements into their operational warning systems. Can we imagine that this could not be sustained in the long term? And if you allow me a digression, it is hard for me to understand why there are still countries today that are not providing data from IMS stations located on their territories.
Let's now turn to a second recent event of global importance. In addition to the waveform-technology data related to the tsunami that hit the Japanese coasts in 2011, the subsequent accident at the Fukushima Daiichi nuclear-power-plant has shown that the data collected by the IMS radionuclide stations has been of great importance for the international community, especially through its use by national institutions and the IAEA. Thus, a process was initiated that led the CTBTO to become a contributor to any future emergency situation in the radiological or nuclear field. Hence, the Organization is now a Member of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), that convenes regularly under the auspices of the IAEA and whose purpose is to co-ordinate the arrangements of the relevant international intergovernmental organizations for preparing for and responding to nuclear and radiological emergencies. The specific contribution of the CTBTO to the IACRNE is being progressively formalized.

I could also have mentioned other cooperation such as the sharing of seismic bulletins with the international seismological centre. And, of course, the remarkable collaboration established over the year with the World Meteorological Organization.

The specific characteristics of the IMS network, the IDC tools in terms of analysis, and the skills developed within the Provisional Technical Secretariat have demonstrated their relevance. And the beauty of it is that all these activities are envisaged in the Treaty, in the paragraph 8 of its article II which states that "*The Organization, as an independent body, shall seek to utilize existing expertise and facilities, as appropriate, and to maximize cost efficiencies, through cooperative arrangements with other international organizations such as the IAEA.*" Their actual implementation is a fair recognition of the unique nature of the IMS network, of the analysis capabilities of the IDC and of the expertise that has been developed over the years within the PTS.

But, and one more time this is the prime purpose of the verification system, we should not forget that all the events in DPRK, in 2013 as I have already mentioned, and also in 2009 and 2006, despite low-energy levels, were detected, localized and identified. On this occasion the PTS demonstrated its ability to deliver, through their National Data Centers, the related data and products to the Member States within the expected time frame. Member States have then been able to exercise their verification capabilities in order to define whether these events were nuclear tests or not. They could also validate the quality and objectivity of the IMS data and of the IDC products. The quality of the deliverable provided by the PTS met the highest expectations and was confirmed by the independent investigations undertaken by the Member States. Indeed, the PTS is today providing what is at the heart of the Treaty: ensuring that no nuclear test would go unnoticed worldwide. And today, no one can reasonably challenge the technical capacity of the CTBTO to maintain this level of performance that already fits the needs.

However, all these achievements even if materialized through the CTBTO are not the result of the sole PTS. We should not forget, not even minimize the contribution of the Member States, without whom, clearly, nothing would have been possible. The fact that we are all gathered here shows that we are a large community. It encompasses various people. Let's start with the decision makers. Without them nothing would have happened in 1996, nor along all those years, nor today, nor tomorrow. In building, running and developing a universal instrument such as the CTBTO, political will is key. But this instrument relies on technical grounds and requires an expertise that was provided initially by the scientists of the Member States and then by the PTS staff members who joined the community. I must also mention the representatives from the National Data Centres. Some of them are scientifically very advanced and have very often contributed to the build-up of the system. Some other NDCs are developing and they are more and more numerous. This leads me to praise the “capacity building” programs that are instrumental in developing the community. Last but not least, I must commend the scientists: the older generation who brought the keystones in establishing the principles of the verification system, and the younger ones who today feed the reflection on the future of the system, in the light of the state-of-the-art and its perspectives.

Some of you may argue that I have hardly touched upon On-Site Inspections. As in this first part I focused on fully demonstrated achievements, I can only regret that we have not been in a position to launch an OSI in DPRK. There we could have proven that the techniques are mature, even if some, such as the gases' measurement, still requires some developments. Of course there is, as always, room for improvement, procedures require testing but the collective approach that has been put in place should pay off and I am confident in the outcome of the Integrated Field Exercise that will take place next year in Jordan will bring us closer to complete readiness for EIF.

Now that I have described where we stand, and how good this position is, I would like, and this will be my second part, reflect on the path that has been followed to reach this point.

This is important since, as I have explained earlier, if we consider that we are close to a final validation of the verification system, we may and we must think about its future. What assurances do we have with regard to the actual completion and the long-term sustainability of the system? What must be done to maintain unchallengeable performances? What are the main driving factors? What is the price to pay ? In any case, any kind of stand-by is out of question. In technical science especially, what does not progress, becomes obsolete.

Since the creation of the PTS, a lot of progress have been made from a scientific and technological perspective but also from an organizational and managerial point of view. This wide variety of progress should be a source of inspiration for envisaging the further evolution of the system.

Let us go back to the nineties and think about the scientific and technological framework of that time. Let's take the example of the GCI, the Global Communication Infrastructure. From an engineering perspective, building up such an infrastructure in order to bring data in real time from about 300 locations all over the world, and to send the data and product of the IDC to the National Data Centers, in all Signatory States, within highly constrained time-frames and high reliability requirements, was a challenge of its own. The maturity level of telecommunication systems was not making this an easy task. For instance, the data-request mechanism of the auxiliary stations was linked to constraints imposed by the telecommunications. Today, the GCI is no more a difficult engineering problem, assuming that the security issues, that are still very critical, are properly taken into account.

This provides a transition to Verification technologies, a topic for which the situation also has much evolved in the past fifteen years. Indeed the history of the development of the technologies used in the verification system differs, depending on the subject. Some topics, such as seismology, could be qualified as “old” or to be more positive “well established”. Some, such as radionuclide measurements, are disciplines with older components and newer ones that developed recently.

Finally some fields of research, such as infrasounds, are what I would describe as "brand new" ones. Hence, their developments carry specific features from which different lessons could be learnt.

As you all know seismology is an old science at least from an observation perspective: the first pendulum-based seismograph was invented in China during the second century by Zhang Heng. But the path of scientific development is more recent. The Mercalli scale based on intensity dates from the turn of the twentieth century. The Richter scale based on energy was defined between the world-wars, and the seismic momentum was defined in the mid-sixties. At that time already the seismic effects of nuclear tests were used for lithosphere tomography and computation of earth-propagation models. In this regard the deployment of broad-band seismometers across Australia is a well-know case to seismologists. Hence, it is not surprising that seismology played a major role as a monitoring technology when the principles of the partial test-ban and later of the comprehensive nuclear-test-ban verification system were set. And recently, all the scientific progresses in data analysis and propagation modeling helped lowering the detection threshold of the CTBT seismic network. This is a typical case of a long-lasting scientific subject with regular incremental improvement.

Let's now turn to the nuclear discriminants of a nuclear explosion. At the time of the signature of the treaty, spectrometry analysis applied to radionuclide particulates collected in the environment was well developed. But the techniques associated with noble gases analysis, especially the relative quantities of Xenon isotopes were still laboratory experiments, with measurement problems. Understanding the propagation of such gases, especially in the atmosphere, was also a difficulty. However, today, a lot of radionuclide particulate stations are also equipped with reliable radioactive Xenon measurement systems, and the IDC has the corresponding analysis tools. In order to support the technique, measurement campaigns of the background noise are conducted worldwide. It turns out that the performance of these new measurement systems (from the sensor to the analysis) are so good that the limitation comes from the background levels. Since radioactive Xenon is a man-made product, a next step might be to start thinking on how to better master the industrial release of that product in order to further lower the detection threshold of an underground nuclear explosion in case of a leak. Of course, any reflection on limiting the releases of radioactive Xenon by the industry must take into account crises such as the Fukushima Daiichi one. To sum it up, in this case we have had a well-known subject, with a new emerging topic that brought a sudden improvement to the detection capabilities.

Let's now turn to something very recent. In 1996, infrasonic waves were known only to a small community and little studied. After all, since the end of atmospheric nuclear-tests no one had invested much effort in the subject. Although the technology seemed necessary to a comprehensive nuclear-test-ban in order to cover atmospheric tests, some experts were wondering whether there was a scientific interest beyond this. Almost everything had to be made, from the sensors to the data analysis, through the conception of the stations. Today, infrasounds have become a research area of their own with great potential benefits, although they still cannot be precisely defined. This extends from volcanism to climatology through the general understanding of the dynamics of the atmosphere. If we consider for instance the impact of volcanic ashes on air traffic, the contribution of an infrasonic monitoring system may not be a very expensive investment compared to satellites. And of course the technology applies to exceptional events in the atmosphere such as the recent fall of a meteorite in Russia … or the underground explosion in North Korea in February 2013 for which infrasonic waves were detected by the IMS.

To sum it up, since the mid-nineties, huge progress has been made. Today, with regard to the detection of nuclear explosions, it is even possible to produce realistic coverage maps describing instant global-detection-capabilities of the IMS infrasonic network. Indeed, this technology is a case study: there was a verification need and an international research program developed around it. This allowed the PTS to develop the analysis tools that are now implemented by the IDC and the infrasonic component of the IMS constitutes today the world reference for the scientific community.

Naturally such a result would never have been achieved without the support of the Member States firstly to the PTS, secondly to their national research teams and more generally to the international efforts in this field. A new community is born and a lot of its members are young researchers who quickly learn to work together.
The European-funded project ARISE, which aims to improve understanding of the Earth's stratosphere and mesosphere dynamics is a show-case: 3 communities (infrasound, Lidar and Air Glow experts) start talking to one another, working together, building a common data base. You may have seen the promising works resulting from synergies between these researchers, you will certainly see much more at the next conference!

Those few examples show without doubt that the development of Science and Technology has had a tremendous impact on the development of the CTBT techniques and that in a reciprocal manner, the CTBT has led to the development of new fields for research, to the benefit of science in general as well as of specific applications.

In other words, since the Verification technologies are attracting from a scientific perspective, these technologies are still evolving. This means that the performance of the system will continue to improve. Because of such potential impact in terms of performance, the decision makers are interested in having those improvements materializing. This means that funds should be available to support innovative research and development in these areas. Because of the two previous points, the attractiveness of the subjects is high among researchers and engineers. This closes the loop, at least for a while.

This leads me to the last part of my talk, <u>what about tomorrow?</u>

How to ensure that this will still be the case the day after tomorrow? How will this situation be impacted by, for instance, the always-faster-evolving information technologies and the growing computation capabilities ? Indeed, Science is facing a cultural revolution that requires thinking out of the box.

Fortunately there are some solid grounds to anchor our reflection: the problematic of monitoring, in a large sense, will remain central. Whatever is being monitored (nuclear tests, environmental crisis, safeguards, global warming,..) there will always be data input, data analysis, and expertise. This will fuel a dynamic virtuous circle that will continuously enhance the performance of the monitoring system. In the normative framework created by a treaty, especially a fundamental one such as the CTBT, such dynamics is not only important, it is a necessity.

And this is the case for the CTBT verification regime. Even so the Treaty has not entered into force; it is a reference, a two-fold world-reference:

- First, it offers a unique international monitoring system, a global coverage, extremely demanding quality requirements, and performances guaranteed by a Technical Secretariat that operates under an international mandate conferred by its Member States. As I have already mentioned all that is already by-and-large demonstrated.

- Second, it is also providing an on-site inspection mechanism, established on a wide spectrum of techniques, and operated by a non-permanent inspectorate that the Member States are keeping available on short-notice. I do not put aside the fact that they are still questions regarding the OSI, but work is underway to solve them. This high priority for the Prepcom is served by the expertise of the entire PTS. Thanks to the support of the national experts and the political will of the Member States, there is no doubt that this endeavour will be successful.

Moreover, let's look at costs and benefits. Spending for the CTBTO is somewhat easy to evaluate: there is a "total" line appearing at the bottom of each annual program-and-budget document. Benefits are more difficult to assess. What is the monetary value of the CTBT role in reinforcing global security for all, be it for its main purpose or through cooperation with other institutions such as the AIEA? I will not make guesses, but just give you two numbers for your reflection. According to the Sipri, last year alone the world military expenditure totalled about 1 800 billion US dollars, around 2.5% of the world Gross Domestic Product. In fifteen years, the CTBTO through the contributions of Member States did spend a little more than one billion US dollars.

If we now look at the other benefits provided directly by the system (tsunami warnings, earthquakes surveillance, radionuclide monitoring, etc.) and less directly (education, science, engineering, etc.) there is no doubt here again that benefits for the States are much higher than costs.

Conduct the assessment by yourself. Benefits are higher than costs. This should lead you to the conclusion that there is a need for an appropriate funding of the Organization by all Member States.

However, this does not mean that there is no need for efficiency in the running of the PTS. The Organization must optimize the use of its resources, and always improve its internal processes in order to maintain the verification capabilities of the PTS at their best. These capabilities must closely follow those of the Member States.

Indeed it is not acceptable that, because of a lack of financial resource, a technical gap be created between the Organization and the Member States to the benefit of the latter. For the sake of the demonstration, should the verification system come to be too far from the state-of-the-art, then in case of a violation of the Treaty, assuming that it enters into force, the forensic value provided by the Organization would be lost, which is exactly contrary to the essence of verification.

It is therefore essential to ensure a long-term strategy of sustainment, in line with what has already been initiated. In my opinion this strategy should be developed along four main axes:

- First, universalization of the S&T community. This means bringing more and more National Data Centers to participate in our common ;
- Second, integration of incoming new technologies. This means for instance being ready for massive computation associated to data mining, which clearly requires thinking out of the box.
- Third, readiness for technological breakthrough. This means being on constant alert with regard to sensors, networks, analysis tools, etc.
- Forth, contribution to the scientific international community with data and product from the organization. In my opinion, this is the only way, in addition to the feed-back from the NDCs, to get valuable contributions that will ensure that we can meet the two previous requirements.

Ensuring the sustainability of the verification rests with the Member States. They must act in order to get a proper return-on-investment. By doing so, we will collectively continue to benefit from a reliable CTBTO, at least for its core forensic purpose, even when we reach an international context with very limited risks of further nuclear-testing.

By that time, the CTBTO may be contributing to other treaties or may have paved the way for other purposes. At present we can hardly identify how the strategic environment will look in a few decades. We can probably agree that there will be an acceleration of globalization and an ever-increasing instability and volatility. In such a context, assuming that there is a political will, what roles could we imagine for the CTBT?

Let me give you some food-for-thoughts.

First, climate change, which could potentially cause more frequent and more severe disasters, seems inevitable within such time frame, even if the scope of its environmental, economic, health and strategic repercussion will depend on international mobilization. We have already seen for instance the role that some CTBT data can play to mitigate the consequences of tsunamis.

Second, since these issues related to climate change are highly politicized and controversial, we could also imagine the need for a new treaty. If all the techniques may not be reused as such, the co-location of specific sensors benefiting from the network and communication system of the CTBT is not impossible to imagine.

A third idea: under the combined effects of increasing demand and the deterioration of the environment in particular, access to natural resources such as energy and mineral resources will be one of the greatest challenges facing humanity. The existence of a worldwide network of sensors able to monitor mining activities, inland or off-shore could be of a specific use.

I will stop this enumeration, but you see that there is a future for the CTBT, in monitoring nuclear-test explosions, or in contributing to other purposes, assuming there is a corresponding need, capability and political will. In any case, when there is a network with over 300 stations spread all over the world, including in the most remote places, there is little doubt that any new world-wide monitoring system will have to co- locate at least some of its own sensors.

Finally, I would like to insist one more time on something I have already touched upon in my remarks. What I have developed before you in the specific case of the CTBT is somewhat generic: the verification body of a treaty is mainly designed to provide scientific and technical information to its Member States in order to support their national assessment of facts, and the resulting political decisions that they may have to make.

To that aim, the deliverable of such verification body must be sustained at the state-of-the-art level with regard to S&T. In addition, the analysis must be provided with knowledge of the methodology that has been used in order to ensure their repeatability. For that reason, an Organization must permanently be aware of developments occurring in the scope of the verification under the Treaty. This includes data input, data processing and analysis. This is what sustainability is about.

Therefore, not only for the CTBT, but also from a more general perspective, the interaction between a technical international Organization and the S&T community is a key for verification sustainability.

And to conclude with regard to the CTBT, let me ask the following question: is the denomination provisional technical secretariat most appropriate for an organization working on long-term sustainability? Let me take this opportunity to call once more for an early entry-into-force of the Treaty.

Thank you.