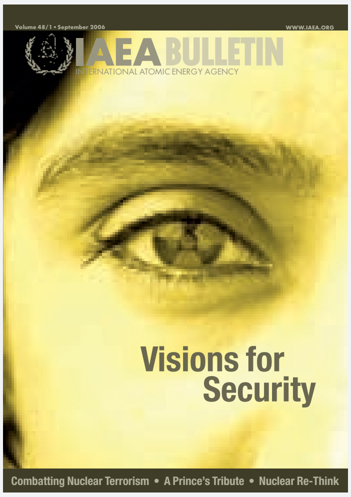

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Division of Public Information
International Atomic Energy Agency
P.O. Box 100, A-1400 Vienna, Austria
Phone: (43-1) 2600-21270
Fax: (43-1) 2600-29610
IAEABulletin@iaea.org
www.iaea.org/Bulletin

Division of Public Information
Director: Marc Vidricaire
Editor-in-Chief: Lothar H. Wedekind
Managing Editor: Linda R. Lodding
Assistant Editor/Layout: Ritu Kenn

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A Cross-Cutting World

The road to security in today's world is a cross-cutting interchange of paths and approaches.

For many, it's a path marked with four-letter words—"f-o-o-d" and "f-e-a-r" of not finding any. For others, it's the path to affording a doctor to save a child's life...finding a well for clean water to drink... gathering waste to warm a home...shielding a family from acts of terrorism.

The IAEA travels these and other paths everyday through its global reach. Agency teams help people in more than 140 countries around the world. Their work, for example, supports countries seeking to:

✔ find and recover dangerous old radioactive sources;

✔ remove high-risk nuclear material from vulnerable places;

✔ block the spread of nuclear-weapons capability;

✔ end the reign of killing diseases, like malaria and cancer;

✔ meet rising needs for energy and electricity;

✔ achieve food security, on the farm and in the home.

Some of the work is deeply rooted, going back to days when the world's political and scientific leaders first moved to set global directions. The IAEA turns 50 in July 2007, and there is a mountain of experience and knowledge to draw upon. Some of today's proposals are doing just that, revisiting old ideas and tailoring them to 21st century realities.

Many challenges are new, some daunting. The IAEA's latest strategic plan sets directions for the first years of the Agency's next half century, through 2011. It cites notable changes driving action. One is the wide realization that nuclear proliferation and terrorism pose big threats to global security. Another is renewed interest in nuclear fuel cycles, including a new framework for the oversight of technologies and materials that can be used for good or ill. A third is the rising need for safe and clean energy to fuel goals of cutting poverty and protecting our environment.

Distinguished contributors to this edition of the *IAEA Bulletin* travel the cross-cutting and bumpy road of our common security, offering their views and perspectives on ways to move ahead. They don't always agree on which way to go. But they agree on the urgency of going forward. The journey calls for seizing every opportunity.

—Lothar Wedekind, Editor-in-Chief

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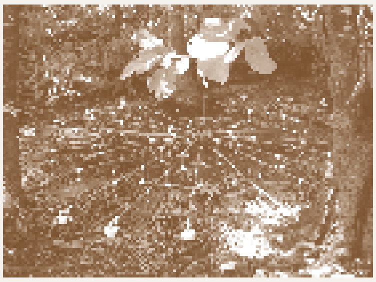


NUCLEAR CONTRIBUTIONS & CHALLENGES

1956 the world

the way it was when the IAEA was born

50 years ago, on 23 October, the IAEA Statute was approved heralding the birth of the International Atomic Energy Agency. This marked the culmination of years of international diplomacy following US President Dwight Eisenhower's 1953 "Atoms for Peace" speech.

The year also saw Elvis Presley, the "King of Rock 'n Roll" ascend the charts, Queen Elizabeth II inaugurate the world's first commercial nuclear power plant in England, and Prince Rainer of Monaco wed Grace Kelley.

But against this background of royal pomp and circumstance, the world witnessed upheaval as the Suez Canal crisis broke out, Hungary revolted against a pro-Soviet government and civil rights unrest boiled in the US. Here is just a glimpse of the way the world was then…

January

- ❖ Sudan becomes independent from Britain. Northern Muslim parties take over rule. Southerners demand autonomy and civil war begins.

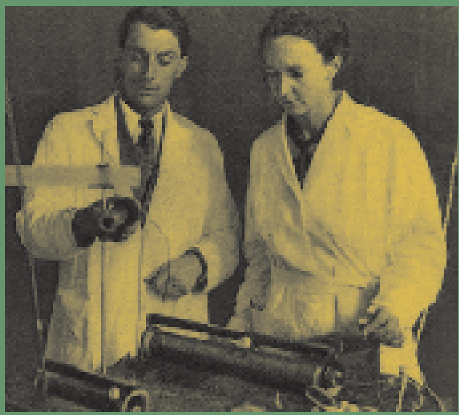
- ❖ Elvis Presley, a truck driver, records "Heartbreak Hotel" for RCA, his first recording session. It sells over 300,000 copies in its first three weeks on the market.
- ❖ The Winter Olympic Games open in Cortina d'Ampezzo, Italy.
- ❖ A stick of dynamite explodes on the porch of Martin Luther King, American Civil Rights leader.

February

- ❖ Nikita Khrushchev denounces Stalin at the 20th Communist Party Congress at Moscow as a "cult of personality."
- ❖ Female suffrage is granted in Egypt.

March

- ❖ Morocco tears up the Treaty of Fez and declares independence from France.
- ❖ The US Supreme Court affirms the ban on segregation in public schools in Brown vs. Board of Education.
- ❖ Tunisia is granted independence from France.
- ❖ Pakistan becomes an Islamic Republic.
- ❖ Irene Joliot-Curie dies. French physical chemist who, along with her husband, Jean-Frederic Joliot, was awarded the 1935 Nobel Prize for Chemistry for their discovery of new radioactive isotopes prepared artificially. She was the daughter of Nobel Prize winners Pierre and Marie Curie.



April

- ❖ American actress Grace Kelly marries Prince Rainier III of Monaco.
- ❖ Calder Hall, the world's first commercial nuclear power reactor in England, was officially opened by Queen Elizabeth II.
- ❖ An Israeli-Egyptian cease fire, brokered by UN Secretary General Dag Hammarskjöld, goes into effect.
- ❖ Last French troops leave Vietnam.
- ❖ Spain gives up its protectorate over parts of Morocco.
- ❖ Revived draft statute of the IAEA is submitted to the UN General Assembly.

May

❖ Austria and Israel form diplomatic relations.

❖ The first known airborne US hydrogen bomb is tested over Bikini Atoll in the Pacific.

❖ Terrorism rages on Cyprus.

June

❖ The 74-year British occupation of the Suez Canal ends.

❖ Golda Meir begins her term as Israel's foreign minister.

❖ Marilyn Monroe and Arthur Miller are married.

July

❖ World's first nuclear power station (5 megawatts) begins operation at Obninsk in Russia.

❖ France raises the tobacco tax 20% to support war in Algeria.

❖ The Bell X-2 rocket plane sets a world aircraft speed record of 3,050 kph.

❖ Egypt's President Nasser nationalizes the Suez Canal.

August

❖ India commissions its first nuclear power reactor, Apsara.

September

❖ The USSR signs nuclear research agreements with North Korea which provide for a number of North Korean scientists to be taught nuclear physics in the USSR.

❖ At a conference on the IAEA Statute, Dr. Homi Bhabha of India declares, "We consider it to be the inalienable right of States to produce and hold fissionable material required for the peaceful power programs."

October

❖ The IAEA Statute is approved by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it enters into force on 29 July 1957. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

❖ Hungary revolts against the pro-Soviet government and attempts to leave the Warsaw Pact. Soviet troops invade Hungary.

❖ Suez Crisis begins: Israel invades the Sinai Peninsula and pushes Egyptian forces back toward Suez Canal.

November

❖ Soviet troops invade Hungary to crush the Hungarian Revolt against Soviet communist oppression.

❖ US Republican incumbent Dwight D. Eisenhower is re-elected by defeating Democratic challenger Adlai E. Stevenson in a rematch of their contest four years earlier.

❖ The 1956 Summer Olympics begin in Melbourne, Australia.

December

❖ Fidel Castro returns from exile with his followers, among them Ernesto "Che" Guevara, and starts a guerrilla war.

❖ 1956 Academy Awards: *Best Picture,* "Around the World in Eighty Days"; *Best Actor*, Yul Brynner for "The King and I"; *Best Actress*, Ingrid Bergman for "Anastasia".

❖ Japan joins the UN.

❖ The world's first transistorized computer, the TX-O is completed.

When the IAEA was born

Fifty years ago, on 23 October 1956, eighty-one member countries of the United Nations system adopted the Statute of the International Atomic Energy Agency. Their action changed the nuclear world.

Bertrand Goldschmidt recounted those times in an essay first published ten years ago. The IAEA marks its 50th anniversary in July 2007.

Three months after the end of the Second World War, on 15 November 1945, the heads of the US, British and Canadian Governments, meeting in Washington, decided to adopt a policy of secrecy in the nuclear field until a system had been established for the effective international control of the new and formidable source of power. By also deciding to buy up all available uranium, they thus created a perfect policy of non-proliferation based on blocking the transfer of the two things essential for nuclear development: the technical knowledge and uranium, both of which are widely dispersed in the world today.

A month later, the Soviet Union accepted an Anglo-American proposal to establish within the United Nations an atomic energy commission consisting of the 11 countries represented on the Security Council, and Canada. On 24 January 1946, the United Nations approved the establishment of such a commission.

The Idea of an "International Authority"

In March 1946, on the initiative of the US Secretary of State, a group of prominent persons—presided over by David Lilienthal, later the first Chairman of the US Atomic Energy Commission, and including also Robert Oppenheimer and three industrialists—was entrusted with the task of studying the problem of the peaceful development of nuclear energy and the elimination of nuclear weapons. The study led to a report which was almost as revolutionary at the political level as nuclear energy was at the technical level. The report centred on the idea that in the atomic age no security system based on agreements banning nuclear weapons or even on safeguards and inspections will work. In the report, it was proposed that all operations which were dangerous from the point of view of nuclear weapons development be placed outside the competence of individual States and entrusted to a single international authority. An international administrative body would own, operate and develop the nuclear industry on behalf of all nations. The international authority would be the owner of nuclear ores and fuels, would carry out research (even in the field of nuclear explosives) and would operate nuclear fuel fabrication plants and nuclear power reactors, while international inspectors would be responsible for discovering any clandestine activities which took place.

Debate at the United Nations

Under Secretary of State Dean Acheson backed the draft report, which was presented almost without change, on 14 June 1946, at the inaugural session of the United Nations Atomic Energy Commission by the US delegate Bernard Baruch. One political clause had been inserted—it concerned abolition of the veto in respect of immediate sanctions against a nation seriously violating the treaty which was proposed. In the US proposal, the authority was called the International Atomic Development Authority, because its purpose was to control nuclear energy worldwide.

The transition from national to international controls would take place in stages still to be specified, the last stage being accompanied by the surrender of nuclear weapons to the international control agency. From the outset, the Soviet Union, supported by Poland, was against the US plan; it demanded as a preliminary step the unconditional prohibition of nuclear weapons, later accepting the idea of periodic international inspections but not subscribing to the principles of international ownership and management, which it regarded as an unacceptable limitation on national sovereignty.

The negotiations continued during the autumn of 1946. For the first time, delegations contained scientists as well as diplomats, the former becoming advisers to the latter. The first headquarters of the United Nations were at Lake Success, about an hour's drive from New York, symbolically located in the reconverted part of an armaments factory which was still in operation. During the long drive we had time to initiate the diplomats into the mysteries of the atom and of nuclear fission.

Despite initial disagreement, Baruch wanted to go ahead and forced a vote; this took place on 30 December 1946, the result being ten in favor and two—the Soviet Union and Poland—abstaining. Four days before—as we learned only several years later—the first Soviet atomic reactor had gone into operation. The Soviet Union had decided to place its trust in its technicians and not to negotiate from a position of weakness.

1955: Opening of the "Atoms for Peace" Conference, Geneva, Switzerland, 8 August.

Seen left to right are Mr. Max Petitpierre, President of the Swiss Confederation; UN Secretary-General Dag Hammarskjöld; Dr. Homi J. Bhaba of India, President of the Conference; and Prof. Walter G. Whitman of the US, Conference Secretary-General.

How Much Nuclear Control?

The US plan, which had become known as 'the plan of the majority', was studied in detail throughout 1947 by experts from the Western countries under the amused gaze of the Soviet representative, who emphasized from time to time the obvious faults of the theoretical structure to which this exercise was leading, for at that time there was no chance of the Soviet Union's joining in.

Even within the majority group, agreement was sometimes difficult to achieve. For example, many meetings were devoted to the question of whether or not uranium ore still in the ground should belong to the future international control agency. Under pressure from Belgium and Brazil, it was finally agreed that uranium and thorium producing countries should remain the owners of ore in the ground; ore would become the property of the international control agency only after extraction.

At the same time, the international control agency would be empowered to impose each year quotas for the extraction of ore or for the production of fissionable materials, which would belong to it together with the reactors in which they were produced and—naturally—the isotopic separation and irradiated fuel reprocessing plants.

It was decided that the international control agency should have the sole right to manufacture nuclear explosives, so that it would be in the forefront in this field also and hence in a better position to detect any prohibited activities. At no time, however, was a study made of the question of the crucial transition period during which the USA would be handing over its nuclear weapons gradually to the international control agency prior to the stage of universally controlled nuclear disarmament.

It was during these meetings, in 1947, that Oppenheimer gave us his views about the future of nuclear energy. He predicted that electricity generation on an experimental basis would start within five years, that a number of nuclear power plants would be built in industrialized regions where electricity is expensive during the next 10-20 years and that large scale development would begin after 30-50 years. His predictions have proved to be remarkably accurate.

Lost Chance, New Direction

After two years' work and over 200 meetings, the UN Atomic Energy Commission informed the Security Council, in 1948, that it had reached an impasse and discontinued its work. The first attempts to achieve international nuclear disarmament had failed and humanity's last chance of living in a world without the atomic bomb disappeared.

In the ensuing years, from 1949, the US nuclear monopoly disappeared. From 1951 onward, the negotiations on nuclear controls were linked with those on traditional disarmament. There was no more talk about the International Atomic Development Authority, the idea of international ownership and management becoming more difficult to put into practice as the world's uranium resources increased and further countries embarked upon large national nuclear programs. Moreover, the safeguards against all diversion of fissile materials which were to have been applied by the international control agency became far less important, for atomic bomb stockpiles were increasing steadily and a substantial fraction of them could always be concealed when controlled worldwide disarmament was being established.

So the direction of the discussions on nuclear disarmament changed and, as in the case of conventional disarmament, attention focused on the transitional stages and the various prohibitions covering the use, manufacture and stockpiling of nuclear weapons which would accompany the gradual establishment of safeguards.

For the first time nuclear terrorism was mentioned in an official document.

The surprising speed with which the Soviet Union was catching up in the nuclear field (and in particular its breakthrough into the thermonuclear field in 1953), the British explosion of 1952 and the French decision—of the same year—to build large plutonium producing reactors fuelled with the uranium recently discovered in France itself made it clear that the Soviet Union and the United Kingdom had reached the most advanced stages of industrial nuclear technology and that France would do the same fairly soon.

The demonstration of the relative ineffectiveness of the policy of secrecy, the risk that a system of international nuclear cooperation and commerce would be established without the Anglo-Saxon powers—excluded by their own rigorous laws—and, above all, the desire to "initiate a process of détente and disarmament" induced the USA to change its policy quite suddenly at the end of 1953.

President Eisenhower's Proposal

In his famous speech of 8 December 1953 before the UN General Assembly, President Eisenhower, just back from the Bermuda Summit Conference between the USA, the United Kingdom and France, after describing the balance of terror which was becoming the principal element in the relations between the two largest of the major powers, again proposed the establishment of an international agency for atomic energy, to which the countries most advanced in the nuclear field would contribute natural uranium and fissionable materials drawn from their national stockpiles. The agency would be created under the auspices of the United Nations and would be responsible for the materials entrusted to it. These materials—available initially in only small amounts—would serve to promote the peaceful applications of atomic energy, especially electricity generation, and would be distributed and used in such a way as to yield the greatest benefit for all.

The new agency would have control powers limited to verification of the peaceful utilization of the materials which it would be responsible for receiving, storing and redistributing. Such a 'bank' would have to be absolutely secure against attack or theft; for the first time, nuclear terrorism—about which so much is talked today—was mentioned in an official document.

Such an embryo international authority for atomic energy would assume even greater importance with the increase in the contributions of the countries most interested, of which Eisenhower stated that as a prerequisite the Soviet Union must be a part.

For the first time since the Second World War, a plan for nuclear détente was not characterized by the opposing demands of the two major nuclear powers—the US demand that the Soviet Union throw itself open to international inspections and the Soviet demand for the prohibition and destruction of nuclear weapons.

Soviet-US Dialogue

At the end of 1953, the Soviet Union agreed to discuss the Eisenhower proposal directly with the USA through diplomatic channels. Initially, however, the Soviet Government was very reluctant: it insisted on prior solemn renunciation of the use of the hydrogen bomb and of other weapons of mass destruction and espoused the US arguments of 1946, pointing out that the production of energy for peaceful purposes could not be distinguished arbitrarily from the production of materials usable for military purposes and that a country could not engage in one without engaging in the other.

Later, at the end of 1954, the Soviet Union subordinated discussions on the future international agency for atomic energy to the conclusion of an agreement on nuclear weapons; it proposed a meeting of Soviet and US experts to consider the technical possibility of preventing the diversion to military uses of fissionable materials originally intended for non-military uses and ways of making such materials unsuitable for military uses without detracting from their non-military value. A meeting of experts from the main nuclear powers took place in Geneva in September 1955, but no solution was found.

The Soviet reluctance did not prevent the USA from preparing and submitting to the Soviet Union several successive drafts of the statute of the future agency, drawn up after consultations with the main nuclear powers and the principal producers of uranium: Australia, Belgium, Canada, France, Portugal, South Africa and the United Kingdom. In the summer of 1954, the US Government relaxed its internal nuclear legislation and authorized the placing of nuclear know-how and materials at the disposal of other countries provided that they were used only for peaceful purposes. It also announced its decision to go ahead with the establishment of the new agency, even without the Soviet Union.

In the autumn of 1954, the UN General Assembly urged a continuation of negotiations and decided on holding—under United Nations auspices—a large technical conference on the peaceful uses of atomic energy, designed to lift the veil of atomic secrecy to a great extent. The conference took place in August 1955 in Geneva, with success and with the full participation of the Soviet Union.

Soon after the conference, the Soviet Government announced its willingness to participate in the future agency, to transfer fissionable materials to it and to accept as a basis for discussion the third draft statute prepared by the US Government in March 1955. The discussion of principles thus ended, to be followed by a period of a year during which the final statute text was arrived at in the course of two conferences, held at the beginning and end of 1956 in Washington and New York, respectively.

In 1955, the UN General Assembly entrusted the USA with the organization—in Washington—of a conference of the 12 countries most interested in the creation of the new agency. The countries invited to participate were those which had been consulted over the drafts of the statute plus the Soviet Union, Czechoslovakia, Brazil and India. The conference took place in February and March 1956.

A feature of the negotiations, which lasted four weeks, was the conciliatory attitude of the Soviet Union. The type of organization which emerged from the negotiations was to have the role of a broker rather than a banker and possess very broad control powers which would apply both to agreements for the transfer of materials which had been placed at the new agency's disposal and—above all—to bilateral or multilateral agreements the parties to which wished the new agency to verify their non-military character.

With regard to the latter type of agreement it was decided, despite Soviet opposition, that the associated safeguards costs should be borne by the new agency, since the safeguards would be contributing to the maintenance of world peace. The Indian delegation, while accepting safeguards on special fissionable materials (enriched uranium and plutonium), opposed safeguards on natural uranium. The only delegation to take this line, it put forward the view that safeguards on natural uranium would divide the countries of the world into two categories: on one hand, countries which did not have uranium deposits on their territory or had not been able to acquire uranium through commercial channels, which would be subject to constant controls in the industrial area—the only one they could develop; on the other hand, countries with a military nuclear programme, which could benefit from such a programme as regards industrial secrecy since they had uncontrolled materials available which could be switched to non-military uses.

The Conference and a Battle

At last, on 23 September 1956, the draft Statute was presented to a gathering of 81 countries at the Headquarters of the United Nations. It was decided that a two thirds majority would be necessary for amending the Statute, so that the final version adopted on 23 October did not differ much from the text which had been drafted in Washington six months previously.

1957: The Viennese public enjoying a sidewalk view of the scientists and diplomats from 55 nations who attended the First General Conference of the new IAEA which met at the Konzerthaus, one of Vienna's famous concert halls.

Most proposed amendments were withdrawn or did not obtain the two thirds majority necessary for acceptance. That was particularly so in the case of the fundamental amendments proposed by the Soviet Union and its allies: admission of the People's Republic of China as a founder member; demands for additional guarantees that the sovereignty of States would be respected; budgetary limitations; a demand that a three quarters majority be required in financial matters; a proposal that the agency should be able to acquire installations and equipment only if they were provided in the form of gifts.

The most controversial issue was that of the scope of safeguards. The principle of safeguards was criticized by many countries (several of them from the Third World) which tried to exempt natural uranium. They likened safeguards to neo-colonialism, pointing out that in general the nuclear weapons powers would be exempted since, owing to their advanced stage of development, they would never have to request the assistance of the new agency.

India spearheaded the opposition to a very strict application of safeguards and France, which I represented, supported it by proposing a relaxation of safeguards on natural uranium and urging that safeguards should not be so severe as to deter future member countries from turning to the new agency for help.

Mr. Bertrand Goldschmidt, representative of France on the first IAEA Board of Governors in 1957. France held one of the five non-elective seats allotted to those members which were most advanced in the technology of atomic energy, including the production of source materials. The remaining four were held by Canada, the USSR, the United Kingdom and the United States.

India's position was stated clearly by Dr. Homi Bhabha, who enjoyed great personal prestige. He was opposed above all to a perpetuation of safeguards applied to successive generations of nuclear materials, which was very likely to occur in the case of his country, which possessed nuclear materials but needed assistance in order to embark on a nuclear programme. He pointed to the illusory nature of strict safeguards and emphasized that any aid in the nuclear field—be it training opportunities or nuclear materials—was potentially military aid since it might allow a country to switch resources to a military programme. At the Conference, he proposed that the new agency give assistance only to those countries which did not have military programmes—defined as programmes in the field of nuclear and thermonuclear explosives and radiological weapons, but not including military nuclear propulsion.

Lastly, the point on which the Indian delegate stated that he would be most intransigent, to the extent of categorical opposition, was the new agency's right under Article XII.A.5, in respect of all facilities subjected to its safeguards, "to decide on the use of all special fissionable materials recovered or produced as a by-product and to require that such special fissionable materials be deposited with the Agency, except for those quantities which the Agency allows to be retained for specified non-military purposes under continuing Agency safeguards." Such power in the hands of the new agency might well give it too strong a hold on a country's economy if the latter were based on nuclear power generation following an effort to which the new agency had contributed only in the initial stages.

Negotiations took place throughout the Conference between the US and the Indian delegations. The US delegation, which had consulted the Secretary of State and had his backing, refused to modify its position to any appreciable extent.

On 19 October 1956, the day the Conference was to end with a vote on Article XII, the Soviet Union, which had not yet declared its position, joined its allies, which had come out clearly on the side of India. Seeing that the vote might lead to an impasse or to approval of the US line by a slight majority, I and my Swiss colleague, Minister August Lindt, permanent observer at the United Nations, decided to table a compromise amendment. This amendment, the form of which was modified slightly the day after it had been tabled, gave a country the right to retain, from the fissionable materials which it had produced, those quantities which it considered necessary for its research activities and for fuelling the nuclear reactors which it already possessed or was constructing.

The US delegation requested 48 hours for reflection and the matter was put before Secretary of State John Foster Dulles and US Atomic Energy Commission Chairman Admiral Lewis Strauss. After discussions which lasted throughout Sunday 21 October and in which the Canadian delegation's influence worked in favour of acceptance of the compromise, while the British delegation tended to be intransigent, the three Anglo-Saxon delegations accepted the Franco-Swiss proposal, to which the Indian delegation agreed in its turn at the beginning of the night. The Indian delegation, in recognition of the way in which we had helped it, stopped pressing its proposal that the new agency should assist only countries which did not have a military programme.

The next day Article XII was voted on and adopted unanimously. A failure of the Conference had thus been narrowly avoided and the last obstacle to the establishment of the International Atomic Energy Agency and its safeguards, fundamental elements in the present world policy of non-proliferation, had been overcome.

Bertrand Goldschmidt, was born in 1912 and educated in Paris. After graduating from the Ecole de Physique et de Chimie, he was recruited in 1933, the year before her death, by Marie Curie, as her personal assistant at the Institut du Radium, Paris. He participated in the founding of the Commissariat a l'Energie Atomique in France in 1946. Ten years later he headed the French delegation to the IAEA's Statute Conference. He served as the French Governor to the IAEA Board for 23 years. Bertrand Goldschmidt died in 2002.

To read the IAEA Statute or more about the IAEA's history, visit www.iaea.org.

Nuclear Security's Global Reach

The world has made progress since 9/11 to upgrade the global framework for nuclear and radiological security. The work goes on. The latest IAEA action plan targets States' needs through 2009

Five years ago, the events of 11 September shocked the world and changed perceptions of the intentions and capabilities of terrorists.

In the nuclear field, work has accelerated dramatically to improve security measures. Much has been achieved but results are uneven across the board. More needs to be done.

The IAEA is at the forefront of international efforts to make the world's nuclear security regime stronger. A new action plan, which started on 1 January, builds on one that the Agency's Board first put into place in March 2002, within six months of "9/11".

While nuclear security is and should remain a national responsibility, international cooperation is essential if security efforts are to be effective. Global cooperation helps States to build up national capacities, and to establish wider networks for combating transnational threats.

The IAEA has supported Georgia and other countries in recovering dangerous old radioactive sources.

Credit: IAEA

The IAEA's Nuclear Security Plan

The IAEA's new Nuclear Security Plan is founded on measures to guard against thefts of nuclear and other radioactive material and to protect related facilities against malicious acts. The work has three main points of focus: needs assessment; prevention; detection and response.

- *Needs Assessment.* Needs assessment underpins the whole plan by providing information relevant to support activities e.g. by ensuring that information on trafficking incidents is shared effectively. The Agency database on illicit trafficking, now with 90 participating countries, has proven valuble in identifying patterns of trafficking activity, potential threats and trafficking routes and methods.

- *Prevention.* Effective physical protection of nuclear and other radioactive materials; the protection of related nuclear facilities and transports; and strong systems for accounting for and control of radioactive materials are the cornerstones of an effective security system. The IAEA has been providing a range of international advisory service missions, training workshops and technical guidance documents on nuclear security, physical protection, "design basis threat" assessments, and nuclear material accounting, to assist States in implementing these preventive measures. The IAEA has been working to promote a common approach to transport security through the development of guidelines and the provision of training courses and has arranged for the recovery and safe storage of large numbers of high activity sources.

Timely Initiatives

Important international and regional initiatives support efforts of the IAEA Nuclear Security Plan. They provide a valuable context through which the Agency can coordinate programmes, establish priorities and, above all, gain support for improving nuclear security worldwide.

The initiatives include the:

- Group of Eight (G8) *Global Partnership Programme;*
- European Union's *Strategy Against the Proliferation of Weapons of Mass Destruction;*
- USA's *Global Threat Reduction Initiative;*
- Australia's *Regional Security of Radioactive Sources* project.

—For more information about Nuclear Security and these initiatives, visit the nuclear security features pages at *www.iaea.org/NewsCenter/Features/NuclearSecurity/index.html*

- ***Detection and Response.*** The aim is to have systems in place that can help countries to identify, at an early stage, illicit activity related to nuclear materials or radioactive sources and to have in place programs that allow a rapid response to such events. The IAEA has developed topical workshops on "response" to acts of illicit trafficking. In addition, the IAEA helps countries from many regions in training customs and border officials and installing better equipment at border crossings.

The Nuclear Security Program is greatly assisted by the work of other IAEA Departments—the IAEA's Nuclear Safety and Safeguards programmes are recognised for their contribution to nuclear security, as are the roles of Department of Technical Cooperation, Office of Legal Affairs, Office of External Relations and Policy Coordination, Nuclear Energy and Nuclear Applications. This is a truly cross-cutting activity.

- ***Scope of Work & Resources.*** When the IAEA established its programme on the Security of Materials in the 1990s, the main concern was the prospect that nuclear or other radioactive materials could fall into the wrong hands. Among the driving forces for that programme was an alarming increase in reported cases of illicit trafficking in the early and mid-1990s and the recognition that States needed better and more coordinated efforts to combat the problem.

The scope and geographic reach of the programme has expanded over the years. Today, the nuclear security activities take place all over the world with more intensive support plans and equipment supply, thereby helping States in tangible ways.

Progress has been made, but the imperatives that first led to the IAEA´s nuclear security plan have not lost their relevance or urgency.

Since September 2001, the IAEA has carried out some 87 projects in Africa; 65 in Latin America; 195 in Europe; 74 is East Asia; and 84 in West Asia. The Agency has held more than 125 security advisory and evaluation missions, and convened over 100 training courses, workshops and seminars.

The work includes securing nuclear and other radioactive material. Working with Russia and the USA, for example, the IAEA implements contracts to dismantle and transport disused vulnerable radiation sources to more secure locations. Sealed sources from Bolivia, Côte d'Ivoire, Haiti, Iran, Malaysia, Panama, Sudan and Thailand have been conditioned for storage or shipped back to the original suppliers. The need for such high-priority assistance efforts is expected to grow.

So far, States and other organizations have been prepared to provide sufficient financial and in-kind resources to fund the IAEA security programme and related activities. Since September 2001, the IAEA Nuclear Security Fund has received over $40 million from more than two dozen countries — as well as from the European Union and the Nuclear Threat Initiative (NTI).

Many countries have provided in-kind support. Countries from all regions have hosted workshops and regional and national training courses, participated in source recovery missions, provided technical insights on how engineered safety features at nuclear facilities can enhance security against sabotage, and contributed to the development of IAEA guidelines and recommendations.

Channels of Cooperation

The cooperation of international organizations has proved instrumental to progress in nuclear security. They include Interpol, Europol, the European Commission, the Organization for Security and Cooperation in Europe, and the World Customs Organization. The benefits of IAEA assistance — and the reach of limited resources — have been maximized by coordinating activities with other organizations, and through regional partnerships. They include the IAEA/EU Joint Actions in the context of the European Council's *EU Strategy against the Proliferation of Weapons of Mass Destruction* and the Global Threat Reduction Initiative.

The IAEA also is working closely with governments interested in assistance for responding to UN Security Council resolution 1540. It called for effective border controls and law enforcement efforts to detect and combat illicit trafficking, and called upon States to refrain from providing any form of support to non-State actors that attempt to develop, acquire, use or transfer nuclear, chemical or biological weapons or their delivery systems. The Agency provides legal and technical advice, training and peer reviews.

Looking to the Future

Progress has been made, but the imperatives that first led to the IAEA's Nuclear Security Plan have not lost their relevance or urgency.

The latest plan extends through 2009, with extra-budgetary resources required to implement the plan approaching US $16 million. The plan draws upon a review of the nuclear security programme over the past years, and the outcomes of international conferences that the IAEA has convened in the field of nuclear and radiological security. The extensive evaluation showed that the programme has established a solid foundation of assistance to States that contributes to higher levels of security. Yet gaps and shortcomings remain that need to be addressed.

In effect, the sights of global cooperation are set on creating a nuclear "security culture" — a mindset that, while providing the impetus for local and regional action, thinks globally and is fully capable of extending across borders. Ultimately, progress will be as strong as the weakest link.

—IAEA Staff Report

In Search of Security

Nuclear security is one part of a bigger global picture

As IAEA Director General Mohamed ElBaradei notes and the UN's Millennium Development Goals enshrine, our security threats cover a broad spectrum, and vary in nature and magnitude. They range from poverty, infectious diseases and environmental degradation to organized crime, terrorism, armed conflict and weapons of mass destruction.

The issues may appear unrelated. But upon closer look, they are clearly connected. And in today's world, they contribute to a prevailing sense of insecurity.

Dr. El Baradei cites a late 2003 Gallup International survey of 43,000 individuals in 51 countries that asked how they felt about the state of international security. Almost twice as many respondents rated global security as "poor" as those who answered "good". And almost half said they believed their children — the next generation — would live in an even more insecure world.

Why do we feel so insecure? What kind of security threats do we face?

He points to the huge and widening gap in living conditions, with 40% of the world´s population surviving on less than $2 per day, inevitably results in diminished opportunities and a sense of despair. These conditions — compounded in many cases by human rights abuses, the absence of good governance, and a sense of injustice and humiliation — provide the ideal environment for civil wars, organized crime, and all forms of extremism. And often, in regions plagued by longstanding conflict, countries hoping to achieve security and project power end up following in the footsteps of those who have resorted to nuclear weapons in search of security.

—Dr. ElBaradei made these points in a speech at the International Institute of Strategic Studies, in London. See the IAEA.org website for full text at www.iaea.org/NewsCenter/Statements/2005/ebsp2005n019.html

Nuclear Trafficking
IAEA's Latest Statistics

There were 103 confirmed incidents of illicit trafficking and other unauthorized activities involving nuclear and radioactive materials in 2005, newly released statistics from the Agency's Illicit Trafficking Database (ITDB) show.

The ITDB covers a broad range of cases from illegal possession, attempted sale and smuggling, to unauthorized disposal of materials and discoveries of lost radiological sources.

Eighteen of the confirmed incidents in 2005 involved nuclear materials; 76 involved radioactive material, mainly radioactive sources; two involved both nuclear and other radioactive materials, and seven involved radioactively contaminated materials.

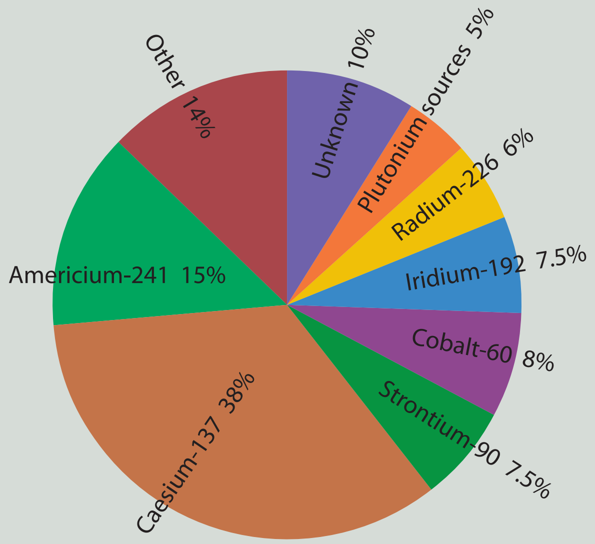
Another 57 incidents from previous years were reported. They involved illicit trafficking and other unauthorized activities and had occurred earlier, mainly in 2004.

Two reported cases in 2005 involved small quantities of high-enriched uranium (HEU) which is a fissile material. In New Jersey, USA, a package containing 3.3 grams of HEU was reported lost. The second incident occurred in Fukui, Japan, when a neutron flux detector containing 0.017 grams of HEU was lost at a nuclear power plant.

"From the terrorism threat standpoint, these cases are of little concern but they show security vulnerabilities at facilities handling HEU," the latest report from the ITDB said. Indeed the majority of cases reported in 2005 showed no evidence of criminal activity.

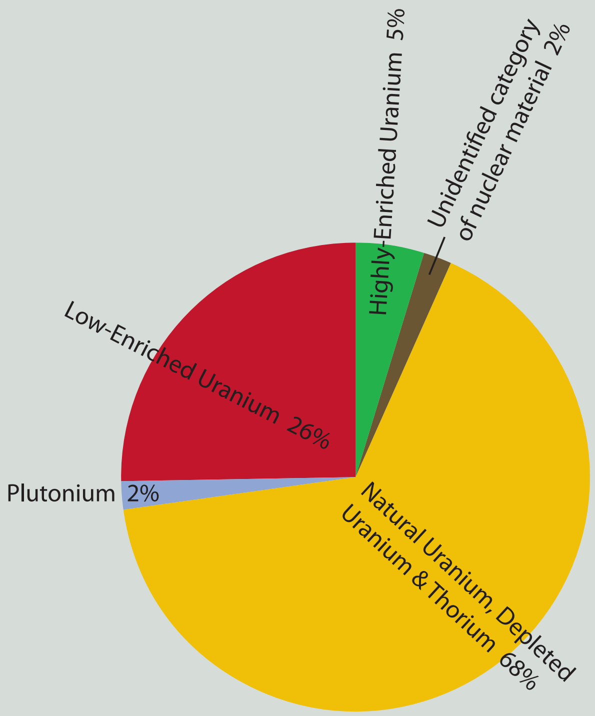
The ITDB facilitates the exchange of authoritative information on incidents of trafficking in nuclear and radioactive materials. There are 91 countries that report to the IAEA's database. For the full report covering the last 13 years, see: www.iaea.org/NewsCenter/Features/RadSources/PDF/fact_figures2005.pdf

Incidents Involving Radioactive Sources, 1993-2005



Note: Incidents as confirmed to the ITDB, by type of radioisotopes.

Incidents Involving Nuclear Materials, 1993-2005



Note: As confirmed to the ITDB, the total is higher than 100% because some incidents involved more than one category of nuclear material.

How the world can combat Nuclear Terrorism

by Mohamed ElBaradei and Jonas Gahr Støre

The simplest way to produce an atomic explosion is to slam together two sizeable chunks of high enriched uranium (HEU), in what is commonly called a "gun-type nuke". The approach might sound comparatively crude, and it is. No country currently uses this design for its nuclear weapons.

But it is worth remembering two things. First, that it was an HEU gun-type nuclear weapon that killed more than 70 000 persons at Hiroshima. Second, that terrorists tend to be less focused on elegance of design than on results.

This brings us to a critical question: after nearly five years of living under the threat of sophisticated terrorism — and with clear signs of terrorists trying to acquire nuclear material through criminal networks — why are we still moving so sluggishly to get rid of global HEU stockpiles, and to minimize civilian uses of HEU?

Much attention is currently being given to the control of uranium enrichment technology, and rightly so. If all enrichment operations were brought under multinational control, it would become far more difficult for any country to divert enriched uranium for use in weapons. But it makes equal sense to protect — or, better still, to eliminate — the bomb-grade HEU that already exists.

Experts say there are about 1850 metric tonnes of HEU in global stockpiles, enough to make tens of thousands of nuclear weapons. The great bulk of this HEU is in military use. On the civilian side, the numbers are much smaller — but the level of security is uneven. Nearly 100 civilian facilities around the world operate with small amounts of weapon-grade HEU — that is, uranium that has been enriched to 90% or greater.

These facilities, primarily research reactors, provide important benefits. The isotopes they produce are vital to medical treatments, industrial productivity, water management and many other humanitarian uses. Research conducted at these facilities has greatly enhanced our quality of life.

But most if not all of these benefits could also be achieved using low enriched uranium (LEU). As far back as the late 1970s, the US and other countries began efforts to convert such facilities from HEU to LEU, to reduce the proliferation risk.

After nearly five years of living under the threat of sophisticated terrorism...why are we still moving so sluggishly to get rid of global HEU stockpiles and to minimize civilian uses of HEU?

In recent years, good progress has been made. Many research reactors have been converted. Large quantities of HEU reactor fuel, both used and unused, have been removed from vulnerable locations and returned to the countries of origin.

Civil society has become involved, raising awareness of the problem and supporting change. A good example is that of the Nuclear Threat Initiative. Just last year it completed a project with the government of Kazakhstan that successfully 'downblended' nearly 3,000 kilograms of fresh HEU fuel to LEU and placed it in secure storage. But more successes like these are needed. Many vulnerabilities remain. We need to ratchet up the sense of urgency. And we need more coherent global action.

First, the countries involved should join forces to minimize and eventually eliminate the civilian use of HEU. Joint research should be conducted to address the remaining technical hurdles involved in converting from HEU to LEU operations. The commercial interests of the companies concerned should be protected. Financing should be made available where needed to assist countries with conversion operations. And the HEU fuel should be sent back to the countries of origin for downblending and reuse.

Second, all countries should agree to stop producing fissile material for use in nuclear weapons. The elements are already in place for such an agreement, in the form of a Fissile Material Cut-off Treaty. It is high time to negotiate and conclude such a treaty.

Third, to build trust, countries with civilian and military HEU stockpiles should be encouraged to release clear inventories of those stockpiles, and to publish a schedule under which the remaining HEU will be verifiably downblended.

By investing in these straightforward measures, we could reduce substantially the risk of nuclear terrorism. The work could be done jointly, as an international community; this is one initiative in which all countries — nuclear weapon states and non-nuclear weapon states alike — could play a role, and from which all would clearly benefit.

Mohamed ElBaradei is the Director General of the International Atomic Energy Agency and the winner of the 2005 Nobel Peace Prize. E-mail: official.mail@iaea.org

Jonas Gahr Støre is the Norwegian Minister of Foreign Affairs. E-mail: info@norway.no

An "International Symposium on the Minimization of HEU in the Civilian Nuclear Sector" was hosted by the Government of Norway at the Nobel Peace Centre in Oslo in June 17-20, 2006. This article first appeared as an Op-Ed in the Financial Times, *June 15, 2006.*

HEU Symposium

Calls for Coherent Global Action

A recent conference in Oslo, Norway highlighted the need for more vigorous and effective actions towards minimizing the civilian uses of highly enriched uranium (HEU). The international symposium, held 17-20 June at the Norway Peace Center and hosted by the Government of Norway in cooperation with the IAEA, aimed to establish international consensus on technical issues associated with the replacement of HEU with low-enriched uranium (LEU) for civilian uses and agree on a way forward for a concerted international effort.

In Mohamed ElBaradei's remarks, he cited the conference's timeliness in view of increasing attention currently being given to the control of uranium enrichment technology.

More than 100 civilian nuclear facilities around the world still run on weapons-grade HEU, which is uranium that has been enriched to 90% or greater. These facilities include research reactors and critical assemblies that were established in the 1950s and 1960s and have played a central role in the development of peaceful uses of nuclear technology. Many experts agree that these reactors can be converted to run efficiently on LEU, thus reducing proliferation risks while continuing to ensure a secure and effective path for nuclear research for peaceful purposes.

At the request of its Member States, the IAEA has been involved for many years in supporting efforts towards reducing the uses of HEU. International and national efforts have also increased in this area and resulted in the full conversion of 33 research reactors as of June 2006.

Although much has been achieved, vulnerabilities remain, Dr. ElBaradei emphasized. "These vulnerabilities, including the clear signs of terrorists trying to acquire nuclear material through criminal networks, were the primary reasons for which Minister Gahr and I called in our recent article for more vigorous and effective actions towards minimizing the civilian uses of HEU. In my view, we need to continue working with a sense of urgency, and through more coherent global action."

In concluding the symposium, it was recognized that considerable scientific and human development benefits are being derived from nuclear facilities using HEU and that substituting HEU with LEU should not affect those benefits. HEU minimization can make an important contribution to international non-proliferation and disarmament objectives while also promoting the peaceful uses of nuclear energy and technology.

For more information on the "International Symposium on the Minimization of Highly Enriched Uranium in the Civilian Sector," see: www.nrpa.no/symposium/index.html

—Staff Report

from High to Low

by Pablo Adelfang and Ira Goldman

The IAEA is helping to reduce the use of high-risk nuclear fuel at the world's research reactors.

Research reactors play a key role in the development of peaceful uses of atomic energy. They are used for the production of isotopes for medicine and industry, for research in physics, biology and materials science, and for scientific education and training. They also continue to play an important role in support of nuclear power programmes.

The IAEA's data shows there are 249 operational research reactors worldwide. Of these, more than 100 reactors are still fuelled with highly enriched uranium (HEU). It is considered high-risk nuclear material since it can be easily used for a nuclear explosive device.

As part of a developing international norm to minimize and eventually eliminate HEU in civilian nuclear applications, research reactor operators increasingly are working with national and international agencies. They are being encouraged and supported to improve their physical security arrangements, convert their reactors to low-enriched uranium (LEU) fuel, and ship irradiated fuel back to the country of origin.

Reducing Use of Highly Enriched Uranium

For more than twenty years the IAEA has been supporting international efforts associated with reducing the amount of HEU in international commerce. Projects and activities have directly supported a programme the United States initiated in 1978, called Reduced Enrichment for Research and Test Reactors (RERTR). The IAEA's work additionally supports efforts to return research reactor fuel to the country where it was originally enriched—so-called "take back" activities.

IAEA initiatives have included the development and maintenance of several databases with information related to research reactors and research reactor spent fuel inventories. These databases have been essential in planning and managing both RERTR and take-back programmes. Other Agency activities through technical cooperation and other channels have supported the conversion of research reactors to using lower enriched fuels.

In other ways, the IAEA supports the exchange of information among experts. It co-sponsors annual RERTR international meetings (in late October 2006, South Africa hosts this gathering). In cooperation with Norway, the Agency also organized the June 2006 "International Symposium on Minimization of Highly Enriched Uranium in the Civilian Nuclear Sector." Consensus at the meeting indicated that LEU can be used for almost all applications in which HEU is currently used.

IAEA support of RERTR and the take-back programmes was strengthened in 2004, following the establishment in the United States of the Global Threat Reduction Initiative (GTRI) and ensuing recommendations of the RERTR meeting. The common goal is to reduce both proliferation and security risks by eliminating or consolidating inventories of high-risk material.

This article outlines a few of the areas where the IAEA is concentrating its efforts.

Technical Support & Assistance

The Agency's regular programme activities are focused on establishing the technical foundation for HEU minimization. This specifically includes supporting research reactor fuel conversion to LEU, radioisotope production from

LEU, and providing overall programmatic support for fresh and spent fuel shipments from research reactors.

Additionally, national and international efforts are supported to develop, qualify, and license LEU research reactor fuel. A guidebook is being developed for use in negotiations of fuel supply and to support fuel development activities. Fuel element manufacturers and national laboratories have developed fuel types suitable for LEU utilization in most of the world's research reactors.

In recent years, requests for IAEA assistance for research reactor conversion have increased considerably. In some cases, such as in Chile, technical assistance was provided for the fabrication and qualification of domestically produced LEU fuel. In other cases, as with the TRIGA research reactor in Romania, the IAEA procured commercially produced LEU fuel assemblies to complete the conversion. In Portugal, the IAEA is supporting the purchase of a full LEU core for the conversion of a research reactor, and in Poland, is procuring LEU fuel for conversion of the Maria reactor.

In Libya, technical assistance supported quality-control inspections of the fuel acquired under a trilateral arrangement with the USA and Russia for the conversion of the Tajoura critical assembly and research reactor. The Agency is providing a pool-side monitoring and visual inspection system, and training and technical assistance for its use.

Bulgaria, Kazakhstan, Ukraine, and Uzbekistan also have requested assistance under national technical cooperation projects regarding LEU core conversions. And a national project with Jamaica will be initiated for full-core conversion of its SLOWPOKE reactor, which will receive technical and financial assistance from Canada and the USA.

While many research reactors still need to be converted to LEU fuel, the IAEA is already looking ahead and considering an expanded scope for future conversion efforts. A meeting in February 2006 of representatives from both government and non-governmental organizations prepared an updated list of operating facilities using HEU. Also examined were other facilities that use HEU, such as critical assemblies, pulsed reactors, and civil propulsion reactors. Follow-up meetings are planned.

The IAEA is involved in various initiatives to minimize the reliance on highly enriched uranium and encourage the "take back" of spent fuel to the country of origin.

Production of Medical Radioisotopes

An element known as molybdenum-99 (Mo-99), whose decay product is technecium-99m, is the most widely used medical radioisotope in the world. It accounts for over 20 million diagnostic tests yearly. The vast majority of Mo-99 is produced by four major commercial firms using HEU targets. However, in recent years, Argentina and Australia have been able to demonstrate the technical feasibility of producing Mo-99 from LEU.

In 2005, the IAEA started a coordinated research project involving ten countries. The aim is to develop techniques for small-scale, indigenous production of Mo-99 using LEU or neutron activation. Institutions in Chile, Kazakhstan, Libya, Pakistan and Romania are receiving technical advice and assistance from Argentina, India, Indonesia, the Republic of Korea, and the USA.

Russian "Take-Back" Activities

The Russian Research Reactor Fuel Return (RRRFR) programme focuses on the recovery of irradiated research reactor fuel originally supplied by Russia to facilities outside the country. It evolved from IAEA efforts. In 2000, Director General Mohamed ElBaradei wrote to fifteen countries possessing such material, inquiring as to their interest in returning such material to Russia. A series of "Tripartite Initiative" meetings were organized that helped facilitate conclusion of a USA-Russia bilateral agreement in May 2004.

The main vehicle for assisting countries in this "take-back" initiative is an IAEA technical cooperation project called "Repatriation, Management and Disposition of Fresh and/

or Spent Nuclear Fuel from Research Reactors". The objective is support the return to Russia of fresh or irradiated HEU and LEU fuel.

A grant from the US-based non-governmental organization Nuclear Threat Initiative (NTI) has enabled the IAEA to play an important role in planning for the "take-back" of Russian research reactor spent fuel. The IAEA is organizing and carrying out, with US and Russian experts, fact-finding missions to research reactor sites in 12 countries. This grant continues to support technical and project management activities related to supporting the RRRFR as a whole. It includes developing workshops, training, and guidance documents, and developing and implementing resource mobilization activities for the programme.

In August 2002, the IAEA cooperated with the US, Russia, Serbia and NTI for the removal of 48 kg of fresh HEU from the Vinca Institute to the Russian Federation. NTI provided $5 million to three IAEA technical cooperation projects in Serbia. This was part of an agreement with the governments of the USA, Russian Federation, and Serbia.

The IAEA projects aim to safely remove 2.5 metric tonnes of irradiated HEU and LEU fuel from Serbia and transport it to the Mayak Reprocessing Plant in the Russian Federation; to improve radioactive waste management facilities at Vinca (including building a secure storage facility for high-activity sources); and to plan for the decommissioning of the Vinca research reactor.

The spent fuel project has achieved important progress in 2006. The IAEA is in final negotiations with a contractor to repackage and transport the spent HEU and LEU fuel at Vinca. In addition to funding from NTI, the US Department of Energy has committed to provide resources to package, transport, and reprocess the HEU spent fuel, and the European Union appears likely to also commit significant resources to the project. This would result in available resources of approximately $15 million, with about another $10 million needed to complete the project by 2009. (Also see box, "The Clock is Ticking" on page 20.)

Fresh and Spent Fuel Shipments

The IAEA carries out studies related to planning fresh and spent fuel shipments. They include examining transport cask options, assessment of transport routes, and providing advice for handling deteriorated research reactor fuel.

Since September 2003, with extrabudgetary funding from the US Department of Energy (DOE), the IAEA has contracted for transportation services for seven shipments of fresh HEU from six countries (Bulgaria, Czech Republic, Latvia, Libya, Romania, and Uzbekistan). The result has been the removal of about 120 kilograms of fresh HEU.

In a mission completed in August 2006, the IAEA helped Polish authorities remove approximately 40kg of highly enriched uranium from a nuclear research reactor near Warsaw.

Another five to six shipments are being planned for the second half of 2006.

In addition, the IAEA is procuring ten high-capacity transport and storage casks at a value of 4 million Euro (contributed by DOE). Available by December 2006, these will initially be used for shipment of spent fuel from the Nuclear Research Institute, Rez, in the Czech Republic. Thereafter, they will be available on a lease-free basis for other irradiated research reactor fuel shipments under the Russian take-back programme.

Contributing to Global Goals

The IAEA contributes significantly to international efforts serving the goal of reducing the use of high-risk nuclear fuel. Programmes for the minimization of HEU involve countries around the world that are home to research reactors.

Through Agency-supported channels, they are receiving technical support and assistance in key areas. The work involves partnerships with governments and non-governmental organizations, and experts with a wide range of experience in the field. Considerable progress has been made, and the cooperative foundation has been set for further advances in the years ahead.

Pablo Adelfang is the IAEA Cross-Cutting Coordinator for Research Reactor Activities and Head of the Research Reactor Unit in the Department of Nuclear Energy. E-mail: P.Adelfang@iaea.org.
Ira Goldman is Scientific Secretary in the Research Reactor Unit. E-mail: I.Goldman@iaea.org

the Clock is ticking

To Secure Serbia's Bomb-Grade Waste

On the outskirts of Serbia's capital Belgrade, nuclear weapons-grade waste sits in a pool of murky water. It is potential material to make dirty bombs: lots of them. An IAEA inspector team is at the Vinca facility, a shut-down research reactor at the Institute of Nuclear Sciences, to check that none of it is missing.

Small in size, the fuel elements fit into the palm of your hand. Each a radioactive cocktail of plutonium and high-enriched uranium (HEU) waste. "The biggest threat is, of course, the terrorists," says Vinca's former operations manager Obrad Sotic, who worries about levels of security on site. It would be very difficult for a terrorist to make a nuclear bomb out of them, experts like Sotic say. But explode a single fuel element with dynamite in a crude "dirty bomb" and it's radioactive aerosol becomes a weapon of terror.

"For terrorists ready to commit suicide it won't be a problem to steal a lot of these fuel elements, which are very light and easy to be taken, and use it as a dirty bomb," Mr. Sotic said.

Two IAEA inspectors lift covers over the pool to inspect the spent fuel. It simmers in stagnant water where it has been cooling for the past three decades. The room is roughly the size of a 25 metre swimming pool yet contains more than half of the HEU fuel that the Soviet Union ever produced to fuel research reactors outside of the Russian Federation.

It's not only terrorist risks that are driving IAEA and Serb concerns about Vinca. The fuel elements are corroding and leaching radiation into the water. "After a long time in such conditions, the fuel starts leaking and the fission products, which are highly radioactive, spread out and of course endanger this room and the people working here. And, if it goes higher and higher it will endanger the surroundings," Dr. Sotic warns.

The sound of Geiger counters crackle and beep, as the IAEA inspectors go about their job. Fears are the contamination will seep into the water table or escape via the ventilation system.

Now is the time to remove this fuel and begin decommissioning before the fuel and facility degrade further. —Mike Durst

A village of 4,000 residents sits at the doorstep of the site. Dobrila Markovic owns a local shop five minutes drive away. "I'm not worried about it," says the mother of three. "But during the war, I was scared that the facility might be bombed and spread radiation."

The bomb-grade waste remained secure throughout major upheavals: the Balkan wars, the break-up of both Yugoslavia

and the USSR. But in today's climate with fears of nuclear terrorism rife, it poses a magnet for would-be nuclear thieves while it remains in such conditions at Vinca.

Mike Durst is the IAEA's point man tasked to clean up the site. "The fuel is clearly both an environmental and a proliferation issue. Therefore in order to prevent an environmental hazard from occurring and to prevent, of course, the material from getting into the wrong hands, we need to get rid of it. And now is the window of time."

It is a complex, costly operation. The price tag is well in excess of $10 million and funds are short. Plans are afoot to ship the nuclear fuel back to Russia, which supplied it during Soviet times to power a nuclear research reactor at Vinca. The reactor was shut down 22 years ago.

With IAEA support, almost 50 kilograms of unused HEU fuel was removed from the reactor on 23 August 2002 in a night-time operation that sealed off half of Serbia and involved 1,200 armed troops. The HEU — enough to make two simple nuclear bombs — was airlifted to Dimitrovgrad in Russia for reprocessing. Now the remaining spent fuel also needs to be sent to Russia, Durst and others say.

Logistically, it is a far more difficult operation. "It's almost like comparing a light bulb to the sun: it is much, much more complicated," Mr. Durst said. "This fuel is highly radioactive, it's leaking, so everything will have to be done remotely." The fuel must be removed from its current containers using special tools that have to be designed to operate remotely. Once it is repackaged, it will be put into heavily shielded shipping containers that are specifically licensed for international transport.

"We're going to ship across several international boundaries — and the whole operation is going to take time, expertise and money," Mr. Durst said.

A donor's conference is planned for September 2006 at the IAEA's Vienna headquarters to help raise awareness and the needed funds. Contributions from the Nuclear Threat Initiative ($5 million), the United States ($4 million) and the Agency's Technical Cooperation programme ($1.5 million) are a first step to making the removal operation a reality.

Until Vinca is stripped of its spent fuel, it will remain a tempting terrorist target. "We need to close the financial gap to remove the fuel," Serbian Science Minister Aleksandar Popovic said. "We need to ensure Vinca is safe from a possible terrorist attack and environmental danger," he said.

The IAEA is working closely with the Serbians to upgrade security and protective measures on-site. From installing centrally monitored alarms and new ventilation systems, to constructing secure storage areas. "Without the help of the Agency, we wouldn't make it," Minister Popovic said.

The top priority is to get rid of the spent fuel. For Obrad Sotic that day can not come soon enough. "Day by day it becomes more and more dangerous. And that's the main reason we have to ship this fuel as soon as possible."

—Kirstie Hansen, IAEA Staff Reporter

Photos: Top—The fuel elements look similar to this but are dangerously radioactive. Each is a cocktail of plutonium and high enriched uranium wastes. Explode just one with dynamite as a crude bomb and its radioactive aerosol can kill and contaminate. Left—IAEA Inspectors during an inspection of the spent fuel. Photos: IAEA

spotlight on the New Nuclear Framework

An IAEA Special Event focuses on multiple new approaches to the nuclear fuel cycle.

A new framework to strengthen controls over access to sensitive nuclear technology—uranium enrichment and plutonium separation—is gaining international attention. A Special Event hosted by the IAEA at its annual General Conference in Vienna this September brings together high-level experts from the Agency's 140 Member States.

On the agenda are options to bring facilities capable of producing weapons-usable nuclear material under multinational control. Dozens of countries today know how to produce such material, experts have estimated.

"The margin of security under the current non-proliferation regime has become too slim for comfort," IAEA Director General Mohamed ElBaradei has said. "It is time to limit the processing of weapons-usable material (separated plutonium and high-enriched uranium) in civilian nuclear programmes, as well as the production of new material through reprocessing and enrichment, by agreeing to restrict these operations exclusively to facilities under multinational control. These limitations would need to be accompanied by proper rules of transparency and, above all, by an assurance that legitimate users could get their supplies."

A nuclear "fuel bank"—where the IAEA administers a nuclear fuel reserve—is among proposals. It would enable the Agency to act as a guarantor for the supply of fissile material to civilian nuclear users.

"The importance of this step is that, by providing reliable access to fuel at competitive market prices, we remove the incentive or justification for countries to develop indigenous fuel cycle capabilities. In so doing, we could go a long way towards addressing current concerns about the dissemination of sensitive fuel cycle technologies," Dr. ElBaradei said.

Both the US and Russia have announced their willingness to make nuclear material available for a fuel bank, under such a scheme. An IAEA administered fuel bank was a key proposal made by an Expert Group in 2005, tasked with finding options to improve controls over fuel enrichment, reprocessing, spent fuel repositories and spent fuel storage.

New Approaches Proposed

A number of suggestions have been put forward regarding new approaches to the nuclear fuel cycle and, more specifically, in connection with the assurance of supply of enriched uranium and associated access to reactor technology:

› An independent international **Expert Group on Multilateral Approaches to the Nuclear Fuel Cycle (MNA)** was established at the IAEA in 2004. This expert group included participants from 26 countries who examined the nuclear fuel cycle and multinational approaches. The Group's report was circulated to all IAEA Member States as INFCIRC/640 and distributed at the May 2005 Review Conference of the 189 States party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

The report of the Expert Group outlined five approaches to strengthen controls over fuel enrichment, reprocessing, spent fuel repositories and spent fuel storage, including: "Developing and implementing international supply guarantees with IAEA participation. Different models should be investigated, notably with the IAEA as guarantor of service supplies, e.g. as administrator of a fuel bank..."

› At the IAEA General Conference in 2005, several Member States addressed the issue of MNAs. The **US announced** that it would make available 17.4 metric tonnes of high enriched uranium (HEU) to be down-blended as fuel and used as part of a fuel bank under an assurance of supply scheme. Later in 2005, the US together with France, Germany, The Netherlands and the United Kingdom initiated discussions on a proposal for establishing a mechanism for reliable access to nuclear fuel.

› In January 2006, **Russian President Vladimir Putin** outlined a proposal to create a system of international centres providing nuclear fuel cycle services, including enrichment, on a non-discriminatory basis and under the control of the IAEA.

› The US announced its **Global Nuclear Energy Partnership** in February 2006 that along with international partners will develop a fuel services programme to supply developing nations with reliable access to nuclear fuel in exchange for a commitment to forgo the development of enrichment and recycling technologies.

› In June 2006, France, Germany, the Netherlands, the Russian Federation, the United Kingdom of Great Britain and Northern Ireland and the United States of America circulated a proposal entitled: **"Concept for a Multilateral Mechanism for Reliable Access to Nuclear Fuel".**

The report outlined five approaches to strengthen controls over fuel enrichment, reprocessing, spent fuel repositories and spent fuel storage, including: "Developing and implementing international supply guarantees with IAEA participation. Different models should be investigated, notably with the IAEA as guarantor of service supplies, e.g. as administrator of a fuel bank..."

› **The Report of the Secretary-General's High-Level Panel on Threats, Challenges and Change,** of December 2004, recommended *inter alia* that an arrangement be set up based on the IAEA Statute, which would enable the Agency to act as a guarantor for the supply of fissile material to civilian nuclear users. The April 2005 Report of the Secretary-General, for decision by Heads of State and Government in December 2005, entitled "In Larger Freedom: Towards Development. Security and Human Rights for All", also proposed, *inter alia*, that States should be guaranteed supply of nuclear fuel at market rates for peaceful purposes with the IAEA acting as a guarantor.

› **The Conference on Multilateral Approaches for the Nuclear Fuel Cycle,** held in Moscow in July 2005, considered assurances of supply of nuclear fuel cycle services together with assurances of non-proliferation.

› Speaking to the Board of Governors in March 2006, the Director General stated that during the 2006 session of the Agency's General Conference, the Secretariat intends to hold a Special Event focused on "...aspects of a potential 'new framework' that would facilitate safety, security and proliferation resistance in the future utilization of nuclear energy".

For more information, see www.iaea.org/NewsCenter/News/2006/assurancesofsupply.html

Securing the Nuclear Fuel Cycle: What Next?

by S. V. Ruchkin and V. Y. Loginov

The greatest challenge to the international nuclear non-proliferation regime is posed by nuclear energy's dual nature for both peaceful and military purposes. Uranium enrichment and spent nuclear fuel (SNF) reprocessing (here after called "sensitive nuclear technologies") are critical from the non-proliferation viewpoint because they may be used to produce weapons-grade nuclear materials: highly enriched uranium and separated plutonium.

When the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was signed in 1968 a compromise was reached between the nuclear-weapon States and the non-nuclear-weapon States to refrain from attempts to develop or acquire nuclear weapons by the latter (Article II) in exchange for "…the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes…" (Article IV), not excluding access to sensitive nuclear technologies. However, as time has shown, some countries, under the guise of peaceful nuclear programmes, were involved in clandestine activities aimed at acquiring nuclear weapons capabilities.

Alternative initiatives to securing the nuclear fuel cycle are once again on the table. Here, at one of the final stages of fuel assembly, a technician checks nuclear fuel rods. Photo: Dean Calma

Sensitive Nuclear Technologies

In the 1970s the world community started to develop further measures to curb the spread of sensitive nuclear technologies. The establishment of a Nuclear Suppliers Group (NSG) in 1975 was one such measure. The NSG united countries which voluntarily agreed to coordinate their legislation regarding export of nuclear materials, equipment and technologies to countries not possessing nuclear weapons.

Alongside measures to limit the spread of sensitive nuclear technologies, multilateral approaches to the nuclear fuel cycle (NFC) started to be discussed. These ideas were reflected in the final document of the NPT review conference in 1975 and in a number of IAEA projects on multilateral approaches. However, due to various reasons, including the freezing of nuclear power programmes following the Three Mile Island (1979, US) and Chernobyl (1986, USSR) accidents, these intentions never materialized.

Subsequent years have presented new challenges to the international nuclear non-proliferation regime, among them illegal transfers of nuclear materials and equipment, substantially increased political instability (terrorist threats) in traditionally tense regions and the booming development of information and communication technologies which simplify access to sensitive information.

Spiralling prices for hydrocarbons and prospects of their imminent extinction are encouraging more and more countries to look at nuclear energy as an alternative means to ensure their sustainable development. To this end, it's becoming increasingly important to link the objective need for an expanded use of nuclear energy with strengthening nuclear non-proliferation by, in particular, preventing the spread of sensitive nuclear technologies and securing access for interested countries to NFC products and services.

Multilateral Nuclear Approaches

With this in mind, at the IAEA General Conference in 2003, IAEA Director General Mohamed ElBaradei called for establishing an international experts group on multilateral nuclear approaches. The proposal was supported, and in February 2005 the international experts, headed by Bruno Pellaud, issued a report (published by the IAEA as INFCIRC-640; see www.iaea.org) with recommendations on different multilateral approaches.

The recommendations can be generalized as follows: reinforcement of existing market mechanisms; involvement of governments and the IAEA in the assurance of supply, including the establishment of low-enriched uranium (LEU) stocks as reserves; conversion of existing national uranium enrichment and SNF reprocessing enterprises into multilateral ones under international management and control, and setting up new multilateral enterprises on regional and international levels.

What has been done in this area since then, and what are the prospects for development of multilateral approaches in the use of nuclear energy?

As noted earlier, one of the instruments to enhance the security of supply of NFC products and services suggested in the experts' report is reinforcement of existing market mechanisms. In this connection it looked quite logical for the World Nuclear Association (WNA) to set up, in August 2005, a dedicated working group comprising experts from the world nuclear industry. Representatives of the four leading world uranium enrichment services suppliers were in the group: AREVA (France), TENEX (Russia), URENCO (Germany, the Netherlands and UK), and USEC (US). As a result, in May 2006, the WNA produced a report entitled "Ensuring Security of Supply in the International Nuclear Fuel Cycle" (see WNA website at www.world-nuclear.org/security.pdf)

The report's most important highlights are:

✔ The existing world market and the capabilities of producers assure a reliable level of supply over the entire spectrum of the NFC products and services required by the world nuclear power industry, and are the prime guarantor of supply. Therefore, questions of additional assurances may be raised not to solve supply problems, which, luckily, do not exist today, but as a safety net in case of a disruption of market mechanisms.

✔ Additional assurances of enrichment services can be given by enrichment companies as a collective commitment, with support from the IAEA and governments, on the basis of a three-level concept similar to the defense-in-depth concept in ensuring nuclear safety. This mechanism can be triggered only if and when a commercial supply contract is disrupted due to political reasons unrelated to non-proliferation. In any case the additional assurances must not impact negatively the existing world market.

✔ Introduction of additional assurances will be on the precondition that the recipient State meets all the non-proliferation requirements pre-defined and agreed upon by the parties, reinforced by intergovernmental agreements and controlled by the IAEA.

In September 2005, the six enrichment services supplier-States, under the leadership of the US, set up an intergovernmental working group to develop a multilateral mechanism for reliable access to nuclear fuel (RANF). The group presented its proposal to IAEA Member States in June 2006 and consultations continue on the next steps regarding their offer, under certain conditions, to provide low enriched uranium to States not pursuing sensitive nuclear activities.

Global Nuclear Power Infrastructure

On 25 January, 2006 Russian President Vladimir Putin announced an initiative to develop a Global Nuclear Power Infrastructure (GNPI) capable of providing secured and non-discriminatory (equal) access to the benefits of nuclear energy to all interested countries in strict compliance with non-proliferation requirements. Establishment of a network of international NFC centers (INFCC), including enrichment services, under IAEA safeguards will become a key element of such an infrastructure. The GNPI-INFCC initiative is aimed primarily at countries who are developing nuclear power but not planning to establish indigenous uranium enrichment and SNF reprocessing capabilities.

As a first step, Russia volunteered to initiate a joint project to establish an International Uranium Enrichment Center (IUEC) on the basis of its enrichment plant in the city of Angarsk (Irkutsk region). Interested Russian governmental and business structures have been working on the basic principles of establishing such a center. Despite the fact that work is far from complete, key principles have been formulated:

❶ Equal, non-discriminatory membership for all interested countries not envisaging the development of indigenous sensitive nuclear technologies and meeting the established non-proliferation requirements;

❷ IUEC membership "advantages" (political, economic, scientific and technical) for the enrichment services recipient countries should outweigh the "disadvantages" of refraining from the development of domestic NFC capabilities; in particular, it is clear that the establishment of national NFC capabilities can be economically justified only for a large fleet of nuclear power plants;

❸ Transparency of commercial IUEC activities (according to international practices), its cost-effectiveness and investment attractiveness in the long term;

❹ IUEC enrichment capacities are to be placed under IAEA safeguards; possible involvement of the IAEA in the Center's management;

❺ Conclusion of an intergovernmental agreement between the interested countries (and possibly the IAEA), joint elaboration and approval of its Charter;

❻ Possible (vertical) integration of the enricher, LEU recipients, and suppliers of source uranium under the aegis of the IUEC;

❼ IUEC products, in the form of enriched uranium hexafluoride, should meet the nuclear reactor requirements of the participants;

❽ Foreign IUEC members will have no access to Russian uranium enrichment technology.

Through IUEC membership, countries intending to build nuclear power plants would be able to pursue their diversification policies and benefit from an additional security of LEU supply on market conditions. This is due to:

❖ Commitments by Russia and other participating countries resulting from the intergovernmental agreement;
❖ IUEC international status, involvement of the IAEA in its activities;
❖ Russian enrichment plant capabilities possessing proven, high-tech and competitive enrichment technology.

There may be some follow-up stages of GNPI-INFCC implementation. These are related to:

♦ Timely solution of SNF management issues by reprocessing and the disposal of residual waste within the framework of international NFC centers with the use of modern fast reactor and spent fuel management technologies;

♦ Expansion of international collaboration on innovative nuclear reactors and associated NFC technologies (IAEA INPRO Project and Generation IV) both on bi-lateral and multi-lateral bases, including the establishment of dedicated international NFC centers;

♦ Establishment of international centers to train and qualify personnel for countries developing nuclear power. The Russian Presidential initiative builds upon G8 policies on curbing the spread of sensitive nuclear technologies and is a practical input into the implementation of the (G8) accords reflected in the Declarations on Non-Proliferation at the summits in Gleneagles (Scotland, 2005) and St. Petersburg, (Russia, 2006). The initiative is also intended to further the efforts of the IAEA and the enrichment services supplier states on multilateral nuclear approaches (MNA).

Global Nuclear Energy Partnership

The US Administration recently put forward a new initiative on a Global Nuclear Energy Partnership (GNEP). The main objective of the US initiative, as well as of the Russian one, is to contribute to the development of a global partnership on the peaceful use of nuclear energy taking into account the global problems facing mankind.

In the area of non-proliferation of sensitive nuclear technologies, GNEP suggests establishing an international consortium comprised of developed countries with full NFC capabilities, including advanced nuclear technologies (a horizontal integration). The members of the consortium are assumed to become the main suppliers of uranium enrichment and SNF reprocessing services to other countries. GNEP also assumes development by NFC services suppliers of a nuclear fuel leasing scheme with developing countries incorporating SNF return in order to discourage them from acquiring indigenous NFC capabilities.

It's obvious that all the above initiatives (RANF, WNA, GNPI-INFCC, GNEP) have common elements related to the security of supply. Therefore, the initiatives may benefit from harmonization. In our opinion, an attempt should be made to develop an International Assured Nuclear Fuel Cycle Products and Services Supply Framework (IANSF) aimed at limiting the spread of sensitive nuclear technologies and, therefore, strengthening the international nuclear non-proliferation regime, and at the same time assisting expansion of peaceful uses of nuclear energy worldwide.

The framework is to be based on the world market of NFC products and services, which is the main guarantor of their availability. In case of a disruption of market mechanisms, some extraordinary measures could be introduced to give additional assurances of supply and encourage the recipient countries to forgo the development and use of sensitive nuclear technologies—collective guarantees of commercial suppliers reinforced by government commitments and the establishment of reserve LEU stocks.

In line with IAEA recommendations, other multilateral approaches could be used—an international NFC center set up based on an existing national plant by converting it into a multilateral enterprise under international control (IAEA safeguards), or international consortia to be made up of supplier States over the entire range of NFC products and services. In both cases one could expect new players in the world market to appear as a result of vertical and horizontal integration.

The concept of an international framework is an attempt at a systematic approach to the efforts of interested countries, the IAEA and the world nuclear industry. It is aimed at the growing role of nuclear energy and strengthening the nuclear non-proliferation regime by granting countries developing nuclear power, without using sensitive nuclear technologies, additional assurances of access to NFC products and services. In our view a harmonization of the recent international initiatives and development of a coordinated plan of action will contribute to reaching the declared goals in the short and long term.

S.V.Ruchkin is the Deputy Director, Department of Strategic Analysis (DSA); Techsnabexport, ("TENEX"), Moscow, Russia. E-mail:Ruchkin@tenex.ru. Vladimir Loginov is a senior expert at the Department of Strategic Analysis at the same company.

TENEX is one of the world's leading suppliers of products and services related to the nuclear fuel cycle. E-mail: tenex@online.ru

Training Nuclear Watchdogs

It is not the kind of enriched uranium for a nuclear bomb. But the powder and the pellets are key parts of the nuclear fuel process under IAEA safeguards. In Sweden, inspectors learn the ins and outs.

1 Fuel for most of the world's nuclear electricity plants is made from enriched uranium at "fuel fabrication" facilities.

Each year, teams of IAEA inspectors verify the peaceful nature of civil nuclear programmes — their work includes some 41 fuel fabrication plants in 22 countries that are under international safeguards.

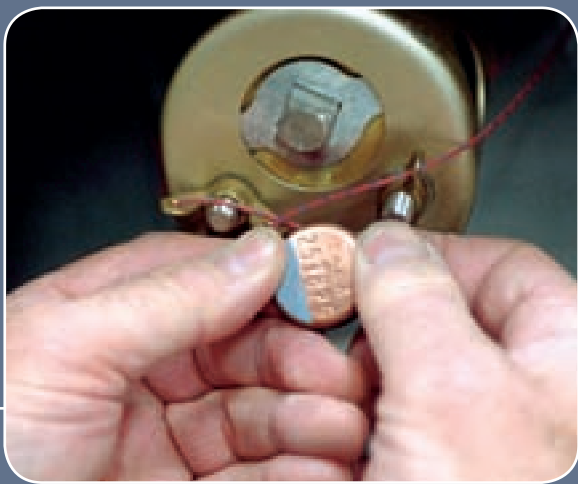
2 Natural uranium contains three different isotopes, U-238, U-235, and U-234. In industry, the isotopes are separated to increase the concentration of one isotope relative to another. The aim is to achieve higher — or "enriched" — concentrations of U-235, which can sustain a nuclear chain reaction.

By itself, low-enriched uranium used for nuclear fuel is not useful for making nuclear explosives. However the material could be diverted and become feedstock for developing them — prime reasons why IAEA safeguards it.

3 Once at the facility, inspectors test their new skills. To untrained eyes, the factory floor is a spaghetti of wires, tubes and pipes giving the impression of organized chaos. Inspectors must know about a variety of plant configurations so they can detect indications to divert sensitive material.

4 Inside a control room, inspectors eye screens displaying schematics of the plant's operational flow. Computer programs monitor key operations — temperatures in the pipes, conductivity measurements, batch weights, precipitation levels, Ph balance and chemical flows, among others. Closed circuit TV cameras zoom in on gauges giving the operator critical indicators from the control room.

5 Checking the cylinder is one thing. Checking what's inside is another. Inspectors rely on sophisticated instruments — such as germanium detectors and sodium iodide, pictured here, to detect enrichment levels — most enriched material emits gamma rays. These tools of the trade help inspectors verify the accuracy of the facilities' records.



6 Once the cylinder's contents are verified, inspectors attach an IAEA metallic seal — commonly used to prevent tampering. The seals provide important evidence of any unauthorized attempt to gain access to the secured material.

7 Another step for inspectors is to verify levels of enrichment during the uranium conversion process. Here inspectors observe a plant operator carefully extracting a UF6 sample to be analyzed for isotopic composition.

8 The UF6 sampling process ends up with concentrated uranium dioxide, a form of "yellowcake". The sample is baked in a furnace for three hours to mimic the uranium conversion process. Thereafter, the sample is sent to the IAEA's Safeguards Analytical Laboratory in Seibersdorf, Austria, for analysis of enrichment levels.

9 A facility operator carefully takes a sample from the tilted hopper. The powder sample is poured into two small glass bottles (inset).

10 Metal boxes hold trays of finished fuel pellets. Each pellet, slightly larger then a pencil eraser, contains enriched uranium dioxide that will be used at nuclear power plants.

11 An inspector verifies the pellet's enrichment using an instrument called a Mini-Multichannel Analyzer that attaches to a palm-sized computer.

12 Going up to the source is sometimes the only way to access the assemblies for critical measurements. In this case, an inspector is hoisted into the air on a crane to get an active length measurement.

13 Once fully trained, inspector teams can spend over 100 days a year on the road at various sites throughout the world, to help make sure that peaceful nuclear materials and activities stay peaceful.

The photos were taken during a safeguards training exercise at the Westinghouse Atom AB, a fuel fabrication facility in Västerås, Sweden in November 2005. Site visit was made possible in cooperation with the Swedish Nuclear Power Inspectorate (SKI) and the IAEA Section for Safeguards Training. Photos: Dean Calma; Text: Linda Lodding by John Bohannon

Staying One Step Ahead

An IAEA Safeguards Inspector Fits The Picture

Paulus Nangonya remembers the moment when his career finally made sense to him. It was last December in Japan when a friend came up and said, "You won." In response to his confused look, the friend exclaimed, "The Nobel Prize!"

At 29, Nangonya, an engineer, is the nuclear inspector at the International Atomic Energy Agency (IAEA). Nangonya and his colleagues at the Vienna-based organisation (along with IAEA's Director General, Mohamed ElBaradei) were the winners of the 2005 Nobel Peace Prize. When Nangonya started three years ago, he says, he felt unsure whether the job was really for him. Like any scientific research discipline, nuclear inspection requires a blend of science and technical knowledge and a sceptical mindset. But a career in nuclear inspection also demands detective and diplomatic skills sharp enough to handle sensitive political issues. To reap the full rewards of the job, says Nangonya, "you have to see how you fit into the big picture. And now I see it."

Nangonya lives and works a long way from Oshakati, his hometown in Namibia, in southern Africa. After winning a scholarship in 1996 to study engineering in China at Shanghai University, he thought he was on his way to an industrial career. At Shanghai, he completed his undergraduate degree in applied electronics while also becoming fluent in Mandarin Chinese. His career took an unexpected turn when one of his mentors noticed his that final-year research project—a system to control heavy machinery from a distance by radio—would be very useful during a nuclear meltdown. "Have you ever considered working for the IAEA?" asked the professor.

He hadn't. In spite of Namibia's significance to the nuclear industry—the country is the world's fifth largest producer of uranium ore and is expected to move into third place by next year—fewer than a dozen Namibians have significant nuclear expertise.

Intense Training

Nangonya joined the IAEA in 2002 by taking the Agency's Safeguards Traineeship Programme, a foundation course on nuclear technology open only to nationals from developing countries. After finishing the year-long programme, Nangonya applied for an IAEA nuclear inspector position—he got it—and then undertook the three-month training course that all newly hired inspectors complete.

At 29, Paulus Nangonya, an engineer from Namibia, is the youngest-ever nuclear inspector at the IAEA.

Most of Nangonya's training covered the subjects that might be expected: the ins and outs of the nuclear fuel cycle, how to verify that each and every reported gram of plutonium and uranium are where they are supposed to be, and how to spot signs of illicit activity. The training, he says, is "intense."

Every year, IAEA hires 15 to 30 nuclear inspectors, typically in their 30s, many with backgrounds far removed from nuclear physics. It is difficult to predict exactly what the Agency is looking in a given year, says Perpetua Rodriguez, IAEA senior training officer, because it depends on "what specific backgrounds are needed from the Operations Division." An inspection team needs a combination of backgrounds, she says. Inspectors come with a range of expertise, from physics, engineering, and chemistry to computer science and even biology; samples from plants and animals often play a role in detecting unreported nuclear materials. "My strength is in understanding instruments," says Nangonya, "how they function and malfunction." His expertise was in demand the year he applied.

But apart from technical expertise, there are also crucial social and psychological skills to be learned, and this is where nuclear inspection diverges most from academic science, says Rodriguez, an inspector since 1987. When you are a scientist working in a university laboratory, "you can disappear into your own private world," she says. "But when the team needs something done during inspection," such as verifying whether a canister really contains a certain amount of uranium hexafluoride, "it must be done right then and there." Teamwork is one of the big perks of the job, says Nangonya, and it's a responsibility he takes seriously. "You're dealing with deadly materials, so you're putting your life in your team members' hands every day. You grow very close."

Nuclear inspectors must learn to trust their colleagues, but during their training they must learn not to trust others. You have to think like a cop, says Nangonya, doubting everything until you have proved it for yourself. "This change in worldview can be difficult for the new arrivals," says Rodriguez, because science is an enterprise built on trust. In the world of nuclear inspection, you never know who might be siphoning off nuclear material to build a bomb or sell on the black market, so it helps to suspect everyone and everything until proven otherwise.

Nangonya had no trouble getting into the sceptical mindset. "You just have to stay one step ahead of potential cheaters," he says. And one thing that enables Nangonya, and other inspectors, to keep ahead of nuclear crooks is coupling his detective work with experimentation. It is often the nuclear inspectors in the field who first identify security weaknesses in a fuel cycle. But confirming a previously unknown method of cheating—and finding a practical way of detecting it—often requires inspectors to regularly interact with IAEA's research laboratories in Seibersdorf, Austria, to test their ideas and improve the inspection process. Having a PhD is not a necessity, but it certainly can be a strength, says Rodriguez.

Working as a nuclear inspector delights Nangonya's inner gadget geek: "When we need a piece of equipment, we get it. Period. We have to stay on the cutting edge." From custom-made hand-held computers to instruments that can detect the faintest radioactivity from a piece of dust, the nuclear inspector's tool kit would make James Bond envious.

But "we are definitely not like James Bond," says Nangonya. Careful diplomacy, not covert intrigue, is the modus operandi. Even when nuclear inspectors turn up bad news, such as the recent discovery of what may be a secret nuclear programme in Iran, inspectors are not enforcers. "When findings have been confirmed, the IAEA Director General reports to the Board of Governors, who decides whether the finding(s) should be reported to the [U.N.] Security Council," says Rodriguez. "In a sense, our job is to help countries to comply with international obligations."

Keep a Low Profile

This provides some tense moments. Inspectors in Iraq in the lead-up to the first Gulf War received death threats, says Rodriguez. Besides your team members, "you're out there on your own," she says—no security force is along to protect you, and no company of medics to care for you. "I keep a low profile," says Rodriguez. "I never use cars with big U.N. signs on them. And when I meet local people, I don't discuss my job."

So far, Nangonya says he has never felt in danger. Nor does he see a significant radiation exposure risk with the job. Inspectors are routinely monitored at IAEA's research laboratories in Austria, and dangerous doses are very rare, he says.

The job's real drawbacks are more mundane, such as the frequent travel. The agency's 250 inspectors are divided into three sections, each with responsibility for one-third of the globe. Nangonya covers East Asia. Japan alone has more than 50 nuclear sites. But for Nangonya, the travel isn't a drawback at all. "Many inspectors knew what they were getting into from the start, and they love it. Like me." But others have a tougher time adapting, like one of Nangonya's colleagues who has children; she was able to shift within the agency to stay planted in Vienna more often. So there is room to adapt, Nangonya says, but not much. As a nuclear inspector, "your middle name should be life-on-the-road," he says.

Nangonya's work requires an unusual degree of care and precision, so it comes with some unusual technological rituals. During this interview, a fellow inspector stopped by Nangonya's office to drop off some documents. Like a scene from a futuristic movie, Nangonya pulled out a laser to scan a bar code on the other inspector's wrist and then his own. Each time sensitive documents are passed, the time and identity of the sender and receiver is recorded by a central computer system. "It's just how the job must be done. I don't mind that," he says. After all, a mistake can mean political disaster.

It is possible to remain a nuclear inspector for life, but returning to industry or academia is always an option, Nangonya says—although many from the developing world find it hard to match their very specific expertise with a job back home. Not so in Nangonya's case. "I will have no trouble finding a use for my nuclear training in Namibia," he says.

But he's not yet ready to start looking. Beyond the globetrotting and gadgetry, nuclear inspection also means being part of an organisation that makes a positive difference in the world, says Nangonya: "The nuclear black market is bad, but it would be much worse without the IAEA." The fact that last year's Nobel Prize went to IAEA and its Director General is recognition of the work's importance. "Now that's job satisfaction," he says.

John Bohannon is a contributing correspondent for Science Magazine. *This article first appeared in* Science Careers, *May 5, 2006; reprinted with permission from AAAS (American Association for the Advancement of Science).*

G-8 Leaders Tackle

Global Energy Security

Summit Endorses IAEA Initiatives in Key Areas

Leaders of the Group of 8 countries backed the IAEA's work at their annual summit held 15-17 July 2006 in St. Petersburg, Russia. A concluding summary statement endorsed IAEA programmes and initiatives in areas of nuclear safety, security, and safeguards.

Global energy security was a major focus of the summit, with G8 leaders agreeing that dynamic and sustainable development of our civilization depends on reliable access to energy. "It is best assured by strengthened partnership between energy producing and consuming countries, including enhanced dialogue on growing energy interdependence, security of supply and demand issues", the statement said.

The G8 nations adopted a St. Petersburg Plan of Action to increase transparency, predictability and stability of the global energy markets, improve the investment climate in the energy sector, promote energy efficiency and energy saving, diversify energy mix, ensure physical safety of critical energy infrastructure, reduce energy poverty and address climate change and sustainable development. Under this plan, G8 nations undertake to reduce barriers to energy investment and trade, making it possible for companies from energy producing and consuming countries to invest in and acquire assets internationally.

G8 countries include Canada, France, Germany, Italy, Japan, the Russian Federation, United Kingdom, and the United States. The European Union also participates in the summit. At the St. Petersburg Summit, leaders of Brazil, China, India, Mexico and South Africa and heads of the African Union, the Commonwealth of Independent States, the International Energy Agency, the IAEA, the United Nations, UNESCO, the World Bank, the World Health Organization, and the World Trade Organization were invited to participate in the discussions.

In a statement on global energy security, the G8 said countries who have or are considering plans for nuclear energy believe it will contribute to global energy security while reducing air pollution and addressing climate change. The G8 said it acknowledged the efforts made in development by the Generation IV International Forum (GIF) and the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). GIF and INPRO both bring together countries to develop next generation nuclear energy systems, including small reactors, very high temperature reactors and supercritical water-cooled reactors.

Recognizing that proliferation of weapons of mass destruction, along with international terrorism, remains the central threat to international peace and security, the G8 nations reaffirmed their determination and commitment to act in concert and together with other States and organizations to fight proliferation of weapons of mass destruction (WMD), including with a view to preventing WMD falling into the hands of terrorists.

The G8 Summit adopted a special statement on non-proliferation, which included:

The Nuclear Non-Proliferation Treaty (NPT)

The G8 reaffirmed its full commitment to all three pillars of the NPT and called on all States to comply with their NPT

The Group of Eight (G8)

is an unofficial forum of the heads of the leading industrialized democracies (Russia, the U.S., Britain, France, Japan, Germany, Canada and Italy), where the European Commission is also represented and fully participates. This forum was designed to harmonize attitudes to acute international problems. The G8 is not an international organization and does not rest on an international agreement nor have formal admission criteria, a charter or a permanent secretariat. Its decisions are formulated as the political commitments of the Member States.

The G8 also has working and expert groups and task forces. As of now, there are the High Level Group on Non-proliferation, the Rome/Lyons Group (on terrorism and organized crime), the Counter-Terrorism Expert Group, the G8 Personal Representatives for Africa, the Global Partnership Senior Officials Group, the G8 Non-proliferation Experts Group (with a plutonium subgroup), the Nuclear Safety and Security Group, and several others. G8 holds an average of 60 to 80 functions annually. The next summit, in 2007, will be hosted by Germany.

obligations, including IAEA safeguards as well as developing effective measures aimed at preventing trafficking in nuclear equipment, technology and materials.

The G8 is seeking universal adherence to IAEA comprehensive safeguards agreements and is actively engaged in efforts to make comprehensive safeguards agreements together with an Additional Protocol the universally accepted verification standard. "We will also work together vigorously to establish the Additional Protocol as an essential new standard in the field of nuclear supply arrangements."

Peaceful Use of Nuclear Energy

The G8 noted that an expansion of the peaceful use of nuclear energy must be carried forward in a manner consistent with nuclear non-proliferation commitments and standards. It discussed concrete proposals on multinational centres to provide nuclear fuel cycle services and recent initiative regarding a concept for a multilateral mechanism for reliable access to enrichment services for nuclear fuel.

G8 nations will continue to discuss these issues jointly with the IAEA to ensure that all States that conscientiously fulfill their non-proliferation obligations have guaranteed access to the benefits of the peaceful use of nuclear energy.

Nuclear Safety and Security

The G8 supported the Global Initiative to Combat Nuclear Terrorism, announced by Russian Federation President Vladimir Putin and U.S. President George Bush. "We look forward to working together with other like-minded nations and the IAEA to expand and accelerate efforts that develop partnership capacity to combat nuclear terrorism on a determined and systematic basis."

The G8 addressed the proliferation implications of Iran´s advanced nuclear programme and confirmed its commitment to see those implications resolved.

G8 leaders also addressed nuclear and other security concerns as well as humanitarian issues regarding North Korea. They expressed support for UN Security Council resolution 1695, condemning North Korea´s launches of ballistic missiles and urged the country to re-establish its pre-existing commitment to a moratorium on missile launching and to respond to other security and humanitarian concerns of the international community.

The G8 called upon all States to become parties, as soon as practicable, to the two most recent universal instruments to combat nuclear terrorism; namely, the *International Convention for the Suppression of Act of Nuclear Terrorism*, and the *Amendment to the Convention on the Physical Protection of Nuclear Material*.

They noted the results of the IAEA International Conference "Effective Nuclear Regulatory Systems" held in Moscow in early March. An effective, efficient nuclear regulatory system is essential for our safety and security, they said, re-affirming the importance for national regulators to have sufficient authority, independence, and competence.

Safety & Security of Radioactive Sources

The G8 nations noted progress made to improve controls on radioactive sources and to prevent their unauthorized use. They reaffirmed commitment to fulfill the *IAEA Code of Conduct on the Safety and Security of Radioactive Sources* provisions, working to put into place the controls over the import/export of radioactive sources at the earliest possible date.

They welcomed the fact that more than 83 countries have committed to implement the *IAEA Code of Conduct on the Safety and Security of Radioactive Sources* and urge all other states to adopt the Code. The G8 said it will continue to support international efforts to enhance regulatory controls on radioactive sources, in particular the Regional Model Projects, the IAEA program to help establish effective and sustainable regulatory infrastructures.

Advancing Against Nuclear Terrorism

by Graham Allison

At the St. Petersburg G8 summit in July 2006, Presidents Bush and Putin took three significant steps forward in addressing what each has identified as the single largest threat to his country's national security: nuclear terrorism.

Meeting a day before the summit, Bush and Putin announced a new Global Initiative to Combat Nuclear Terrorism; a plan for multiple, multilateral guaranteed suppliers of nuclear fuel to States that forgo building their own enrichment plants; and a Civil Nuclear Agreement that will lift restrictions on cooperation between the two countries in developing peaceful nuclear power.

Each of these initiatives provides a framework for dozens of specific actions that can measurably reduce the risk of terrorists acquiring a nuclear weapon. Together they suggest that the Bush Administration is finally beginning to see this challenge whole and to develop a comprehensive strategy for addressing it.

The significance of the Global Initiative against Nuclear Terrorism lies not only in its substance but in Russia's visible joint ownership of the Initiative. At a press conference, President Putin led with the Global Initiative and explained it with conviction. After years in which Washington lectured Moscow about this threat, Putin's joint leadership in securing nuclear material worldwide should give added impetus to this undertaking inside Russia as well.

Globally, this initiative calls for work plans in five arenas: prevention, detection, disruption, mitigation of consequences after an attack, and strengthening domestic laws and export controls against future A.Q. Khans. This skeleton has all the required limbs. The test will be how rapidly governments put meat on these bones.

Fortunately, officials at the Departments of State and Energy have already been at work with their Russian counterparts to do that. For example, they have scheduled for autumn 2006 the first-ever joint field exercise that will seek to find and capture hypothetical terrorists who have stolen nuclear material. This will involve Americans and Russians working together in Russia. The Initiative is open to other States prepared to undertake these commitments and we should see new members signing up by year's end.

The guaranteed nuclear fuel supply tightens the noose around Iran as it seeks to exploit a loophole in the global Nuclear Non-Proliferation Treaty. By guaranteeing States that six separate international suppliers will provide backup guarantees against interruption of supply for any reason other that breech of commitments under the NPT, this proposal eliminates Iran's excuse for Natanz—the enrichment plant it is rushing to finish today. This system for supply will be subject to the supervision by the IAEA, which will also have nuclear fuel reserves that allow it to be a supplier of last resort.

The Civil Nuclear Agreement will allow joint research on next-generation, proliferation-proof reactors, including technologies where Russian science is the best in the world. It will permit sale to Russia of US technologies that can improve the safety and efficiency of Russian nuclear power plants. In time, it will allow Russia to import for safe storage US-origin nuclear waste from power plants in Japan, South Korea and Taiwan.

While several obstacles must be overcome before Russia is open for business, this has the promise to become the largest source of income for Russia's nuclear industry. Requiring that 25% of the profit be spent on sustaining security for all nuclear material would be a classic example of win-win. It will also relieve nuclear power plant operators worldwide of spent fuel that has been accumulating onsite, providing another positive talking point for opponents of nuclear power.

In their Joint Statement, the two Presidents "recognize the devastation that could befall our peoples and the world community if nuclear weapons or materials or other weapons of mass destruction were to fall into the hands of terrorists."

If terrorists succeed in exploding a nuclear bomb in Washington or Moscow or Tel Aviv, the pictures of 9/11 and the London subway bombings will pale. Although pictures of war in the Middle East overshadowed the progress made at this year's G8, Russia and the United States made productive use of the summit as an action-forcing deadline to advance in the war against nuclear terrorism.

Graham Allison is Director of Harvard's Belfer Center for Science and International Affairs. He served in the Clinton administration as Assistant Secretary of Defense. He is the author of Nuclear Terrorism: The Ultimate Preventable Catastrophe (2004). *Email: graham_allison@harvard.edu*

talking about Terrorism

She has interviewed some 75 terrorists; served as a US National Security Council Director and consulted on a Hollywood nuclear thriller based on her work.

Jessica Stern talks terrorism with the IAEA Bulletin.

Q: How big a threat is nuclear terrorism — the risks from so-called "dirty bombs" or even nukes in the hands of terrorists?

Nuclear terrorism remains a potent threat. We have known for some time that terrorist groups have been seeking weapons of mass destruction. There are various ways that terrorists could use nuclear and other radioactive materials: they could acquire a nuclear weapon from a nuclear State; they could acquire the necessary fissile material and produce a weapon on their own, creating an improvised nuclear device; they could attack a nuclear power plant; or they could create a radiation dispersal device, a so-called dirty bomb. The first possibility would be the most devastating, but it is also probably the least likely. Stealing a bomb would be difficult because of the generally high security of facilities where nuclear weapons are stored. And a State that gave nuclear weapons to terrorists would have to seriously consider the probability that the source of the bomb could be identified, so retaliation against the State would be likely. In this regard, the revelation that terrorist groups were carrying out reconnaissance missions at Russian nuclear-weapon storage sites in 2001 was troubling; but the terrorists' efforts quickly became known to security personnel.

The second possibility—the risk that terrorists will acquire nuclear-weapons usable materials—must be taken extremely seriously, especially in light of revelations about meetings between Pakistani nuclear scientists and al Qaeda, and about a clandestine effort to export nuclear technology run by the Khan network. Terrorists' dispersal of radioactive materials — either by attacking a nuclear plant or disseminating those materials with a homemade device—is the most likely scenario. Still, it is important to keep the threat in perspective. Dirty bombs are far more frightening than lethal.

The US government considered developing radiological weapons during the Second World War, but abandoned the project as impracticable. In contrast, chemical agents can be stored for a long time, and are easier to transport. That makes them more attractive to terrorists than radiation devices if the main objective is to kill many people.

But radioactive weapons can be effective instruments of terror because of their psychological impact. Many studies have shown that people have a dread of radiation out of proportion with the danger it poses to human health. The media also tend to highlight terrorist incidents, heightening dread and panic still further. We feel a gut-level fear of terrorism, and are prone to trying to eradicate the risk entirely, with little regard to the cost. In contrast, when risky activities are perceived as voluntary and familiar, danger is likely to be underestimated. On average, more than 100 US citizens a day die in car accidents. Yet people expose themselves to the risk because it is a voluntary act and drivers feel the illusion of control.

Q: What can be done to minimize the risks of nuclear terrorism?

First, we need to realize that this is a new kind of war. Our enemies deliberately target civilians. But uncertainty, dread and disruption are their most important weapons.

Our most important response, then, is an informed public that understands not only the risks we face, but also the role of fear.

But public education is only the first step. Many policy measures can reduce the likelihood and impact of such threats. Nuclear power plants must be secured. Evacuation and clean-up plans should be readied and hospitals should be prepared. Radiation detectors should be deployed at ports and borders. Tracking systems for radioactive isotopes must be improved. Despite the relatively low casualty rate for radiological attacks, the psychological impact will be far more devastating if governments are perceived to be unprepared.

Unconventional weapons, used in a total war, require an unconventional response. New agencies and organizations will have to be involved. Businesses will play an increasingly important role. The food industry needs to be aware that the enemy in this war will not be dressed as a soldier and may not carry a gun. Instead, the enemy in this new war might be seemingly innocent pregnant woman looking nothing like your fantasy of a terrorist — perhaps an insider working at a food processing plant aiming to steal radioactive sources or contaminate food products, for example.

Terrorism is a form of psychological warfare, requiring a psychologically informed response. Our hardest challenge is not to overreact—the terrorists' fondest hope—and not to give in to fears. We will need to find the right balance between civil liberties and public safety.

Terrorism is a form of **psychological warfare** requiring a **psychologically informed response.** Our hardest challenge is **not to overreact** — the terrorists' fondest hope — and **not to give in to fears.**

Q: Are States doing enough to combat the roots and reach of terrorism?

The answer is a resounding 'no.' There is still a great deal of debate in my country about whether it is necessary to consider the causes of terrorism, or the broad appeal of terrorist ideology, in order to reduce the danger. This lack of interest strikes me as remarkably shortsighted. It will take a global effort to contain terrorism's spread. Part of what needs to be done is to reduce terrorist access to the materials of mass destruction by continuing the global effort to secure nuclear materials and expertise, including shutting down clandestine nuclear supplier networks, as I mentioned earlier. But we also need to study how terrorist ideologies spread, and why certain populations seem particularly susceptible to the idea that a good way to counter the seemingly unstoppable train of globalization and Americanization is through violence against civilians.

Terrorism is unquestionably evil, but I believe we have to try to understand what makes young men, and increasingly, young women, become terrorists. We won't be able to stop it if we just focus on the evil of terrorism and don't bother to try to understand the grievances that give rise to it.

Q: You did some work with Ted Turner's Nuclear Threat Initiative (NTI) and with India and Pakistan to help them improve security of nuclear weapons and materials, and in your recent book you cite vulnerabilities in Russia. How did you help those countries improve their nuclear security?

I was involved in helping to formulate a vision for NTI when it first began. And then NTI funded Stanford Professor Scott Sagan and me to look at whether there was a way to help India and Pakistan improve security of nuclear weapons materials, in the same way we had done and, in fact, we continue to do for the former Soviet States. I had been involved in the effort to secure nuclear materials in the former Soviet Union. And, it just seemed like a good idea to try to do it in Pakistan.

We have to try to understand what makes young men, and increasingly, young women, become terrorists.

I went to Pakistan and Scott went to India. The Pakistanis were very forthcoming and really wanted assistance with personnel reliability, in particular. Personnel reliability involves helping to ensure that custodians of nuclear materials and nuclear weapons do their jobs, that they are reliable, that they don't suddenly start getting involved in Islamist groups that might be fighting the Pakistani government or someone else.

When the extent of A. Q. Khan's nuclear network became clear, I couldn't help but wonder whether our contacts in Pakistan's nuclear establishment had any knowledge about what the former head of Pakistan's nuclear program was up to — whether they were worried about precisely what transpired — Islamist-leaning scientists becoming private proliferators.

Q: Can you tell us about your involvement with the film *The Peacemaker*? Were you surprised to find your life influencing a film?

After a two-year postdoctoral position at the Lawrence Livermore National Laboratory analyzing terrorism and weapons of mass destruction, I became the National Security Council's (NSC's) director for Russian, Ukrainian and Eurasian affairs. As it turned out, nobody at the NSC was really working on the aspect of nuclear security I wanted to work on — the possible theft of nuclear materials or weapons and the threat of terrorism. I was fortunate that some of the world's foremost experts on nuclear smuggling and terrorism — including the physicist Frank von Hippel and the nuclear expert Matthew Bunn — were working in the government at that time. But perhaps because there was so little understanding of the importance of these threats, and perhaps because many of the important issues were highly technical, their voices were not being heard and their expertise was not being properly utilized. They helped me a great deal.

One day the NSC press office asked me to meet with a famous journalist from *Vanity Fair* named Leslie Cockburn. They warned me that Leslie was a skilled investigator known for her ability to ferret out information that might embarrass the White House. Leslie had spent time in Russia and saw that security conditions for nuclear-weapons components were poor. She was interested in the possibility that nuclear weapons or their components might be stolen and used by terrorists. The situation was dangerous, she reasoned, and she wanted to know what the White House was doing to protect the American people.

I explained to Leslie that I was just as concerned as she was and that many people from all over the government were meeting regularly to try to solve the problem. I told her how the United States government had carried out a mission to airlift a large cache of nuclear-weapons material out of Kazakhstan. There was enough material there to make dozens of bombs, and the government of Kazakhstan was afraid it could be stolen. I told her that I was running an interagency group called the Nuclear Smuggling Group, which met regularly to discuss reported incidents of nuclear theft and to develop national policies. Leslie listened and took notes. She seemed impressed that there were so many people in different parts of the government who took the problem seriously. After the interview was over I went back to work. I was too busy to think much more about it.

Several months later I got a call from DreamWorks, the entertainment company that Steven Spielberg founded with two colleagues. Without telling me, Cockburn and her husband wrote a movie based on my experiences and persuaded DreamWorks to make it. In the film starring Nicole Kidman and George Clooney, the two search for nuclear weapons around the world. I was on the set as a consultant. I saw the film as a kind of "op-ed," intended to warn the world about the dangers of nuclear terrorism and the need to take action to thwart the threat. But prior to 9/11, few people took terrorism seriously, and the film did not do as well as it undoubtedly would have had it been released after the attacks.

Jessica Stern is a US expert on terrorism and author of Terror in the Name of God: Why Religious Militants Kill (2006)*—a book that shares her analysis of five years of interviews with over 75 members of extremist groups. She is a lecturer in public policy at Harvard University, served as director for Russia, Ukraine and Eurasian Affairs at the National Security Council and was the Superterrorism Fellow at the Council on Foreign Relations.*

The author defines terrorism as "an act or threat of violence against non-combatants with the objective of exacting revenge, intimidation, or otherwise influencing an audience."

What We Need to Know ...and when

by Igor Khripunov

Educating the public about nuclear terrorist risks can help raise levels of security

Nuclear power infrastructures could be the target of terrorist acts of theft, sabotage, unauthorized access or other malicious acts given their radiological and chemical content and potential for building weapons. Attacks on its major components, including fuel production, reactors, waste handling, and reprocessing facilities, would lead to serious consequences—even if there is little or no damage to a nuclear power plant itself and other related structures. Public fear of nuclear radiation, in combination with a possibly massive resultant blackout and other aggravating factors, could create significant distress and panic. In other words, successful terrorist attempts to attack nuclear power infrastructure can easily bring about systemic disaster.

Systemic risks impact society on a large scale and their effects may spread much further from the original hazardous source. Those risks widely affect systems that society depends on, such as health, transport, environment, telecommunications. Their consequences may be technical, social, environmental, psychological and economic and involve different stakeholders.

In this context, however, one important stakeholder has been under-appreciated, under-utilized and somewhat misunderstood: the general public. The nuclear power infrastructure must learn how to efficiently communicate to the public and develop better options for public risk communication that relate to deliberate attacks or accidents. The public is also a challenging stockholder because citizens are deeply split regarding the acceptability and value of nuclear power generation and tend to express their feelings emotionally. However, there is growing recognition that because of skyrocketing oil prices and evidence of the greenhouse effect, nuclear power may be approaching renaissance. Hence, the public must no longer be looked upon only as potential victims or panicked masses but rather as an important contributing factor for better nuclear security throughout all stages of a possible incident.

Common risk perception

Common risk perception is built on objective and transparent risk communication. This means an interactive process of exchange of information and opinion among individuals, groups and institutions and the transfer of risk information to the public, and from the public to decision-makers and infrastructure operators. In reality, a common level of acceptance of risk is based not only on technical expertise, but is strongly affected by cultural and individual aspects and values. To achieve this goal through risk communication regarding nuclear power infrastructure, the process must be based on a dialogue among major stakeholders — risk experts, policy makers, infrastructure operators, and the public involved.

For some, if not most professionals and experts, risk is the likelihood of an event multiplied by its estimated consequences, ranging from mild to catastrophic (risk=probability x consequences). There are at least three types of probabilities regarding nuclear facilities: deliberate attack, interruption failure, and neutralization failure.

The magnitude of a risk to individuals varies depending on their background and objectives. This leads to different opinions and interpretations of the risk and vulnerabilities. The public often tends to base its views of risk on personal experience and impacts. Hence, the probability that something bad will happen to people, combined with the aspects of the situation that upset them, leads to their perception of risk, which is based more on emotion than on analysis of the contributing probabilities. Thus, preventative actions are sometimes hard to prioritize by outsiders and even harder to explain to the public. There is also a question of understanding the language used, especially when the terminology differs and confuses the discussion between different fields of risk assessment.

Factors that may influence public attitudes include the perceived magnitude of the consequences, ignorance about the nature of the hazard, distrust of the institutions attempting to manage the hazard, and the level of media attention devoted to an event. Also important for understanding public perceptions are the proximity of area residences and schools to a specific segment of the nuclear energy infrastructure; the local population density; and the activities of local interest groups. Even within a given population, risk perceptions are not uniform and may vary depending on experience, gender, social status, and world view.

Stages in risk communication

Risk communication is vital in the process of achieving a common risk perception. It can be defined as a two-way process of information exchange that includes multiple types of information with multiple purposes. As an important benefit, risk communication has the potential to build public trust and resilience in times of crisis.

There are different perspectives to approaching and understanding the meaning of risk communication based on a perceived notion of the public. On one hand, there is a perception of a passive public complacently waiting for the transmission of vital information from authoritative sources while, on the other, there is an image of a proactive public striving to understand the reality and contribute to shared management of risks. The second perspective provides the most optimal scenario of social mobilization consisting of an interactive process of information exchange and opinion among individuals, groups, and institutions.

A mode of risk communication is not seen as successful if its objective is the acceptance of the views or arguments of experts by non-experts. It may, however, be regarded as successful to the extent that it raises the level of understanding of relevant issues or actions for all stakeholders, including the public and ensures that they are adequately informed within the limits of available knowledge and, if necessary, can play a meaningful role in risk management.

Accordingly, in order to achieve desired objectives consistent with a given segment of the nuclear power infrastructure, any communication with the public ideally must proceed through three stages:

① **Public information sharing:** a one-way process in which information flows from government and/or operators to the public for educational purposes;

② **Public outreach:** a proactive campaign undertaken by government and/or operators to respond to emerging public concerns; and

③ **Public involvement:** an ongoing relationship in which communities become partners with government and/or operators for certain agreed-upon purposes.

The last stage is naturally more mature when the public is aware of the stakes involved and has the requisite knowledge to take on specific roles at pre-incident and post-incident stages.

Public involvement

Security is now a concern that affects public perceptions about nuclear and radiological risks and terrorist threats. To communicate effectively about security-related issues, government and operators must understand and respect the public's very real worries about safety and security. The public understands and is largely concerned that terrorists may be intent on breaching the safety features built into nuclear installations by denigrating security systems. The public typically questions whether security systems are adequate and develops an active interest in making the security regime robust enough to keep safety features reliably operational.

However, emerging threats of terrorism increasingly elevate security including physical protection to a more independent and unique status beyond a simple safety-security synergy. In other words, the overlap between safety and security is somewhat shrinking, revealing conflicting elements that need to be reconciled. First, terrorist attacks have the potential to increase significantly the impact of an accident, making routine safety procedures inadequate. Second, as adaptive adversaries, terrorists not only have the ability to change tactics as an attack unfolds but also are capable of concurrent and/or subsequent multiple attempts against infrastructures. Third, terrorist attacks are criminal acts and, as such, include the additional complications of securing a crime scene and conducting an investigation during the response phase.

For effective risk communication, safety and security must be explained and presented to the public as two sides of the same coin which is trouble-free operation of the nuclear power infrastructure under any conceivable circumstances. Hence, by getting the public on-board and recognizing it as an important stakeholder, a meaningful risk communication strategy can achieve four interrelated missions:

1. Reach a common risk assessment enabling the public to be educated and prepared. Gaining public support requires a realistic portrayal of risk that is accurate and draws a fine line between hyping the threat to spur people to action and trivializing it to provide them false reassurances. Preparedness provides a way for the public to translate risk awareness into action and can consist of a range of activities, including developing and practicing contingency plans, such as communication, evacuation, or sheltering. Preparedness also serves as a bridge between risk education which occurs in advance of an event and taking protective actions during a crisis.

Much, if not all of the information available to the general public about the risk of terrorism, preparedness programs, assessments or response capabilities, and so on will also be available to potential terrorists, who may use it to decide whether to undertake an attack and which segments of the infrastructure are most vulnerable. It must be understood that the ultimate target for terrorists is public confidence in itself and the government rather than infrastructure specific units per se. Risk communication, in this respect, represents a careful balancing act for government and industry. Both must understand the benefits of keeping the public adequately informed, the deterred potential of certain kinds of public communication for terrorists and the need for confidentiality regarding sensitive information. These competing aspects must be weighed when deciding what types of information should be made available and in what detail.

2. Encourage a well-informed and well-motivated public to contribute to a healthy nuclear security culture, not only at the nuclear plant or other associated unit level but also nationally. Security culture at the facility level can be defined as a linked set of characteristics that together ensure that the workforce pays sufficient attention to nuclear security. Shared beliefs, assumptions, principles which guide decisions and actions, and patterns of behavior hospitable to security represent the ordered and hierarchical set of characteristics that make up nuclear security culture. It is important to understand that most members of the nuclear plant workforce are part of the community adjacent to the site. They have families there and socialize with local citizens on a regular basis. Hence a strong commitment to nuclear security on the part of the local community heightens the public visibility of security-related issues, indirectly improving the motivation of the staff that operates that site.

3. Build up public vigilance, persuading citizens to cooperate more closely with law enforcement. This vigilance will manifest itself in reports of unauthorized efforts to gain access to sensitive infrastructure sites or breach the site's boundaries. An engaged public will even report suspicious people or activities near the site. A small portion of local citizens could be trained to perform such functions on a voluntary basis, particularly in sparsely populated and difficult-to-monitor areas.

Such initiatives must, however, draw lessons and avoid the pitfalls of what is described as "vigilantism." Also, these programs need to be leery of creating a cadre of members of the public who rush to the scene of a terrorist incident and attempt counterterrorist actions because they believe, wrongly, that they are qualified in terrorist response operations. However, there is a niche for a security conscious public to fill. Training of local citizens, when and if it is deemed necessary, must be a well thought-out, stably funded, and widely publicized campaign.

4. Reduce the immediate and long-term physical and psychological impact of a terrorist incident by fencing off panic, boosting morale, maintaining credibility, and providing guidance. This emphasis is especially important while counter-terrorist actions are underway or other terrorist acts are likely. These post-incident arrangements consist of steps that individuals and communities can take to save lives and reduce losses when an event occurs. The ultimate test is their effectiveness in a real crisis when traditional societal institutions tend to unravel as was evidenced in the wake of hurricane Katrina which hit the US last year. Such actions include forms of sheltering, evacuation, and quarantine as well as using individual protective equipment and a variety of medical counter measures.

How much information and when?

A major question is: how far in advance is it necessary to intensify the risk communication campaign and educate citizens about the actions they should take in response to various types of terrorist incidents? While a large swathe of the public will likely not pay much attention to these efforts or retain the information and materials provided in anticipation of future incidents, some people will—perhaps because they are convinced that terrorist incidents will occur and perhaps because they feel empowered by information. Given the potential of this activist group to influence the behavioral and psychological response of others—at home, in the office, or at school—it is worth investing at least some time and resources in educating the public.

Ultimately, it all comes down to creating a more resilient and prepared population in the face of terrorist adversaries. Resilience is usually defined as the ability to handle disruptive challenges, characterized as emergencies that can lead to or result in crisis.

Technical solutions and competence can contribute to resilience but ultimately real resilience is about attitude, motivation and will. Engendering such attitude requires a cultural change and more focus on the mindset of people. Resilient citizens will be more than bystanders in the effort to deal with terrorist acts—be it nuclear power infrastructure or any other target—and will be less prone to fear and anxiety before an during crisis situations. Resilience-building and other public-related campaigns, however, cost time and money, and they have to be sustained over the long term. Careful forethought should go into the planning and execution of such campaigns in order to reap maximum benefits.

Igor Khripunov is Associate Director of the Center for International Trade and Security at the University of Georgia, USA. E-mail: igokhrip@uga.edu

Remote Control

by Malgorzata K. Sneve

Russia's northwest coastline is dotted with hundreds of old and large radioactive sources. Known as RTGs, they mostly power remote lighthouses. Now the power packs are being safely dismantled. Norway is helping Russia do it.

Several hundred radioisotope thermoelectric generators (RTGs) are deployed along the Russian Federation's Arctic coast to power remote lighthouses and navigation beacons. Similar RTGs were also used as power sources in other remote locations in the Russian Federation and elsewhere in the former Soviet Union. All Russian RTG's have out-lived their lifespan and are in need of decommissioning. Radioactive incidents involving such sources, such as in Georgia, underscore the urgency of this task.

The RTGs typically contain one or more radionuclide heat sources (RHS) each with an activity of thousands of TBq of strontium-90. This means that they are Category 1 sources as defined in the IAEA international "Code of Conduct on the Safety and Security of Radioactive Sources". In fact they are among the largest single radioactive sources ever used.

According to the Federal Atomic Energy Agency of the Russian Federation (Rosatom), there are 651 RTGs at various locations in the Russian Federation which are subject to decommissioning or replacement with alternative sources of energy. In 1993, there were almost 200 RTGs in lighthouses in the Murmansk and Arkhangelsk regions of northwest Russia, relatively near the Norwegian border.

Due to the remoteness of these lighthouses, maintenance and security of RTGs is difficult to achieve. Most Russian RTGs are unprotected against intruders and there have been several examples of unauthorised interference. While there is no evidence of any intent to use the radioactive sources for malevolent purposes, there have been incidences of theft of shielding materials, presumably for their value as scrap metal, with the RHS being abandoned.

Naturally, concern has grown about the potential misappropriation of these radioactive sources as well as the broader issues of continuing maintenance and safe use of RTGs. This has become a matter of both national and international concern. The Norwegian Government has played a significant role in international efforts, fully cooperating with Russian authorities to safely decommission RTGs and provide alternative power sources.

Norway has actively supported improvement of nuclear safety and security in northwest Russia for more then ten years. Over this period, the Norwegian Government has spent approximately $150 million on a variety of industrial projects, including specific improvements in radioactive waste treatment and storage, physical security, and infrastructure support. The national authority, the Norwegian Radiation Protection Authority (NRPA), takes an active part advising the Government regarding prioritization and quality assurance of all these activities.

In addition, the Plan of Action places great emphasis on adequate regulatory supervision. Accordingly, the NRPA programme includes a variety of regulatory support projects. These are designed to assist the Russian authorities in ensuring that work is properly carried out within the framework of Russian law, taking into account international standards and recommendations from bodies such as the IAEA. The regulatory cooperation between NRPA and various Russian regulatory bodies is critical in maintaining an effective and efficient regulatory process.

Taking RTGs Out of Service: Industry Support

The Norwegian Government has been operating an industrial project to support decommissioning of RTGs in northwest Russia since 1997. Since project initiation, more than 60 RTGs have been removed from lighthouses on the Kola Peninsula. They are being replaced with solar panels and nickel-cadmium battery packs.

As part of this project, inspection and preparatory work took place before the RTGs were transferred by helicopter, boat and road to a temporary storage point at ATP "Atomflot" near Murmansk. The RTGs were then transported via road and rail to the dismantling point in the Moscow Region, where the heat sources (RHS) were removed. The RHS were then transported by road and rail to FSUE PA "Mayak", where they are stored pending final disposal.

While there are important security, environmental and radiological protection incentives for decommissioning RTGs (such as threats to the local environment, public safety, and possible misuse of the source of radioactive material), the decommissioning process is not without risks. Decommissioning itself could result in radiological and other environmental impacts and risks. In addition, the operational and regulatory responsibilities with respect to RTGs have evolved in the last few years, including changes from military to civilian control. It was necessary, therefore, to review the situation in order to weigh the associated risks.

The NRPA, in cooperation with Russian organizations, carried out a study to assess the environmental, health and safety consequences of decommissioning RTGs in northwest Russia. It was concluded that the decommissioning project should continue, since leaving the RTGs *in situ*, inadequately monitored, could lead to an undesired access to radioactive material.

It was also noted that the relevant authorities and organizations need to clarify their separate responsibilities throughout the entire process of inspecting, collecting, and dismantling RTGs, as well as the storage and disposal of radioactive waste so generated. Additionally, radiation protection guidelines should be reviewed and amended where necessary with correct procedures and checklists to ensure compliance. The need for regulatory support to help achieve this was recognised.

Regulatory Support

NRPA has provided support to regulators in the Russian Federation. The general goal of regulatory support is to help Russian bodies develop guidelines and require-

what is an RTG?

A Radioisotope Thermoelectric Generator (RTG) is a simple electrical generator which is powered by radioactive decay. In an RTG, the heat is released by the decay of a radioactive material and converted into electricity using an array of thermocouples. RTGs can be considered a type of battery and have been used as power sources in satellites, space probes and unmanned remotes facilities such as lighthouses. RTGs are usually the most desirable source for unmanned and unmaintained situations needing a few hundred watts or less of power for durations too long for fuel cells, batteries and generators to provide economically and in places where solar cells are not viable.

RTGs use a different process of heat generation from that used by nuclear power stations. Nuclear power stations generate power by a chain reaction in which the nuclear fission of an atom releases neutrons which cause other atoms to undergo fission. This allows for the rapid reaction of large numbers of atoms, thereby producing large amounts of heat for electricity generation.

Chain reactions do not occur inside RTGs, so a "nuclear meltdown" is impossible. In fact, RTGs are designed so that fission does not occur at all; rather, forms of radioactive decay which cannot trigger other radioactive decays are used instead. As a result, the fuel in an RTG is consumed much more slowly and less power is produced.

In spite of this, RTGs are still a potential source of radioactive contamination: if the container holding the fuel leaks, the radioactive material will contaminate the environment. To minimize the risk of the radioactive material being released, the fuel is stored in individual modular units with their own shielding.

Recovery mission in Georgia

Two abandoned and potentially dangerous radioactive devices have been successfully secured in the first three days of a summer 2006 campaign to trace lost radioactive sources in Georgia. Such abandoned sources are known as orphan sources.

A Georgian Ministry of Environment and IAEA team, scouring the isolated alpine region of Racha, found a powerful source in a pile of dirt on the floor of a derelict factory. The team also found a second smaller source inside a house—in a tin of nuts and bolts above a work bench. Just a thin, wooden wall separated the source from the family bedroom.

In the village of Iri, where the first source was located, background radiation levels were elevated 12 times above normal in the village centre.

"It could have resulted in serious injuries, or even death, if someone had picked it up and put it in their pocket for a period of time," said Carolyn Mac Kenzie, a radiation source specialist in the IAEA, who accompanied the start-up of the mission.

Villagers were shocked by the discoveries. "Of course no one had any idea it was here," said 14-year-old Salome Gagnigze, standing near the derelict factory in Iri as Georgian inspectors equipped with sensors combed the complex of ruined buildings.

An animal shelter is among the ruins but continues to be used as a place of storage for farmers. Neatly stacked bean poles stand a few metres from where the source was found.

In the second village, Likhaura, residents requested investigators to check their houses for possible sources after the discovery.

The radioisotope in both sources was caesium-137, a powerful gamma emitter, among the most common radioactive isotope in industrial use for instrumentation to check materials for flaws and for industrial measurements. New, powerful, backpack-mounted instrumentation with which the search team was equipped helped reveal and locate both sources.

Because records are not available, search team leaders said they had no clear knowledge of the origin of the sources. The first source may have been overlooked when the factory was abandoned—the second was presumably picked up and taken to the house where it was found. Both would originally have been contained in shielded containers.

As many as 300 radioactive sources have been recovered in Georgia since the mid-1990s and there has been at least one death and many injuries to the public as a consequence.

Among the most powerful orphan sources found have been unshielded strontium-90 sources that powered radioisotope thermoelectric generators (RTGs). Some RTGs, originally located in remote areas as stand-alone electrical generators, remain unaccounted for.

A legacy of Georgia's sharp economic decline after the break-up of the Soviet Union was a loss of control of radioactive sources used in industry. The collection and sale of scrap metal from abandoned factories has also provided a

ments for planning, licensing and implementing industry projects.

The NRPA's main partner in the RTG Regulatory Support Project (RSP) is the Nuclear, Industrial and Environmental Regulatory Authority of the Russian Federation (Rostechnadzor). However, it is important that all relevant organizations work together — for example, those organizations concerned with transport, operators and regulators from the Russian Federation and Western organizations. This is the "2 plus 2 approach." Russian and Western operators cooperate on the industry project, and Russian and Western regulators cooperate on licensing/approval of this industry project.

In order to provide the most relevant international inputs to Russian regulators, the NRPA involves regulators and technical support organizations from other countries, including France, Sweden and the UK.

Assessing the Threats

As a first step in the RSP, an Initial Threat Assessment was carried out to clarify the steps in RTG decommissioning and to identify priorities for regulatory action, based on the main radiological threats presented by each step. A series of steps were identified from the operator's inspection of RTGs at the point of origin through loading them means of livelihood and some orphan sources have been found in shipments of scrap. Many orphan sources have also been found on former military bases.

An added impetus to recovery operations is concern that some radioactive sources could be used for radiological dispersal devices (RDDs) if they fell into the hands of terrorists.

Since 1997 the IAEA has been working with Georgia to upgrade levels of radiation safety and to secure orphan sources. The latest search and recovery mission, funded by the United States through the IAEA's Technical Cooper-ation Program, scoured the mountainous region of Racha, about 300 km north-west of the capital Tbilisi, focusing on former industrial centres in the valleys of the Rioni River. It is the last area of Georgia to have gone unchecked for orphan sources.

But the problem of unaccounted for radioactive sources is not confined to Georgia, said Ms. Mac Kenzie. "Although there have been significant strides in improved security, there are frequent reports of incidents where sources go missing and accidents occur. This is a global problem, an indication that the control and management of radioactive sources still needs to be improved. Yet radioactive sources are an irreplaceable tool providing a huge benefit to society, in the practice of medicine, in industry and research."

The technical assistance provided by the IAEA to Georgia is part of its global effort to improve the security of radioactive sources and nuclear material. Georgia is nearing the final steps of commissioning a new secure storage facility where radioactive sources will be stored.

—Peter Rickwood, IAEA Staff Report.

Lerry Meski, a radiation specialist with the Georgian Ministry of Environment, inspects an abandoned factory where a powerful radioactive source was found during an IAEA-supported mission. (Photo: P. Pavlicek/IAEA)

onto the ship, placing them in temporary storage, transporting them via rail and road links to their final processing at FSUE PA "Mayak".

The risks associated with the steps must be addressed for each RTG. This is done through the preparation of a decommissioning plan, a safety analysis, and an environmental impact assessment (EIA), which should be developed for each RTG before work starts on decommissioning.

While there will be common features in the plans and assessments between different RTGs, plans should be tailored to take account of the specific characteristics of each RTG (location, history, condition, etc.) and the specifics of the decommissioning process for that RTG.

The physical form of the RHS is intended to make it very unlikely that significant dispersion or leaking of activity could occur—even under extreme conditions such as severe impact, intense fire, long-term immersion in water (e.g. in the sea) or explosion (presumably deliberate).

The primary radiological threat is direct exposure to radiation from the source in the event that shielding is removed or is no longer effective. The key operator must take actions to reduce the threats. These actions need to be systematically planned for all steps in the process and addressed in

RTG accidents

1999 **Leningrad**

An RTG was found ravaged by metal looters. The radioactive heat source (RHS) core was found emitting radioactivity at a bus stop in the town of Kingisepp. It was recovered.

2001 **Kandalashka Bay, Murmansk region**

Three radioisotope sources were stolen from lighthouses located in the area. All three RHS were found and sent to Moscow.

2001 **Georgia**

In December 2001, three woodsmen found two heat-emanating ceramic objects near their campsite in the remote Inguri river valley of Georgia. Two of the woodsmen involved in the accident carried the containers on their backs and experienced nausea, vomiting, and dizziness within hours of exposure. The third carried the source attached to a wire. At a hospital in Tbilisi, Georgia, the woodsmen were diagnosed with radiation sickness and severe radiation burns, and at least two of the three were in serious condition. A Georgian team recovered the sources in early 2002 with the assistance of the IAEA. They were the unshielded, ceramic sources of two Soviet-era RTGs each containing about 30,000 Ci of Strontium-90. Two of the victims were treated in hospitals in Paris and Moscow for many months before recovering from severe radiation burns.

2002 **West Georgia**

Three shepherds from the Tsalendzhikha region were exposed to high radiation doses after they stumbled upon a number of RTGs in a nearby forest. Shortly after the accident the IAEA established that, during the Soviet time, eight such generators altogether were delivered to Georgia.

2003 **Cape Pihlissar, near Kurgolovo Leningrad region**

An RTG was ravaged by metal scavengers and found 200 meters from the lighthouse, sunk in the shoals of the Baltic Sea. It was removed by a team of experts.

2003 **Golets Island in the White Sea**

The Northern Fleet service personnel discovered the theft of metal from an RTG-powered lighthouse on the small island of Golets. The door inside the lighthouse had been forced. The lighthouse contained a particularly powerful RTG with six radioactive heat sources, which were not taken.

Ref: The Bellona Foundation. These accident reports are drawn from a more comprehensive listing of accidents involving RTGs in the former USSR, Russia and the Commonwealth of Independent States.

the decommissioning plan and in the safety and environmental assessments.

Defining Tasks, Closing Gaps

Rostechnadzor has recognised that there is a need to upgrade the regulatory framework for the safe decommissioning and disposal of RTGs in the Russian Federation, taking account of the magnitude of the problem and the associated high hazards, as well as the lack of experience in this area.

The aim of the RSP is to upgrade the existing regulatory framework of the Russian Federation for the safe decommissioning and disposal of RTGs. The focus is on the following priority areas:

- Regulatory requirements based on the Initial Threat Assessment;
- Requirements for data, safety assessment and quality assurance;
- Supervision over radiological safety and security, including physical protection; and
- Requirements for emergency preparedness and response, based on environmental impact assessments made for each stage of RTG decommissioning.

Other areas of interest include preparation of an inspection handbook, training and certification of personnel, compliance monitoring; and providing information for the public.

The first task is to clarify the roles and responsibilities of the different organizations involved—particularly operators and regulators—with respect to the safety and security of RTGs. The aim is to ensure that there is clear allocation of responsibilities, consistent coordination of regulatory control and compliance requirements, effective transfer of responsibility at each stage in the overall management process and transparency within the Russian regulatory regime. There are gaps in these areas.

This task needs to address both the roles and responsibilities relating to RTGs *in situ*, but also those relating to the other stages involved in decommissioning. They include the transport of complete RTGs and RHS, the dismantling of RTGs, and the storage and ultimate disposal of RHS.

In addition, Rostechnadzor has responsibility for the regulation, control and supervision of all RTGs in Russian Federation, but the Defence Ministry is responsible for radiation and nuclear safety in military units. The Defence Ministry therefore has its own military nuclear regulatory body, and Rostechnadzor often does not have access to military sites with RTGs.

In line with the Code of Conduct requirement for a national register of Category 1 and 2 sources, the operating organizations are developing—through a parallel industrial project—a database containing comprehensive information related to each RTG. This includes their location, description, key characteristics (including size of radioactive source) and associated potential hazards. The database will also provide an assessment of vulnerability specific to each RTG. Based on analysis of information from this database, Rostechnadzor considers whether the types of data held are adequate for all locations and RTGs, and thus identifies gaps in information to be filled through the industrial project.

Another major task is to identify Russian Federation regulations relevant to the control of RTGs and to consider—taking into account international standards and recommendations and best practice in other countries—whether existing regulations need to be supplemented or modified and/or whether new regulations need to be developed. Again, this review needs to consider safety and security measures at the various stages of the RTG life cycle: use, recovery, transport, decommissioning, storage and disposal. Regulations identified through this process as 'missing' or requiring modification (and which fall within the remit of Rostechnadzor) will then be developed or modified.

Application and Enforcement

Once the basic regulatory infrastructure has been updated, it is proposed that further assistance will be provided in relation to some specific aspects of Rostechnadzor's role within the infrastructure.

Accordingly, support can be provided to Rostechnadzor in developing an assessment capability, independent of the operators, sufficient to perform its two main assessment functions for the various activities involving RTGs, namely:

- developing regulatory guidance for operators on conducting assessments that satisfy regulatory requirements for each stage of the RTG life cycle; and
- critically reviewing and evaluating safety and security assessments and EIAs submitted by operators in support of licensing and authorization applications at different stages, as a basis for regulatory decision-making.

While there are important security, environmental and radiological protection incentives for decommissioning RTGs, the process is not without risks.

Support is also provided to adapt inspection procedures, or develop new ones, to be applied to the various stages of an RTG's life cycle in accordance with the updated regulatory requirements. In addition an inspection handbook focusing on safety and security of RTGs is under development. This will provide a system for tracking and recording inspection findings and monitoring of the risks. The audit trail would ensure compliance with regulation and help promptly identify any irregularities, or potential problems.

Finally, support is provided for the development of regulatory guidance on requirements for emergency planning in relation to accidents or unauthorized actions involving RTGs at any stage of their life cycle, and to improve the capabilities of Rostechnadzor and technical support organizations to fulfil their functions in the event of such an emergency.

The Government of Norway continues to support the safe decommissioning of RTGs in northwest Russia. This involves close cooperation with Russian authorities and other countries supporting the wider programme on RTG decommissioning. So far about a third of the RTGs in the region have been removed with Norwegian support, and without incidents.

One lesson is clear: regulatory support is a vital adjunct to carrying out such industrial projects so that the whole process is safe and efficient for everyone involved.

Malgorzata Sneve is a Senior Adviser at Norwegian Radiation Protection Authority in Østerås, Norway. E-mail: Malgorzata.K.Sneve@nrpa.no

by Manne Wängborg

Wake Up Call

A recent report, issued by the WMD Commission, outlines sixty proposals on how the world could be freed of nuclear, biological and chemical weapons.

The title of the Weapons of Mass Destruction Commission report "Weapons of Terror" is meant to be an alarm bell and an eye-opener. As is immediately made clear by the subtitle, "Freeing the World of Nuclear, Biological and Chemical Arms," the report is not primarily about terrorism in the current, conventional, narrow sense of the word, but about the possession of weapons of mass destruction—or weapons of terror—by governments, not only tolerated but generally respected and quite influential in the international community.

Chaired by former IAEA Director General Hans Blix, the Weapons of Mass Destruction Commission attempts to tackle the seeming paradox that the key category of weapons of mass destruction—the roughly 27,000 nuclear weapons—in the hands of the established major powers are generally regarded as a legitimate source of military strength and political prestige and largely a stabilizing force, while in the hands of others are seen as an existential threat to the international community.

The 14-member Weapons of Mass Destruction Commission advances the opposite perspective. Contrary to the currently fashionable rhetoric about *rogue States,* it takes the view that weapons of mass destruction are inherently dangerous, irrespective of whose hands they are in. Echoing the 1996 *Report of the Canberra Commission on the Elimination of Nuclear Weapons,* the WMDC affirms that "so long as any State has such weapons—especially nuclear arms—others will want them. So long as any such weapons remain in any State's arsenal, there is a risk that they will one day be used, by design or accident. Any such use would be catastrophic." This is the basic credo of the independent Weapons of Mass Destruc-tion Commission.

> In the ten years that have passed since the Canberra Commission report was published, global economic interdependence has accelerated. All States of the world have come to face the same environmental threats and risks of contagious diseases. There have been no serious territorial or ideological conflicts between the major military powers. Yet, amazingly, the climate for agreements on arms control and disarmament has actually deteriorated.
>
> — WMD Report, Chairman's Preface

The Weapons of Mass Destruction Commission was established in 2003 by the late Minister for Foreign Affairs of Sweden, Ms. Anna Lindh, acting on a proposal by Jayantha Dhanapala, then United Nations Under-Secretary-General for Disarmament, who was subsequently appointed a member of the Blix Commission. The other Commissioners, all invited by the Chairman Hans Blix to serve in their personal capacity, were Dewi Fortuna Anwar, Alexei

G. Arbatov, Marcos de Azambuja, Alyson J. K. Bailes, Gareth Evans, Patricia Lewis, Masashi Nishihara, William J. Perry, Vasantha Raghavan, Cheikh Sylla, Price El Hassan bin Talal, and Pan Zhenqiang.

The *raison d'être* for establishing the Commission was a growing unease at the stagnation in global disarmament efforts in the late 1990s and first years of the 21st century. Since 1996, when the Comprehensive Nuclear-Test-Ban Treaty was signed, there have been several setbacks, but hardly any successes. The case could and still can be made that, counter-intuitively, there was more progress during the Cold War than after it ended.

Confronting this deadlock, the Blix Commission presents 60 recommendations—30 related to nuclear arms, and 30 to other weapons of terror and various cross-cutting issues —with a view to breathing new life into the global disarmament efforts and consolidating the rule of law in the field of arms control and disarmament.

While in no way belittling the fundamental differences between nuclear, biological and chemical arms, the report is based on the premise that they are all rightly called weapons of terror. Designed to terrify as well as destroy, they are the most inhumane of all weapons. Whether in the hands of States or terrorists, they can cause destruction on a vastly greater scale than any conventional weapons, and their impact is far more indiscriminate and long-lasting. This is the point of departure of the international Weapons of Mass Destruction Commission.

While there already exists a total ban on biological and chemical weapons—the 1975 *Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (BTWC)* and the 1997 *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (CWC)*—there is no corresponding ban in force on nuclear weapons. On the other hand there is the 1970 *Treaty on the Non-Proliferation of Nuclear Weapons (NPT),* initially of 25 years' duration, then in 1995 extended indefinitely, which requires its parties to negotiate nuclear disarmament and which is far closer to universal membership than either the BTWC or the CWC.

The Blix Commission, accordingly, argues for the strengthening and universalization of both the BTWC and the CWC, while presenting a number of mutually reinforcing partial measures to limit and reduce nuclear weapons, with a view to their eventual outlawing. Topping its list of nuclear-weapon recommendations is the entry into force of the now ten-year-old *Comprehensive Nuclear-Test-Ban Treaty (CTBT).*

Opened for signature in 1996, it was first signed by then President of the United States Bill Clinton. By April 2006, it had been signed by 176 States and ratified by 132. However, 10 of the required 44 ratifications required for its entry into force remain, including those of the nuclear-weapon States China and the United States. The report is under no illusion that entry into force of the CTBT is to be expected in the near future, not least in view of the current US administration's staunch opposition to it and consistent rejection of pursuing its ratification by the US Senate that once already turned it down.

> In today's rapidly integrating world community, global treaties and global institutions, like the UN, the IAEA and the OPCW, remain indispensable. Even with their shortcomings they can do some important things that States acting alone cannot achieve. They are…essential instruments in the hands of the State community to enhance security, to jointly operate inspection systems and to reduce the threat of weapons of mass destruction.
>
> — WMD Report, Chairman's Preface

While focussing on arms control and disarmament, the Blix report realistically places this issue in a broader perspective, demonstrating that progress in disarmament, including the eventual outlawing of nuclear weapons, requires the emergence of a world order where countries will no longer feel dependent on weapons of terror for their security.

A Swedish diplomat and writer, Manne Wängborg, currently Consul General of Sweden in Kaliningrad, Russia, was Deputy Secretary-General of the Weapons of Mass Destruction Commission.
E-mail: manne.wangborg@foreign.ministry.se

Challenges for Effective WMD Verification

by Berhanykun Andemicael

Keeping Nuclear & Chemical Arms in Check

Effective verification is crucial to the fulfillment of the objectives of any disarmament treaty, not least as regards the proliferation of weapons of mass destruction (WMD).

The effectiveness of the verification package depends on a number of factors, some inherent in the agreed structure and others related to the type of responses demanded by emerging challenges.

The verification systems of three global agencies—the IAEA, the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO, currently the Preparatory Commission), and the Organization for the Prohibition of Chem-ical Weapons (OPCW)—share similarities in their broad objectives of confidence-building and deterrence by assuring members that rigorous verification would deter or otherwise detect non-compliance.

Yet they are up against various constraints and other issues, both internal and external to the treaty regime. These constraints pose major challenges to the effectiveness and reliability of the verification operations inspection experience.

The Nuclear Scene. In the nuclear field, the IAEA safeguards process was the first to evolve incrementally from modest Statute beginnings to a robust verification system under the global Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The nuclear non-proliferation regime is now being supplemented by a technology-intensive verification system of the nuclear test-ban treaty (CTBT), a product of over three decades of negotiation. However, there still remain fundamental gaps and loopholes in the regime as a whole, which tend to diminish the combined effectiveness of the IAEA and the CTBT verification capabilities. At least three major problems can be identified:

❶ The most intractable is the lack of universality of membership, essentially because of the absence of three nuclear-weapon-capable States—India, Pakistan and Israel—from both the NPT and the CTBT.

❷ The second problem concerns the changes in US disarmament policy, especially in the nuclear field.

❸ The third problem is the failure of the Conference on Disarmament to conclude a fissile material cut-off treaty. The world is already awash in fissile material and is increasingly threatened by the possible consequences of illicit trafficking in such material.

The Chemical Field. The chemical field poses fewer problems. The ban on chemical weapons is a virtually complete post-Cold War regime, with state-of-the-art concepts and procedures of verification resulting from decades of negotiation.

The concept of challenge inspection, as adapted from the bilateral INF (Intermediate-Range Nuclear Forces Treaty) model, is far-reaching but needs to be tested in an international setting.

Compared with verification problems in the incomplete and fragmented nuclear non-proliferation regime, the inspection challenges for the chemical ban regime seem to be less formidable. They have to do mainly with the subsequent erosion of inspection authority as State parties interpreted the provisions of the Convention in elaborating operational procedures. The absence of some States in tension areas, especially in the Korean Peninsula and the Middle East, from the OPCW diminishes the universality of the Organization. Operationally, there is also the damaging practice of some key States to secure precedent-setting exceptions for them while expecting other States to allow greater access to inspectors.

Special & Challenge Inspections. The detection of prohibited materials and activities is the common goal of the nuclear and chemical regimes for which the most intrusive and intensive procedures are activated by the three organizations.

In the nuclear arena, a special inspection in a State with a comprehensive agreement can be initiated by the Director General which, in theory, makes this process less cumbersome, than the so called "challenge inspections." In the context of the strengthened safeguards, the new procedures now have a better prospect of discovering undeclared activities, particularly at the upper end of the fuel cycle where weaponization of enriched uranium and plutonium is within reach.

In the CTBTO and the OPCW, requests for challenge inspections are within the domain of State Parties. They are expected to be relatively easy to initiate once a State manages the difficult task of assembling credible evidence to justify its request. There is insufficient experience to judge conclusively about the relative merits of the two types of special measures.

The IAEA has used some leverage from its capacity to mount special inspections; the probability of such action does enhance the authority of the Director General. The OPCW has yet to launch a real challenge inspection, despite some public allegations of non-compliance that have fallen short of a request for action. There is some concern that inaction may degrade the value of this measure as a usable tool and may deny the suspected State a chance to disprove the allegations. For the CTBTO this is not an issue at present, as the treaty is yet to enter into force.

Access, Accountability, Authority. Accounting for the strictly peaceful application of dual-use items constitutes the bulk of the work of the inspectorates at the IAEA and the OPCW. A common challenge in both fields is the advance of science and technology in the vast nuclear and chemical industries and the ingenuity of some determined proliferators to deceive by concealing illicit activities under legitimate ones. Inspection procedures and technologies need to keep up with the requirement for flexibility and adaptation to change.

However, there is no doubt about the necessity of greater transparency by inspected States, especially through physical access to entire sites. The recent case of Libya has set a positive model of transparency where adequate access was given to the inspectorates of both the IAEA and the OPCW. It has in addition shown that the shady network of illicit nuclear trafficking may well overlap with that of warfare agents. One of the lessons is that this type of problem may call for a coordinated approach by the IAEA and OPCW.

The effectiveness of verification in the three organizations depends heavily on the leadership of the respective Directors General, and the integrity and independence of the inspectorates. It also depends on the efficient management of the inspections, which involves a balancing act — to reconcile the high expectations from on-site inspections with the increasingly limited resources available for them.

Often, the inspectorates of the IAEA and the OPCW operate without the full benefit of all the assets provided for them in the agreed procedures, especially when an inspected State insists on its own interpretation of sovereignty rights and confidentiality needs. However, the inspectorates have been known to compensate for any drawbacks by combining different elements of verification to sketch an overall picture with minimal intrusiveness. For example, fuller access to documentation and to interviews with plant officials may narrow down the questions that may require clarification by extensive physical inspection and sample analysis.

Common Aims, Complex Issues. The common objective of the three organizations is to assemble and analyze all relevant information in order to conclude reliably whether a State is or is not complying with its treaty obligations.

This task is perhaps easier for the CTBTO that relies mostly on technologies monitoring, with chaallenge insepections as the last resort. For the IAEA and the OPCW, the management of verification is more complex, involving a combination of issues: (a) priority-setting for better allocation of inspection resources between high-risk and low-risk facilities; (b) planning for inspections with adequate coverage and intrusiveness; (c) optimizing the combination of human and technology assets for such inspections; (d) ensuring efficient and cost-effective management of operations; and (e) reporting findings with thoroughness, objectivity and impartiality.

The issue of priority-setting and resource allocation is a greater challenge for the OPCW than for the IAEA, which has a longer history of pragmatic adjustments in personnel and technological resources within the limitations of a virtually flat budget. The OPCW is yet to meet the challenge of dismantling chemical weapons and facilities within set deadlines without unduly diminishing the resources available for routine inspection of the chemical industry. Both agencies also face the challenge of balancing inspections—between the inspections in the vast area of declared facilities to build confidence about compliance and the inspections focusing on detection of possible undeclared facilities that might cause compliance concerns.

The positive lessons learned from the IAEA's verification experience today are valuable in advancing concepts and technologies that might also benefit the other areas of WMD verification. Together with the emerging, more comprehensive verification practice of the OPCW, they may provide a useful basis for developing common standards, which may in turn help in evaluating the cost-effectiveness of verification methods for the Biological and Toxin Weapons Convention and other components of a WMD control regime.

Berhanykun Andemicael is a former Representative of the Director General of the IAEA to the United Nations. His essay is based on the recent book he co-authored with John Mathiason, entitled Eliminating Weapons of Mass Destruction: Prospects for Effective International Verification *(London & New York: Palgrave Macmillan, 2004). The consent of both the co-author and the publisher to this adaptation of passages from the book is gratefully acknowledged. E-mail: andemicael@un.org*

CTBT

A Treaty's Testing Times

The world's Nuclear-Test-Ban Treaty just turned ten.
Ola Dahlman *looks at the record and the coming challenges.*

On 10 September 1996 the UN General Assembly adopted the Comprehensive Nuclear-Test-Ban Treaty (CTBT), prohibiting nuclear test explosions in all environments by all States. The Treaty is thus an essential element in the global nuclear non-proliferation regime.

Today, ten years later, 176 states have signed the treaty and 132 have ratified it. To enter into force, all the 44 States that possessed nuclear power or research reactors ten years ago must ratify the treaty and so far 34 have done so. As for the others—China, Colombia, Egypt, Iran, Indonesia, Israel and US—they have signed the treaty but not yet ratified it. India, North Korea and Pakistan have not signed.

It is disappointing that an important treaty that has been high on the international agenda ever since it was first introduced by the Indian Prime Minister Nehru in 1954, is still not in force. The fate of the treaty depends on political developments, especially in the key countries listed above. The treaty has, however, already established a global norm against nuclear testing, a norm that only India and Pakistan have broken.

Elaborate verification regime

The Preparatory Commission and its Provisional Technical Secretariat (PTS) were established in Vienna in 1996 to implement the treaty and to prepare for its entry into force. The Preparatory Commission has enjoyed a close cooperation among the States Signatories in implementing the treaty and its elaborate verification regime.

The key task for the PTS is to establish the verification arrangements specified in the treaty. The PTS has a staff of 300 people and a yearly budget of $100 million.

The treaty demands the most elaborate international verification regime ever created.

The assessment of compliance or non-compliance is a political process among the States. The verification regime provided by the treaty facilitates this process by giving all States a common base of information to use in their assessment. Individual treaty parties might have additional national technical means and additional capabilities of their own to analyze raw data.

The verification regime consists of two complementary parts; an International Monitoring System and an On-Site Inspection regime. In addition, there are provisions for consultations and clarification.

The International Monitoring System

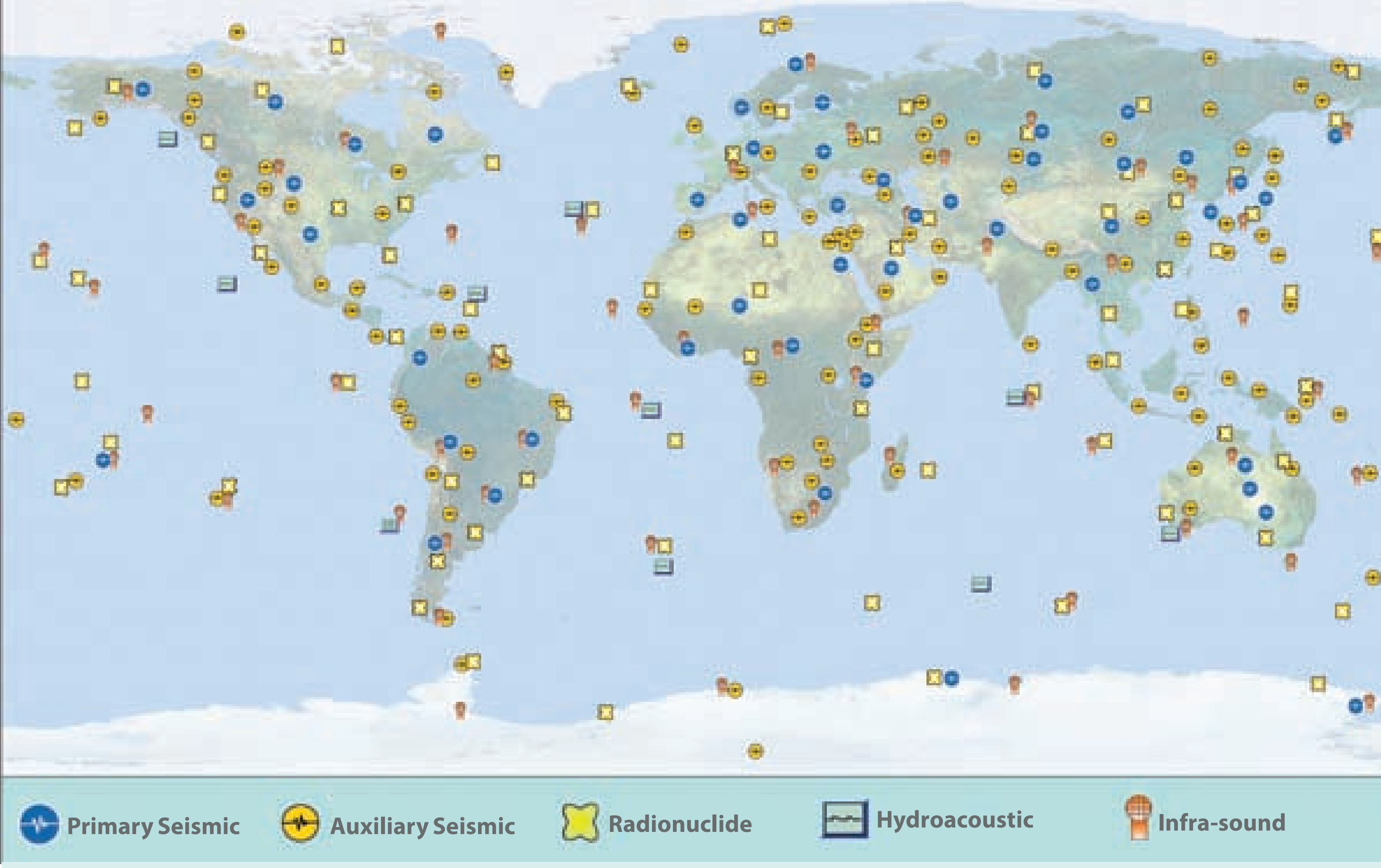
The International Monitoring System has a global reach with a total of 321 monitoring stations in 92 countries. It uses four different technologies to monitor all possible testing environments underground, in the oceans and in the atmosphere.

❶ The seismic network, consisting of 50 "primary" stations that report all data on line and 120 "auxiliary" stations from which data can be requested, is the main tool to monitor underground explosions.

❷ Only 11 hydro-acoustic stations are needed to monitor the oceans as signals in the water are transmitted with very little attenuation over global distances.

❸ A network of 60 infra-sound stations is designed to monitor explosions in the atmosphere. They detect acoustic signals with frequencies far below what the human ear can detect.

❹ The fourth component of the international monitoring system is the radionuclide network consisting of 80 stations to detect radioactive particles, 40 of which are also equipped to detect xenon, a radioactive noble gas. The pur-



More than 300 monitoring stations are set up in 92 countries under the nuclear-test-ban treaty.

pose of the radionuclide stations is to monitor the unique radioactive fallout that might emerge from a nuclear explosion in any environment. To analyze data from the radionuclide stations, 16 globally distributed laboratories constitute part of the system.

Data from the monitoring stations around the world are transmitted on-line to the international data center at the PTS in Vienna. Modern communications and computer technology make it possible to bring together and analyze the large amount of data created by monitoring stations.

At the data center, information from individual stations is analyzed together to detect and locate the source of the signal. This is a most complex process involving automatic signal processing and analysis by well-trained experts. States are provided with the results of this analysis as well as the raw data for their assessment.

On-site Inspection Regime

If, after consultations, a party is still concerned about another party's possible non-compliance, it may request an on-site inspection. The inspection request must be supported by at least 30 of the 51 members of the Executive Council to be set up after entry into force of the treaty. The requested inspection area can be as large as 1000 square kilometers. A number of intrusive tools can be used during an inspection ranging from over-flight observations, seismic and radioactive measurements to actual drilling.

Building the System

Building the monitoring system is a challenge in its own right, given its technical complexity and global reach. Building such a system in a political environment and in cooperation with 92 host countries with different legal systems, cultures and technical infrastructures makes the challenge even bigger.

The establishment of the system has proven more difficult and costly and taken more time than initially expected. Today two-thirds of the stations are completed and 170 stations are sending data to the PTS data center. According to the somewhat optimistic plans presented by the PTS, all but a few stations should be completed by the end of 2007.

The international data center has demonstrated that it is able to collect and handle large amounts of data. The focus so far has been on the analysis of seismic and radionuclide data. Routine reports of seismic events are being distributed to States.

All hands on deck as a crew installs a hydro-acoustic station in the ocean.

There is still a need to develop the analysis procedures to cover all technologies and to create an integrated bulletin. There is also a need to make the analysis procedures more efficient to cope with an increased data flow when all stations will be reporting data.

To specify the on-site inspection procedures in an operational manual has proven to be a difficult and politically sensitive task that is yet to be completed. It has been decided to carry out a large-scale trial inspection in 2008 to test methods and procedures using a special test manual. This test is expected to provide experience to finalize the preparation for the on-site inspection regime.

Under the treaty, the first conference of State parties must establish that an operational verification regime exists. This is a political decision based on an overall assessment of the verification facilities and procedures available at that time. Based on what has been achieved so far and on existing PTS plans, the international verification regime is, within a year or two, approaching the needed state of readiness for such a decision, should the treaty enter into force.

Coming Challenges

In the coming years, new challenges will be faced. The extensive verification regime is approaching completion while entry into force is not on the horizon: How will political interest be maintained? Will qualified persons in the activities of the PTS and at the many national monitoring facilities around the world be kept engaged?

Global capacity-building

To maintain and develop the CTBT as a global treaty is a question of capacity-building in States. We have so far successfully connected stations and instruments around the world. Now it is time to connect people and their institutions. Through international cooperation on a regional and global scale, we have to develop the knowledge base and the facilities needed for States around the world to participate fully in the implementation and monitoring of the treaty. Such cooperation will also enable States to benefit from the technologies involved in the verification system and the data produced for civil and scientific applications.

Knowledge recapitalization

The global verification system is now in an important test and evaluation phase. This is likely to continue for an extended period of time and there are good technical reasons to do so. The global infra-sound, hydro-acoustic and radionuclide networks are unique and a lot of experience is to be gained on how to analyze and interpret the observations.

Establishing cost-efficient procedures for the analysis of a growing flow of data is crucial to the PTS and also at the top of the agenda of scientific institutions around the globe. A closer cooperation between the PTS and scientific institutions would thus be of great mutual benefit. Such knowledge recapitalization is essential to keep up the vitality of the organization and to make it attractive to new generations of experts.

Data for disaster mitigation

The International Monitoring System, designed and established for the sole purpose of verifying the treaty, provides, in many cases, unique observations that are also useful for disaster mitigation globally.

On an experimental basis, data is being provided to tsunami warning centers. Infra-sound data might prove useful in detecting volcanic eruption in remote areas to warn against ash-plumes, which pose a danger to air traffic. Infra-sound might also detect monster waves that could pose a threat to ocean-bound ships. The filters used to collect radionuclide particles also catch a lot of non-radioactive particles that might prove valuable in addressing global pollution issues.

States must find procedures for making data available for such humanitarian purposes. The radionuclide observations could provide information of great value for the non-proliferation regime as a whole. They are, however, the politically most sensitive ones to apply for non-CTBT purposes. (See "Sensing the Danger: Can Tsunami Early Warning Systems Benefit from Test Ban Monitoring," in the *IAEA Bulletin*, vol. 47-1, 2005.)

Looking Ahead

The CTBT has proven that it is possible to design, establish and provisionally operate a complex global monitoring system involving the cooperation of a large number of States. It has also been possible to agree on and implement the methods and procedures to be used for international analysis of collected data.

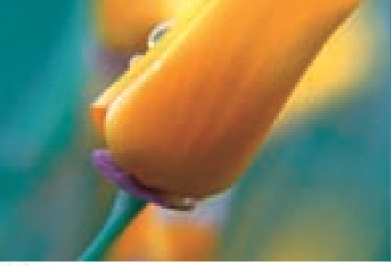
Infra-sound monitoring stations are established in a wide variety of environments — arctic, deserts and tropics.

Pictured here is a monitoring station in Diego Garcia, an atoll located in the heart of the Indian Ocean.

The design and testing of such a complex system takes a long time and can start well ahead of the political treaty negotiations. This was demonstrated by the Group of Scientific Experts at the Conference on Disarmament that paved the way for the CTBT.

Proposals have been made to establish a similar group of experts to address the verification of a cut-off treaty banning the production of weapon-grade nuclear material. Successful work on extensive and intrusive verification is in itself a confidence-building measure.

Ola Dahlman is Adviser to the Swedish Ministry of Foreign Affairs. His professional experience includes serving as member of the Swedish delegation in the Test-Ban Negotiation at the Conference of Disarmament and its predecessors; Chairman of the Group of Scientific Experts at the Conference on Disarmament; and Chairman of Working Group "B" on verification within the Preparatory Commission of the CTBTO.
E-mail: ola.dahlman@scienceapplication.com




Nuclear Re-Think

Patrick Moore, avid environmentalist and co-founder of Greenpeace, makes the case for nuclear energy

In the early 1970s when I helped found Greenpeace, I believed that nuclear energy was synonymous with nuclear holocaust, as did most of my compatriots. That conviction inspired Greenpeace's first voyage up the spectacular rocky northwest coast to protest the testing of US hydrogen bombs in Alaska's Aleutian Islands.

Thirty years on, my views have changed, and the rest of the environmental movement needs to update its views, too, because nuclear energy is the only non-greenhouse-gas-emitting power source that can effectively replace fossil fuels while satisfying the world's increasing demand for energy.

Let's examine the largest global greenhouse gas emitter: coal. Although it provides cheap electricity, worldwide coal burning creates approximately nine billion tons of CO_2 each year, mostly from power generation. Coal-fired plants cause acid rain, smog, respiratory illness, mercury contamination, and are major contributors to greenhouse gas emissions.

On the other hand, 441 nuclear plants operating globally avoid the release of nearly 3 billion tonnes of CO_2 emissions annually—the equivalent of the exhaust from more than 428 million cars.

To reduce substantially our dependence on coal, we must work together to develop a global nuclear energy infrastructure. Nuclear energy is clean, cost-effective, reliable and safe.

In 1979 Jane Fonda and Jack Lemmon both won Oscars for their starring roles in "The China Syndrome." In the film, a nuclear reactor meltdown threatened the survival of an entire city.

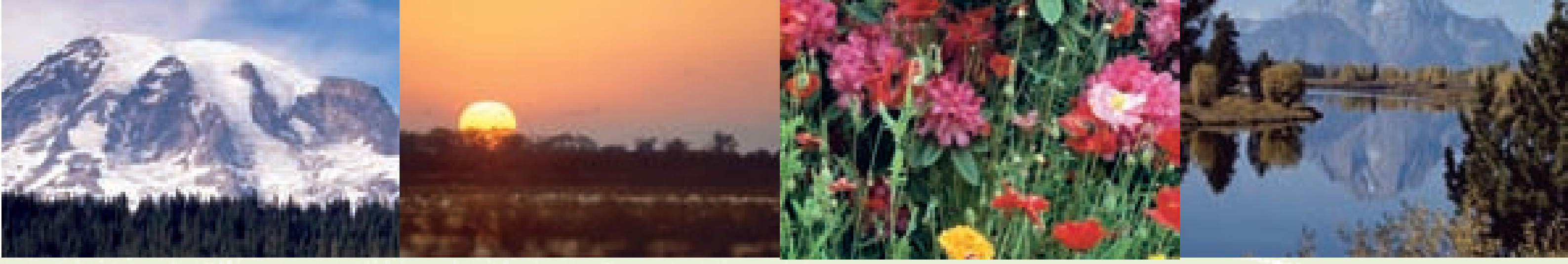
Twelve days after the blockbuster film opened, a reactor core meltdown at Three Mile Island sent shivers of fear through the country.

At the time no one noticed Three Mile Island was a success story. The concrete containment structure did as it was designed to do: it prevented radiation from escaping into the environment. While the reactor was crippled, there was no injury or death among the public or nuclear workers.

This was the only serious accident in the history of nuclear energy generation in the United States. There hasn't been a nuclear plant built since.

In the USA today, there are 103 nuclear reactors quietly delivering 20% of America's electricity. About 80% of the people living within 10 miles of these plants approve of them. That high approval rating doesn't include the plant workers who have a direct personal interest in supporting their safe, well-paying jobs. Although I don't live near a nuclear plant, I am now squarely in their camp.

I am not alone among seasoned environmental activists and thinkers in changing my mind on the subject. James Lovelock, father of the Gaia theory and leading atmospheric scientist, believes nuclear energy is the only way to avoid catastrophic climate change. Stewart Brand, founder



of the Whole Earth Catalogue and holistic ecology thinker, says the environmental movement must embrace nuclear energy to reduce its dependence on fossil fuels. The late Bishop Hugh Montefiore, founder and director of Friends of the Earth UK, was forced to resign when he penned a pro-nuclear article in a church newsletter. Such opinions have been met with inquisition-like excommunication from the anti-nuclear priesthood.

There are signs that attitudes are changing, however, even among the staunchest anti-nuclear campaigners. I attended the Kyoto climate meeting in Montreal in December 2005 where I spoke to a packed house on the question of a sustainable energy future. I argued that the only way to reduce fossil fuel emissions from electrical production was through an aggressive program of key renewables (hydroelectric, geothermal heat pumps and wind) plus nuclear. The Greenpeace spokesperson was first at the mike for the question period and I expected a tongue-lashing. Instead he began by saying he agreed with much of what I said, not the nuclear bit, of course, but there was a clear feeling that common ground was possible.

Wind and solar have their place, but because they are intermittent and unpredictable they simply can't replace big baseload plants like coal, nuclear and hydroelectric. Natural gas, a fossil fuel, is too expensive already and its price is too volatile to risk building big baseload plants. Given that hydroelectric resources are largely built to capacity, nuclear is by elimination the only viable large-scale, coast-effective and safe substitute for coal. It's that simple.

That's not to say there aren't real challenges—as well as various myths—associated with nuclear energy. Each concern deserves careful consideration:

Myth 1: Nuclear energy is expensive

Fact: Nuclear energy is one of the least expensive energy sources. In 2004, the average cost of producing nuclear energy in the United States was less than two cents per kilowatt-hour, comparable with coal and hydroelectric. Advances in technology will bring the cost down even further in the future.

Myth 2: Nuclear plants are not safe

Fact: While Three Mile Island was a success story, the 1986 accident at Chernobyl was not. But Chernobyl was an accident waiting to happen. This early model of Soviet reactor had no containment vessel, was an inherently bad design and its operators literally blew it up.

The multi-agency UN Chernobyl Forum reported last year that only 56 deaths could be directly attributed to the accident, most from radiation or burns suffered while fighting the fire. Tragic as those deaths were, they pale in comparison to the more than 5,000 deaths in coal mine accidents worldwide every year. Or the 1.2 million people who die in automobile accidents annually. No one has died of a radiation-related accident in the history of the US civilian nuclear reactor program. (Sadly, hundreds of uranium mine workers did die from radiation exposure underground in the early years of that industry. This was long ago corrected).

Myth 3: Nuclear waste will be dangerous for thousands of years

Fact: Within 40 years, used fuel has less than one-thousandth of the radioactivity it had when it was removed from the reactor. And it is incorrect to call it waste, because 95% of the potential energy is still contained in the used fuel after the first cycle.

Now that the United States has removed the ban on recycling used fuel, it will be possible to use that energy and to greatly reduce the amount of waste that needs treatment and disposal. Last month, Japan joined France, Britain and Russia in the nuclear-fuel-recycling business.

Myth 4: Nuclear reactors are vulnerable to terrorist attack

Fact: The five-feet-thick reinforced concrete containment vessel protects the contents from the outside as well as the inside. And even if a jumbo jet did crash into a reactor and breach the containment, the reactor would not

My views have changed because nuclear energy is the only non-greenhouse-gas-emitting power source that can effectively replace fossil fuels while satisfying the world's increasing demand for energy. — Patrick Moore

explode. There are many types of facilities that are far more vulnerable, including liquid natural gas plants, chemical plants and numerous political targets.

Myth 5: Nuclear fuel can be diverted to make nuclear weapons

Fact: Nuclear weapons are no longer inextricably linked to nuclear power plants. Centrifuge technology now allows nations to enrich uranium without first constructing a nuclear reactor. Iran, for example, lacks a reactor for generating electricity, yet may already have the ability to make a nuclear bomb. The Iran nuclear weapons threat is completely distinct from peaceful nuclear energy generation.

Over the past 20 years, one of the simplest tools—the machete—has been used to kill more than a million people in Africa, far more than were killed in the Hiroshima and Nagasaki nuclear bombings combined. Yet no one suggests banning machetes, as they are valuable tools for farmers in developing countries.

The only practical approach to the issue of nuclear weapons proliferation is to put it higher on the international agenda and to use diplomacy and, where necessary, force to prevent countries or terrorists from using nuclear materials for destructive ends.

New technologies, such as the reprocessing system recently introduced in Japan (in which the plutonium is never separated from the uranium) can make it much more difficult to manufacture weapons using civilian materials.

Cleaner and greener

In addition to reductions in greenhouse gas emissions and the shift away from our reliance on fossil fuels, nuclear energy offers two environmentally-friendly benefits.

First, nuclear power offers an important and practical path to the 'hydrogen economy'. Hydrogen, as a generating source of electricity, offers the promise of a clean, green energy. Automobile manufacturers continue to improve hydrogen fuel cells and the technology may, in the not-too-distant future, become a major source of energy production. By using excess heat from nuclear reactors to create hydrogen, an affordable, efficient, emission-free way of hydrogen production could be developed to power this future green energy economy.

Second, around the world, nuclear energy could be used as a solution to another growing crisis: the increasing shortage of fresh water available for human consumption and crop irrigation. Globally, desalinization processes are being used as a means of creating fresh water. By using excess heat from nuclear reactors, water could be desalinized and the ever increasing demand for fresh water could be met.

A combination of nuclear energy, wind, geothermal and hydro is a safe and environmentally-friendly means of meeting the world's increasing energy needs. By sharing information, a growing network of consumers, environmentalists, academics, labor organizations, business groups, community leaders and governments now realize the benefits of nuclear energy.

Nuclear energy is the best way to produce safe, clean, reliable baseload electricity, and will play a key role in achieving global energy security. With climate change at the top of the international agenda, we must all do our part to encourage a nuclear energy renaissance.

Patrick Moore is an ecologist and environmentalist. He began his career as an activist and founder of Greenpeace, where he worked in the top committee for 15 years. In 1991, Dr. Moore founded parent Greenspirit Enterprises and is Chair and Chief Scientist of Greenspirit Strategies Ltd based in Vancouver and Winter Harbour, Canada (www.greenspiritstrategies.com).
E-mail: pmoore@greenspirit.com

A Prince's Tribute...and Trial

Monaco's Prince Albert II followed the footsteps of his great great grandfather when he ventured to the Arctic Archipelago to track climate change, this time with IAEA Marine scientists.

Known as the Father of Oceanography, Monaco's Prince Albert I first explored Svalbard Island, in the Arctic Archipelago, in the early part of the last century. His team of scientists studied glaciers, mapped previously unknown areas of Svalbard and carried out other scientific research. Their findings are still regarded as a valuable contribution to oceanography by today's scientists.

One hundred years later, as a tribute to his great great grandfather's noble and courageous undertaking, Prince Albert II charted a similar journey — one that would take him from the Russian Base of Borneo to the North Pole, approximately 100 kilometres away — and hopefully add to the scientific body of work started by his ancestor. Just as important, Prince Albert undertook this trip to draw global attention to the environmental damage to the Arctic regions caused by global warming.

Speaking at a news conference in Monaco before the trip in April 2006, the Prince explained his hopes: "If, in our modest way, by this action we are able to bring environmental problems to the forefront and force some leaders to take stronger actions, this expedition will have achieved its objectives."

Secrets from the Watery Depths

Prince Albert was accompanied on his expedition by marine scientists and other experts in his week-long journey aboard the vessel, *Origo,* before starting his journey via sled-dogs to the North Pole. To collaborate on the scientific chapter of his expedition, Prince Albert invited two experts—Dr. Samantha Smith, Director of the World Wildlife Fund polar programmes and Mr. Roberto Cassi, an IAEA scientist working at the Agency's Marine Environment Laboratory in Monaco. Both advised the Prince and other team members about the Arctic's natural values and the environmental challenges now facing the region, in particular climate change.

Although far away from industrialized areas, Svalbard Island is eminently suitable to observe the evolution of climate change and long-range pollutants transported from

northern European countries by water currents and from North America by winds. Using nuclear techniques, it is hoped that some of the causes of climate change can be unlocked. Mr. Cassi focused his work on two projects: mollusc shells as biological artefacts and biomonitoring of pollutants in zooplankton.

The first of these studies was undertaken to evaluate the shell laminations of a very long-lived marine bivalve mollusc, the Ocean Quahog. The mollusc, with a life expectancy well over a century, acts as a recording of temperature variations and water chemistry. Day after day, it absorbs and retains heavy metals and temperature marks in the nacreous layers of its shell. The shells serve as an "archive" of long-range contaminants and changes in the sea surface, in a similar way to tree rings which bear witness to environmental change.

An analysis of the collected shells may enable scientists to construct, with very detailed precision, the history of pollution brought by the winds and currents, as well as the evolution of sea temperature. The same species of mollusc was collected in Norwegian waters by Prince Albert I in the early 1900s and housed in the Oceanographic Museum in Monaco. A comparison of the two sets of specimens potentially could be a key to unlocking a century of climate change.

The second project aimed at determining levels of contaminates in marine zooplankton in remote arctic environments for comparison with other climatic regions.

Problems and Predictions

Prince Albert is a keen environmentalist and sportsman but his trip to the Arctic was no 'day at the beach'. The Prince and his crew faced frigid and hostile conditions on their nine-day-trip in April this year. Alaskan Husky dogs manoeuvred the expedition team around ice cracks and pack-ice (blocks of ice) which hampered their progress. Two members of the team were thrown from their sleds into the sub-zero Arctic waters when the dogs pulled the sled into large block ice while crossing the open water. All survived the ordeal but more days of harsh conditions loomed for the team when weather conditions worsened, giving way to poor visibility, violent winds and rough icy terrain.

After days of unceasing efforts, Prince Albert and the members of the expedition team reached the North Pole. However, the real work of the trip is just beginning as scientists continue to probe the Arctic clues to answer lingering questions and predict where the environment is heading.

—Linda Lodding, IAEA Staff Report

Photos: Top—The Ocean Quahog mollusc acts as a recording of temperature variations and water chemistry.

Middle—Roberto Cassi and Prince Albert dissect Arctic molluscs on board "Origo".

Bottom—IAEA scientist Roberto Cassi, who was on board the "Origo" to study the effects of global warming on mollusc shells and zooplankton, inspects the nets.

Photos: Palais Princier de Monaco and the IAEA Marine Environment Laboratory, Monaco.

MONACO & Marine Environmental Protection

by Prince Albert II of Monaco

We all know the importance of the protection of the marine environment for sustainable development and economy of coastal countries, like Monaco. Sadly, this environment has been under continuous threats from development, tourism, urbanisation and demographic pressure. The semi-enclosed Mediterranean sea is challenged by new pollutant cocktails, problems of fresh water management, over-fishing, and now increasingly climate change impacts.

Monaco has a long history in the investigation of the marine environment. Prince Albert I, was one of the pioneers in oceanographic exploration, organizer of European oceanographic research and founder of several international organizations including the Musée Océanographique.

We are very proud that the International Atomic Energy Agency established in 1961 its Marine Environment Laboratory in Monaco, the only marine laboratory in the United Nations system. More than 40 years ago the IAEA joined forces with the Grimaldi family and several interested governments to establish the Marine Environment Laboratory in Monaco. Their first purpose-built facilities, dedicated to marine research, launched a new era in the investigation of the marine environment using radioactive and stable isotopes as tracers for better understanding of processes in the oceans and seas, addressing their pollution and promoting wide international cooperation. We are pleased that the Government of the Principality of Monaco has been actively engaged in these developments and is continuously supporting activities of the Monaco Laboratory.

We are very proud that the IAEA established its Marine Environment Laboratory in Monaco, the only marine laboratory in the United Nations system.

Prince Albert launched a new foundation in June 2006 for protection of the environment.

The Centenary of Prince Albert I's Arctic Expeditions was recently celebrated by retracing part of this expedition in the vicinity of Svalbard Island before completing a trip to the North Pole by dog sled. This expedition to Svalbard also provided opportunities for scientific organisations based in Monaco, including the IAEA Marine Environment Laboratory, to undertake research in a relatively remote location and in the sensitive Arctic environment. I was pleased to support and work with scientists from the IAEA Marine Environment Laboratory on projects related to the evolution over time of climate change and the transport of long-range pollutants.

My continuous contribution in these research projects and expeditions convinced me that it is absolutely necessary and urgent to change mankind's mentality towards our planet. As for me, I will do my best through initiatives and projects initiated by the foundation I created to be part of one of the biggest challenges of the 21st century.

For more information about Prince Albert's foundation, contact the Palais Princier in Monaco. E-mail: presse@palais.mc

Early Warning

by Sándor Belák

Avian flu has spread to 51 countries—36 this year alone—many of which are densely populated and deprived.

Can nuclear technologies help detect such contagious diseases?

Highly contagious animal diseases are transboundary threats of growing concern.

Such diseases include foot-and-mouth disease, swine fever, rinderpest—and the highly pathogenic avian influenza or "bird flu" making so many headlines. The diseases—which experts call TADs, (transboundary animal diseases)—are regularly emerging and re-emerging all around the world. They cause billions of dollars in losses and threaten the health, lives and livelihoods of millions of poor farming families and their neighbours.

Within the last 18 months alone, the Office International des Epizooties (OIE, World Organisation for Animal Health) reported a high number of TAD outbreaks on several continents—foot-and-mouth disease in Africa, Asia and South America, classical swine fever in Africa, Asia and Europe and rinderpest in Africa and Asia. And, most recently, there has been intense media coverage of the highly pathogenic avian influenza (HSNI) that has caused severe outbreaks in Asia, Africa and Europe. Many birds, animals, and people became sick, and millions died.

The costs of TAD outbreaks should be viewed both in terms of the efforts to bring the disease under control and the consequent loss of livelihoods. As an example, with regard to the UK foot-and-mouth disease outbreak in 2001, the cost to the public sector was estimated at over 4.5 billion euro, and the cost to the private sector at over 7.5 billion euro. The ethical problem raised under the eradication strategy and the social consequences of the slaughter of large numbers of animals are just some of the hidden costs to consider when evaluating the effects of these threatening diseases.

Today more organizations and experts are banding together to prevent and combat TADs. They include veterinary health services, research institutes and international organizations, including the IAEA and the Food and Agriculture Organization, which run a joint division in Vienna, Austria. The joint FAO/IAEA programme is working on the rapid detection of emerging diseases, including bird flu, and using nuclear and radiation techniques in the process.

The problems are serious and challenging, but nuclear technologies may offer a solution.

For most developing countries, TAD detection is still vital. The bottleneck is their inability to rapidly detect the virus and to determine early enough whether it is H5N1 or another subtype, so that authorities can take appropriate control measures. Serious efforts are focused on the early detection of the agents. Timely recognition of such viral infections would prevent the spread of the diseases to large animal populations in huge geographic areas. Thus, the development of novel, powerful diagnostic nuclear and nuclear-related assays is a crucial issue today in veterinary research and animal health care.

Molecular virology offers a range of new methods, which are able to accelerate and improve the diagnosis of infectious diseases in animals and in man. The molecular detection assays, like the polymerase chain reaction (PCR) technologies, provide possibilities for a very rapid diagnosis. The detection of viruses can be completed within hours or hopefully even within minutes with a sensitivity level of less than one pathogenic organism.

Molecular approaches have contributed significantly to the rapid detection of well-established, as well as newly emerging, infectious agents such as Nipah and Hendra viruses or corona viruses in the SARS scenario and the detection and molecular characterisation of the highly pathogenic avian influenza H5N1 subtype that threatens the world today. The nucleic acid amplification assays, although they were at first expensive and cumbersome, have become relatively cheap and user-friendly tools in the diagnostic laboratories.

In Sweden, the first diagnostic PCR assays were established as early as 1987, just two years after the first description of the PCR principle. In the last two decades more than 50 PCR assays were developed and validated here, and are in routine use in the diagnostic laboratory.

When examining the genetic relatedness of various viruses, the purpose is not to achieve wide-range detection, but to obtain a high phylogenetic resolution or fingerprint of the particular virus or isolate. For this, the variable genomic regions of the viruses are targeted and these give a direction of virus evolution often indicating the origin of the original infection. Such phylogenetic PCR assays are used to group pestiviruses, including classical swine fever virus and bovine viral diarrhoea virus and to classify pathogenic isolates (H5N1 as a case in point).

The PCR assays of high phylogenetic resolution are useful tools for the rapid identification of various virus variants. The genetic identification is very exact and rapid (several days or hours). The spread of virus variants can be traced and cut rapidly, in order to prevent distribution of the virus to large geographic areas.

The rapid phylogenetic identification and tracing of the viruses is termed "molecular epizootiology." For example, such studies were conducted when genetic variants of classical swine fever virus were identified in several countries of Central Europe and when it was hypothesised that EU and US genotypes of the porcine respiratory and reproductive syndrome virus evolved from a common ancestor found in East Europe.

The real-time PCR assays provide novel rapid means of virus detection. The diagnostic work can further be automated by using robotics for nucleic acid extraction and pipetting. Compared to previous amplification assays, the real-time PCR has a further advantage: it allows running *quantitative PCR*, allowing an estimation of viral load (the amount of virus in the blood). The quantitative aspect is crucial when a virus commonly found in animals is possibly causing symptoms in relation to viral load, for example feline coronaviruses or porcine circovirus 2. The measurement of viral load is also important when estimating the effects of anti-viral treatments, especially in human virology.

To assure the reliability of the diagnostic PCR assays, it is important to incorporate internal controls. By including such an *intrinsic control* with its specific reporter fluorophore, we obtain information on the sample quality and on pipetting errors. Simultaneously, the system shows the amplification of the target nucleotide sequences and provides safety for the diagnosis.

Today, both national and international authorities require rigorous proof that the diagnostic assays are as reliable as possible. International agencies like the OIE, FAO/IAEA, national research institutions and commercial companies make great efforts to agree on international standardisation.

Considering these requirements, diagnostic laboratories have started the validation and standardisation of the routine diagnostic PCR assays. For example, the EN ISO/IEC 17025:2000 standard gives directives for an accredited laboratory and it specifies many important parameters. OIE also has published, in 2000, a standard for the validation of diagnostic assays in the veterinary field.

How fast can we identify and characterize a pathogenic virus like bird flu?

Using molecular approaches, the time is one or two days — much faster that conventional methods. In Sweden, a one-step, real-time PCR assay has been developed for the rapid and simultaneous detection of a broad spectrum of influenza viruses, including those associated with highly pathogenic avian influenza.

Rapid identification and detection can serve as an early warning tool, an important need particularly for developing countries. The simultaneous detection of different sub-types of avian influenza allows authorities to monitor the occurrence of influenza strains in wild birds, in farmed poultry, and in mammalian species. The method provides a very rapid and highly reliable molecular tool for diagnosing one of the world's worst transboundary animal diseases.

Sándor Belák works in the Joint Research and Development Division, Department of Virology, Swedish University of Agricultural Sciences (SLU) and the National Veterinary Institute (SVA), in Uppsala, Sweden.
E-mail:sandor.belak@sva.se.

Bird Flu Background

Technically, avian influenza or "bird flu" is known by numbers and letters—HPAI of the sub-type H5N1.

Today's avian flu outbreak started in Asia in 2004 and is caused by a virus of the H5 sub-type. Additionally the virus was characterized as of the N1 sub-type—an important finding which revealed that the flu could be deadly to humans.

HPAI is caused by the animal's infection with some strains of influenza-A virus. The strains are classified into sub-types on the basis of their two external proteins, named haemagglutinin (H) and neuraminidase (N).

How is the virus identified and detected? Usually, from the pathological sample, the virus is first isolated in the embryos of chicken eggs. This takes between four and seven days. The sub-type of the isolated virus must then be identified by a a battery of specific antibodies raised against the different H and N proteins.

Identification can only be made in specialized laboratories. To confirm a sub-type's pathogenicity, the isolated virus (isolate) has to be subsequently inoculated into chickens that are four to eight weeks old and susceptible to the virus. Strains are considered to be highly pathogenic if they cause more than 75% mortality in inoculated chickens within ten days.

A big problem is that existing detection procedures are time-consuming. Fortunately, faster methods are emerging, with the support of the IAEA, FAO and other institutes and organizations.

finding Peace from Hiroshima

by Matthew N. Skoufalos

One oncologist's fight to rectify the damage caused by radiation

In a small town just outside Osaka, Japan, Ritsuko Komaki was born, quite literally, into the atomic age. She was just an infant in 1945 when the first atomic bomb ever detonated on a human population devastated her family's ancestral home of Hiroshima. At that moment, Komaki became one of a generation of Japanese for whom life was forever altered by the fury of a sun brought to earth.

Half the relatives on her father's side of the family were slain in the blast itself. Despite having been pinned under a collapsed wall, her maternal grandmother survived the explosion, but later presented every side effect of total-body radiation exposure. So did Komaki's then-19-year-old aunt. When Komaki's father returned to the city to search for his in-laws, black rain carrying soot, ash and radioactive particles from the firestorm contaminated a vast area stretching northwest from the hypocenter of the explosion. The toxic downpour made him another victim of exposure.

Yet, when Komaki was only 4 years old, her family — parents, older brother and sister — relocated to Hiroshima, bound by a responsibility to care for survivors of the attack and to rebuild the devastated city. Food was in short supply, and the reconstruction took a long time in a nation that had been rationing supplies during wartime.

Public health concerns might have dictated that the re-settlers avoid the city for as many as 20 years to safely avoid contamination, yet Hiroshima residents returned after six months merely to defend the rights to their property. Land was so precious in Japan that squatters and opportunists frequently turned the confusion in the wake of the disaster to their advantage. With all the deeds, titles and documents of ownership destroyed in the attack, many of those leaving the city for treatment returned to find their land seized in their absence.

Such was the case with Komaki's grandmother, who found most of her family's property usurped by developers in her absence. "My childhood was very depressing, I have to say," Komaki recollects.

Just as England had done during the early days of World War II, most of the children of Hiroshima were scattered throughout the countryside to keep them away from urban centers that were the most likely military targets. "[The children] returned to find most of their parents dead," she says. "Most of my friends grew up in orphanages."

A Friend Remembered

Tragedy was nothing new to the families who lived within the cities of Hiroshima and Nagasaki, the other Japanese city that experienced an atom bomb attack a few days after Hiroshima. But nowhere was anguish more personified than in the death of Komaki's elementary school classmate, Sadako Sasaki. Sasaki was born just a short time before the Hiroshima bombing. Komaki remembers her as a cheerful, upbeat child upon whom family members recuperating from the effects of radiation sickness relied greatly. Even at a young age, both she and Sasaki were runners and often competed against one another.

"Sadako loved to run," Komaki says. "She was so active. The most memorable thing about her was her activity and sense of competition." When she was 10, Sasaki began to suffer from shortness of breath that sidelined her from the physical activity she so enjoyed. A physician's diagnosis found that she was anemic, but her condition soon deteriorated beyond that mere explanation. Sasaki was diagnosed with leukemia, and was later hospitalized with bone marrow suppression. She was only 11 years old when she died.

Sasaki's death puzzled Komaki. Her grandmother had been exposed to the same chemical radiation that Sasaki had, yet never contracted leukemia despite presenting with all the other side effects of exposure. "I'm a very curious person," Komaki says. "Why did my grandmother never have any leukemia, but Sadako did? She never had any cancer, but she had all the symptoms of exposure — hair loss, diarrhea and bone marrow problems. This was a very curious phenomenon for me because we knew so many different stories about the post-exposure effects."

"It was a very sad time," remembers Komaki. "Sadako really wanted to get better and run again, but she couldn't make it. It was striking to me that a person who was so alive, so beloved by family members and classmates should die so young."

"In Japan, they hate radiation," Komaki says. "This mood is changing somewhat, but for so many years, they did not want to hear about radiation therapy. Patients had an illogical fear of it that delayed offering it as treatment there."

Sasaki's memory was then immortalized, with a little help from her friends and ancient Japanese lore. When Sasaki fell ill, her friends offered hundreds of prayers for her recovery. One classmate reminded her of an old custom that centered on the crane, a Japanese symbol of happiness and longevity, and origami, the art of paper folding: If she could

Ritsuko Komaki was just an infant in 1945 when the atomic bomb devastated her family's ancestral home of Hiroshima. She grew up to become one of the chief physicians at a leading cancer care centre in the US.

craft 1,000 origami birds, Sasaki was told, the prayers for her recovery would be answered and she would get well.

In the hospital, the medication with which Sasaki was treated for her bone marrow suppression was wrapped in wax paper. Every time she took the medicine, she folded a crane from the wrapper. In fact, some of Sasaki's cranes are still displayed in Hiroshima at the Peace Memorial Park. On her own, she folded 644 origami cranes before succumbing to the leukemia; her classmates helped craft the remaining 356 cranes to achieve the 1,000 that was her final goal.

"When Sadako died, we decided to build a statue in memory of her and the other children who suffered because of this exposure to radiation," says Komaki. "We made a documentary about her story, *1,000 Cranes,* to raise money for the memorial, and we raised a lot of money. We wrote letters to the deans of the elementary, junior and high schools in the city. We stood on the street to collect donations. We just hoped that children in the future would not suffer these problems. That's the way I grew up."

"When Sadako died," Komaki recalls, "I knew I wanted to become a physician."

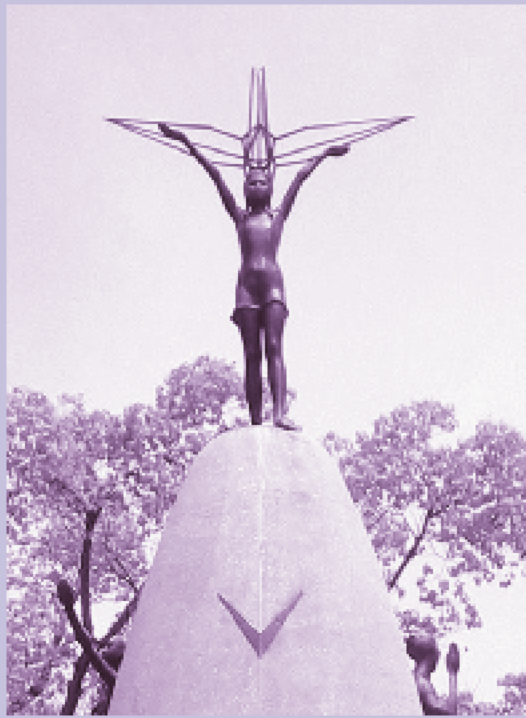
A Life-long Mission

During medical school, Komaki volunteered her summers at the Atomic Bomb Casualty Commission, the institute the United States built in Japan to examine the victims of atomic exposure. Anyone diagnosed as anemic underwent a bone marrow exam, and Komaki learned a great deal

Dr. Ritsuko Komaki was inspired to become a physician after her friend and classmate, 11-year-old Sadako Sasaki, died of leukemia caused by exposure to radiation from the atomic bomb dropped on Hiroshima. After Sadako's death, 12-year-old Komaki led her classmates on a fund-raising campaign that raised $100,000.

The money was used to build a statue in Hiroshima's Peace Memorial Park. The monument, which depicts Sadako holding aloft an origami crane in a gesture of peace, has become an international symbol of hope for a world without war.

The Japanese statue has since inspired several memorials in the United States, and Sadako's story has been told in books, plays and films.



about chromosomal abnormalities by performing blood tests alongside visiting researchers from Yale University and other American hospitals. But when a nationwide strike by medical students closed the more than 40 hospitals attached to the Japanese university system for almost three years beginning in 1969, Komaki decided to travel to the United States for her post-graduate education and enrolled at the University of Wisconsin in Madison to study radiation oncology.

"I started to do some general internal medicine," says Komaki. "I had wanted to be a hematologist, but I was still very curious about the effects of radiation. I had seen patients cured by radiation treatment, and I started to see the difference between focused, localized radiation treatment and the lethal dosages to which my grandmother had been exposed." The bombings of Hiroshima and Nagasaki had fostered a national paranoia about radiation and radioactivity that Komaki says reverberated in the national consciousness of Japan for decades.

"In Japan, they hate radiation," Komaki says. "This mood is changing somewhat, but for so many years, they did not want to hear about radiation therapy. Patients had an illogical fear of it that delayed offering it as treatment there." In Japan, the majority of cancer treatment culminated in surgery, Komaki says, which was befitting of the culture. Japanese surgeons were renowned for their skill and attention to detail, and the Japanese people, who did not have much coronary heart disease, could generally tolerate the physical stress of surgery.

Radiation oncology was not a recognized specialization; oncologists were grouped in with diagnostic radiation techs. Neither did the nation have any medical physicists, which delayed the adoption of most standard radiation treatments in the country. Japan's Ministry of Technology commanded a vast budget that awarded physics grants and purchased high-tech devices, but did not improve the quality or pace of oncology studies — or dispel any of the longstanding fears about the therapeutic use of radiation. Since technology was given the highest priority among national spending, physicists came to research advanced proton and carbon treatments, passing on the more elementary radiation therapies upon which radiation oncology is founded (and in which Komaki was trained).

Yet today, Ritsuko Komaki, MD, is the chief operating officer of one of the most sophisticated radiation oncology treatment facilities in the United States: the $120 million M. D. Anderson Cancer Center in Houston. And ironically, the technical equipment that forms the cornerstone of M. D. Anderson was built in Hitachi City, Japan.

The system is composed of three rotating gantries, a fourth that produces a fixed beam and a fifth specifically devoted to experimentation. They are used to accelerate protons to a very low-radiation dosage that penetrates the skin at an adjusted depth — only 10 to 20 % of the radiation enters the tumor at first. The proton effect is very similar to that of an X-ray: almost no radiation spreads through the body beyond the localized penetration of the tumor. The greatest efficacy of proton therapy lies in its ability to confine the treatment field to cancerous cells without disturbing normal cells, which is especially important when treating cancer in developing children.

"This procedure is most effective with cancers in the middle of the body," says Komaki, "[such as] prostate cancer, brain tumors, lung cancer, some pediatric tumors, head and neck tumors — localized cancers. If we put a lateral beam in the prostate area, for example, it spares any damage to the rectum or bladder. Even [intensity-modulated radiation therapy] scatters radiation around that can damage bone, blood and the surrounding area, but the proton treatment spares normal tissue."

Usually the treatment takes six to seven weeks of 10- or 15-minute sessions before the beam can safely be brought up to full strength, and although the procedure is approved by the US Food and Drug Administration, it is costly: as much as $150,000 to $200,000 depending upon the complexity of the treatment. However, Komaki points out that the cost of a radical prostatectomy is nearly identical to this figure and far more invasive.

Finding Peace

Giant origami cranes soar, frozen in flight, above the entranceway to the patient waiting room at M. D. Anderson. They are steel mobile replicas of a bird Komaki herself folded; a remnant of her memory of Sadako Sasaki and a looming reminder of the hope with which she entered her chosen profession. They echo the "peace" inscription that adorns the memorial statue of Sadako in the Hiroshima Peace Park, and Komaki believes they help to comfort and protect the children entrusted to her care.

In addition to educating others about her cause and overseeing treatment at the center, Komaki is also involved in a few prospective proton therapy trials that must be overseen to their maturity. Even at 61, it seems the work she has been called to do is even now barely escalating.

Yet, of the numerous roles she has been called upon to assume since her initial experience with radiation — student, advocate, researcher, philanthropist and mourner — what matters most to Komaki is her life as a clinician. Her passion to provide the highest standard of care for her patients drives her to progress and improve the treatment options in a field to which she has already given so much, both personally and professionally.

"I cannot cure every patient I see," Komaki says, "and every time I fail, I really feel like I should have done something better. I have learned so much from my patients, and I care about [them]. I would like to be remembered as a good physician, as a good doctor to my patients."

But what drives Komaki and has always underscored the story of her life is her uncompromising curiosity at the strange gift of her birthright. Even as it spurs the research that steers the future direction of her career, the power of the atom traces a line through Komaki's life that extends back to Hiroshima, back to her childhood. It is why, among all the lectures she delivers worldwide, she still honors invitations to speak at the elementary schools of her coworkers' children.

But what drives Komaki and has always underscored the story of her life is her uncompromising curiosity at the strange gift of her birthright. Even as it spurs the research that steers the future direction of her career, the power of the atom traces a line through Komaki's life that extends back to Hiroshima, back to her childhood.

"My friends and coworkers have all those kids, and they are all reading Sadako's story," says Komaki. "So when they hear that I'm from Hiroshima, a lot of people feel it's strange that I became a radiation oncologist."

But Komaki knows this much: If 10-year-old Sadako Sasaki were diagnosed with juvenile leukemia in 2006, she would have a great chance at life.

"I'm just lucky," she says. "Whatever I'm doing is very rewarding. I feel like I'm doing something for Sadako, and, hopefully, my message will be heard."

Matthew N. Skoufalos is a US-based freelancer. Reprinted with the permission of RT Image/Valley Forge Publishing Group, www.RT-image.com

turning brain drain into BRAIN CIRCULATION

by Ashok Parthasarathi

Immigration policies can be a ticket for scientific talent to recirculate among countries.

In the 1960s and 1970s, the flow of scientists, engineers and medical personnel from developing to industrialised nations was thought to have almost entirely negative consequences for the source countries, affecting their university staffing and availability of industrial personnel.

Recently, however, there has been growing emphasis on reverse flows of knowledge and skills, and of money the migrants send home. What was once termed brain drain is now seen as brain circulation, but this has blurred important issues affecting most developing countries.

Evidence for Reverse Flows

First, although developed countries benefit from immigration of highly skilled personnel, evidence of reverse benefits flowing back to source nations is far from convincing. While for many developing countries, the money sent home by all migrants can be very large, there are good grounds for believing that the amounts sent by highly skilled migrants in particular are fairly modest.

Another supposed reverse flow is the 'diaspora effect', whereby emigrants' skills, networks and knowledge can generate important benefits in their home countries. But much of the evidence of this comes from the very specific circumstances of the substantial contributions expatriate Indians based in Silicon Valley in the United States made to the growth of India's IT sector.

Countries can also benefit when emigrants return home with accumulated skills and experience. But a large part of the evidence for this comes from the experiences of South Korea and Taiwan, China. There, returning emigrants were attracted to fill key roles in what were already advanced research and development environments. In other words, the pre-existence of considerable 'absorptive capacity' appears to be a necessary condition for significant reverse migration.

There are no systematic balance sheets on net flows of skilled scientific personnel, but trends indicate that most brain 'circulation' is highly asymmetric. Reverse flows seem to be far smaller than initial outward flows, and the latter can sometimes be massively destructive, as happened in Ghana with the wholesale emigration of many doctors and nurses.

Meanwhile, the argument that the possibility of emigration and expectations of higher incomes abroad will increase incentives for developing countries to invest in their human capital does not hold true.

An Economic Analysis

Efforts to design a 'pro development' response to this situation must not include restrictions on migration as they violate the fundamental values of human rights and individual freedom. In addition, from the perspective of the global allocation of resources, overall efficiency and welfare increase when human capital migrates from areas of low return to ones with high returns.

But development is not just about accommodating resource allocation. It is the taxpayers of poor countries who make the investments in human capital that give rise to the migration-derived benefits in rich countries. From a returns-to investment perspective, two crucial points arise: there are substantial flows of skilled scientific and technological capital from poor to rich countries; and so there are poor returns on the investment in human capital.

Much of the recent policy discussions have only nibbled at the basic issues with approaches such as voluntary codes and agreements by rich countries to limit recruitment from developing nations, or take steps to promote return migration.

However, almost entirely absent from these discussions has been an approach suggested by noted Indian economist Jagdish Bhagwati in the 1970s. This rested on the idea that the losses incurred by developing countries should be offset to some degree by the transfer of resources from the beneficiaries of migration.

Bhagwati proposed levying a low tax—say 5% of salary costs—on companies in rich countries that employ of highly skilled immigrants, and using the proceeds to create a global fund for developing human capital in poor countries. From the United States alone, this could yield as much as US$2.5 billion a year.

Such a fund could promote 'diaspora' contributions to development and measures to accelerate return migration. But it should also take a long-term view by aiming primarily at strengthening capabilities in developing countries to offset losses from asymmetric brain circulation. In the scientific sector, for instance, it could focus on innovative ways to strengthen capacity in engineering and related management skills, and on developing infrastructure, manufacturing, agriculture, mining and other industries.

Policies Promoting Recirculation of Talent

Among the key reasons that highly-skilled migrants are often reluctant to go home is that they fear losing the cultural, scientific or entrepreneurial environment necessary to maintain or enhance their skills base. Most foreign graduate students from developing countries fear that after their return they will be cut off from knowledge exchange because of administrative hassles and restrictions on visa applications.

It is essential, therefore, to accompany any reform of how such workers are recruited in rich countries, with a better 'offer' closer to their wishes in their home nations.

This could be solved if recipient nations issued 'permanent visas' to scientists and other skilled workers. In The Netherlands, for example, the director of the University of Maastricht has proposed awarding foreign graduates a permanent visa, allowing a voluntary 'recirculation'—at a time of their choice — that both their country of origin and country of training could support rather than block.

Patrick Weil, director of research at France's National Centre for Scientific Research, says that under a 1998 law foreign workers who retire after spending at least 15 years working in France have the right to a 'retirement card' which lets them to move freely between their country of origin and France, without fear of being refused a visa.

This policy concept could be extended to workers on shorter-term contracts, who could be granted multi-year permits. Similarly foreign graduates from Western universities could be granted a permanent visa that lets them move to and from their country of origin.

Such facilitation of 'return tickets' or 'recirculation' according to a regime adapted to each category of migrants will be one of the new tasks for immigration policy in the 21st century and could be a useful way to tackle the brain drain.

Ashok Parthasarathi is former science advisor to the late prime minister Indira Gandhi and permanent secretary to several scientific departments in the government of India.

Higher Education

INIS Reaches Up and Out

From brain drain to brain "retain", there is no "quick fix" on the horizon to try and attract the next generation of scientists, engineers and specialists in the fields of nuclear science and technology. But one initiative gaining ground is the efforts of the IAEA to bring nuclear information and science to students around the world.

The International Nuclear Information System (INIS) is the world's leading information system on the peaceful uses of nuclear science and technology and is operated by the IAEA in collaboration with its Member States and co-operating international organizations. Today 114 Member States and 22 international organizations are participating in INIS.

Outreach to Universities

The IAEA recognizes the importance of nuclear knowledge transfer and the need to attract students to nuclear fields if there is hope of reversing the projected shortfall of specialized expertise. Access to reliable information—especially to students in the developing world—is key to keeping pace. INIS provides students and researchers with access to reliable resources that demonstrate the importance and the advantages of nuclear science and technology .

The INIS Database is available on the Internet and free of charge to students at universities and academic institutes in Member States. To date, the response has been positive and 307 universities in 59 Member States have database access.

"For our nuclear scientists at the Romanian Institute for Nuclear Research (INR), the INIS Database is the first place any nuclear scientist looks for information," says Mrs. Daniela Diaconu, Administrator of the database at INR. "Information is knowledge and helps to confirm theories or results of technology developed by our researchers."

Inside INIS

INIS processes most of the world's scientific and technical literature that falls within its subject scope covering the peaceful uses of nuclear science and technology. The database currently contains over 2.6 million bibliographic references with English abstracts.

Central areas are nuclear reactors, reactor safety, nuclear fusion, applications of radiation and radioisotopes in medicine, agriculture, industry and pest control as well as related fields such as nuclear chemistry, nuclear physics and materials science. Legal and social aspects associated with nuclear energy are also covered. And, from 1992, the economic and environmental aspects of all non-nuclear energy sources are also included. INIS also maintains an extensive collection of documents of grey literature not available elsewhere.

If you are interested in this free access, or know of universities that need to access such nuclear information, please contact: Ms. Taghrid Atieh, INIS & Nuclear Knowledge Management Section. E-mail: T.Atieh@iaea.org. For more information about INIS please visit www.iaea.org/inis

the House that Abdus Built...

by Juan G. Roederer

The ICTP in Trieste

The Abdus Salam International Centre for Theoretical Physics stems the brain drain of physicists from developing nations at a time of new scientific challenges.

In the early 1960s, both the decision-makers and the public in the industrialized world, shared a faith in the usefulness and importance of fundamental science. There was unfaltering trust in the scientific community. Although the world was ideologically split into two camps, science was recognized as an integral part of human culture and development. Science, however, did not fare as well in most developing countries, some of which had just gained their independence. The number of scientists active in research in such countries was small. As scientists emigrated to more developed nations, the resulting brain drain delivered serious blows to the scientific communities of those researchers, leaving deep scars in the intellectual fabric of their countries.

Abdus Salam, a Nobel Prize-winning Pakistani physicist, recognized that improving science locally would not be enough to stem the flight of fledgling scientists from developing countries. International mechanisms would be needed to allow scientists—especially those returning home after training abroad—to stay connected with the world, to refresh their knowledge periodically, and to engage in international research collaborations. The time was right for the conception of an international centre for theoretical physics. And Trieste, Italy, was the right place, located in the West, but at the doorstep to the Eastern bloc.

Not Just Another Institute—A Home

Established in 1964 under the aegis of the IAEA, the Abdus Salam International Centre for Theoretical Physics (ICTP) was intended to be not just another international research institute. The intention was a model organization designed to promote training and research in the physical and mathematical sciences in developing countries; serve as a forum for scientists from all over the world; and operate as a first-class scientific institution.

All three goals reflect the desire of its founding director, Abdus Salam, to confront the issues of isolation and brain drain that have continually dimmed the prospects for scientific excellence across the developing world.

Today ICTP each year hosts some 6000 scientists in its facilities in Trieste, Italy, while maintaining strong and enduring links with scientific communities in more than 170 countries. Closer to home, it has forged cooperative relationship with many Italian scientific institutions. Through its efforts, the Centre has built a worldwide family of loyal alumni—tens of thousands of associates, lecturers, and students, many of whom are now internationally recognized scientists, university leaders, research-council presidents, and leading statesmen in their own countries.

Adhering to its original vision, ICTP is an institution of the highest academic standards that many young physicists from Third World countries consider their second home—a welcoming place where they are treated with dignity and respect. The Centre affords its visitors access to the critical tools of modern science, including a world-class library and state-of-the-art computer facilities. While ICTP focuses on promoting science in the Third World, many scientists from industrialized nations also benefit from its programmes. Indeed nearly 50% of its visitors come from developed countries, creating a truly global forum for science on the shores of the Adriatic in northeastern Italy.

Why Theoretical Physics?

People unfamiliar with the history and role of the ICTP may ask: “Isn’t theoretical physics the last thing a Third World country would want to consider on its road to development?” Consider the following:

Research in theoretical physics does not demand a costly infrastructure. It gives young scientists early exposure to the great mysteries of the universe, stimulating their scientific imagination and making them feel they are participants in the great quest for knowledge. The study of theoretical physics trains the mind in scientific thinking and strategies of problem solving that scientists can later apply to any part of science. Theoretical physics is the glue that binds physics subdisciplines together and links them to mathematics. It is a key component of basic science, which is being seriously challenged in many parts of the world these days by people who are demanding more societal-good or economy-driven research. In short, the study of theoretical physics is in accord with the admonition from the late Argentine Nobel laureate Bernardo Houssay: "Before you can apply science, you must first *have* science!"

Starting from its original programme in high-energy physics, ICTP extended its activities to condensed matter physics in 1967 and mathematics in 1971. In the 1980s, the Centre moved into subjects of more direct relevance to society, such as the study of the structure and dynamics of Earth. A decade later, ICTP established a group in the physics of weather and climate and a programme on mathematical modelling and simulation of complex realities. Most recently, under the leadership of its current director, K.R. Sreenivasan, ICTP has added to its research and training agenda and is now contemplating the creation of a broad-based programme that would apply its scientific research and training capabilities to issues of sustainable development.

The Centre has not only expanded into new areas; it has also strengthened its capabilities in its traditional sectors of high-energy physics, mathematics, and condensed matter physics as part of an abiding belief that all developing countries must have a strong foundation in the basic sciences if they hope to build a strong framework for sustainable growth.

ICTP is not a university. But it does have a permanent scientific staff of 30 that is responsible not only for conducting research but also for organizing ICTP's training programmes. Each year, ICTP holds about 60 training activities on topics ranging from string theory to seismological risk management to the preservation of cultural resources through the use of accelerators.

ICTP also organizes several long-term activities to assist graduate students from developing countries. The ICTP Diploma Course, established in 1991, provides graduate-level training to students with undergraduate degrees from universities in the world's least developed countries. Many of these students, upon completing the one-year Diploma Course at ICTP, either return to their home countries or enrol in master's and doctorate programmes at universities in Europe and the United States. More recently, ICTP has partnered with the University of Trieste to offer doctorate degrees in several different fields of science. The Centre also extends its reach through its support of affiliated institutions in developing countries and by serving as a source of active support and a sounding board for those seeking to build research centres in their countries along the lines of ICTP.

Keeping Pace

The world of science has changed profoundly since the establishment of ICTP more than four decades ago, not only in terms of the fields of study but also in terms of its reach and structure. When Abdus Salam first proposed the creation of a centre for theoretical physics, the age of computers had barely begun; the field of biotechnology would not emerge for another decade; and the words 'nano' and 'technology' bore no relationship to one another. Meanwhile, China was experiencing a cultural revolution not a scientific renaissance; India was bearing the first fruits of the green revolution; and Brazil was entering a dark period of military dictatorship.

Today, the Centre's scientific staff and visitors often pursue fields of inquiry that did not exist five (let alone 40) years ago, and they do so with startling effective new tools at their disposal—most notably high-powered computers and the Internet. Meanwhile, the vastly improved quality of education and training in a number of countries—most notably, Brazil, China and India—enable a growing number of our visitors to come to the Centre as instructors instead of students.

ICTP itself is seeking to extend its reach by holding an increasing number of its activities in partnership with scientific institutions in the developing world. And, it is seeking to apply the knowledge and principles of physics and mathematics to ever-larger circles of concerns, including ecology, seismology, sustainable development, weather and climate.

Yet, while ICTP's initiatives have changed to meet the changing circumstances of the world of science, the Centre's fundamental goals have not. As was the case 40 years ago, ICTP is determined to be not just another international research institution. Instead it continues to pride itself as a model organization designed to promote science in developing countries while doing science itself; to serve as a forum for the exchange of information among scientists worldwide; and to operate as a first-class research institution. It seeks to accomplish all of this without losing sight of its fundamental purpose: to help scientists from the developing world acquire the knowledge and skills they need to be productive researchers and teachers at home and not become another sad statistical entry in the chronic brain-drain problem.

Juan G. Roederer is Professor of Physics Emeritus at the University of Alaska, Fairbanks. Between 1997 and 2003 he was Senior Advisor to the director of the Abdus Salam International Centre for Theoretical Physics in Trieste. Parts of this article are drawn from the author's article, "The Constant Yet Ever-Changing Abdus Salam International Centre for Theoretical Physics," Physics Today, September 2001.

For additional information about the Abdus Salam International Centre for Theoretical Physics (ICTP), see www.ictp.trieste.it.

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1957 **Afghanistan,** Albania, Argentina, **Australia, Austria, Belarus, Brazil,** Bulgaria, **Canada,** Cuba, **Denmark**, Dominican Republic, Egypt, El Salvador, Ethiopia, **France,** Germany, Greece, **Guatemala,** Haiti, Holy See, Hungary, Iceland, **India,** Indonesia, **Israel,** Italy, **Japan,** Republic of Korea, Monaco, Morocco, Myanmar, Netherlands, New Zealand, **Norway, Pakistan,** Paraguay, Peru, Poland, **Portugal**, **Romania**, **Russian Federation**, Serbia, **South Africa**, Spain, Sri Lanka, **Sweden**, **Switzerland,** Thailand, Tunisia, **Turkey,** Ukraine, **United Kingdom**, **United States**, Venezuela, Vietnam

1958 Belgium, Ecuador, Finland, Islamic Republic of Iran, Luxembourg, Mexico, Philippines, Sudan

1959 Iraq

1960 Chile, Colombia, Ghana, Senegal

1961 Lebanon, Mali, Democratic Republic of the Congo

1962 Liberia, Saudi Arabia

1963 Algeria, Bolivia, Côte d'Ivoire, Libyan Arab Jamahiriya, Syrian Arab Republic, Uruguay

1964 Cameroon, Gabon, Kuwait, Nigeria

1965 Costa Rica, Cyprus, Jamaica, Kenya, Madagascar

1966 Jordan, Panama

1967 Sierra Leone, Singapore, Uganda

1968 Liechtenstein

1969 Malaysia, Niger, Zambia

1970 Ireland

1972 Bangladesh

1973 Mongolia

1974 Mauritius

1976 Qatar, United Arab Emirates, United Republic of Tanzania

1977 Nicaragua

1983 Namibia

1984 China

1986 Zimbabwe

1992 Estonia, Slovenia

1993 Armenia, Croatia, Czech Republic, Lithuania, Slovakia

1994 The Former Yugoslav Republic of Macedonia, Kazakhstan, Marshall Islands, Uzbekistan, Yemen

1995 Bosnia and Herzegovina

1996 Georgia

1997 Latvia, Malta, Republic of Moldova

1998 Burkina Faso, Benin

1999 Angola

2000 Tajikistan

2001 Azerbaijan, Central African Republic

2002 Eritrea, Botswana

2003 Honduras, Seychelles, Kyrgyz Republic

2004 Islamic Republic of Mauritania, *Togo*

2005 Chad

2006 Belize

Total Membership: 140 (as of March 2006)

Eighteen ratifications were required to bring the IAEA's Statute into force. By 29 July 1957, the States in bold — as well as the former Czechoslovakia — had ratified the Statute.

Year denotes year of membership. Names of States are not necessarily their historical designations. For States in italic, membership has been approved by the IAEA General Conference and will take effect once the necessary legal instruments are deposited.

Note:

♦ The Democratic People's Republic of Korea (DPRK), which joined the IAEA in 1974, withdrew its membership of the Agency 13 June 1994.

♦ Cambodia, which joined the IAEA in 1958, withdrew its membership of the Agency 26 March 2003.

♦ The former Federal Republic of Yugoslavia was changed to Serbia and Montenegro as of 4 February 2003. In June 2006, IAEA membership of Serbia and Montenegro was continued by the Republic of Serbia. This followed the Declaration of Independence adopted by the National Assembly of Montenegro on 3 June 2006. The Republic of Montenegro subsequently, on 14 June 2006, applied for membership of the IAEA, a process that is pending completion of procedures required to become an IAEA Member State.

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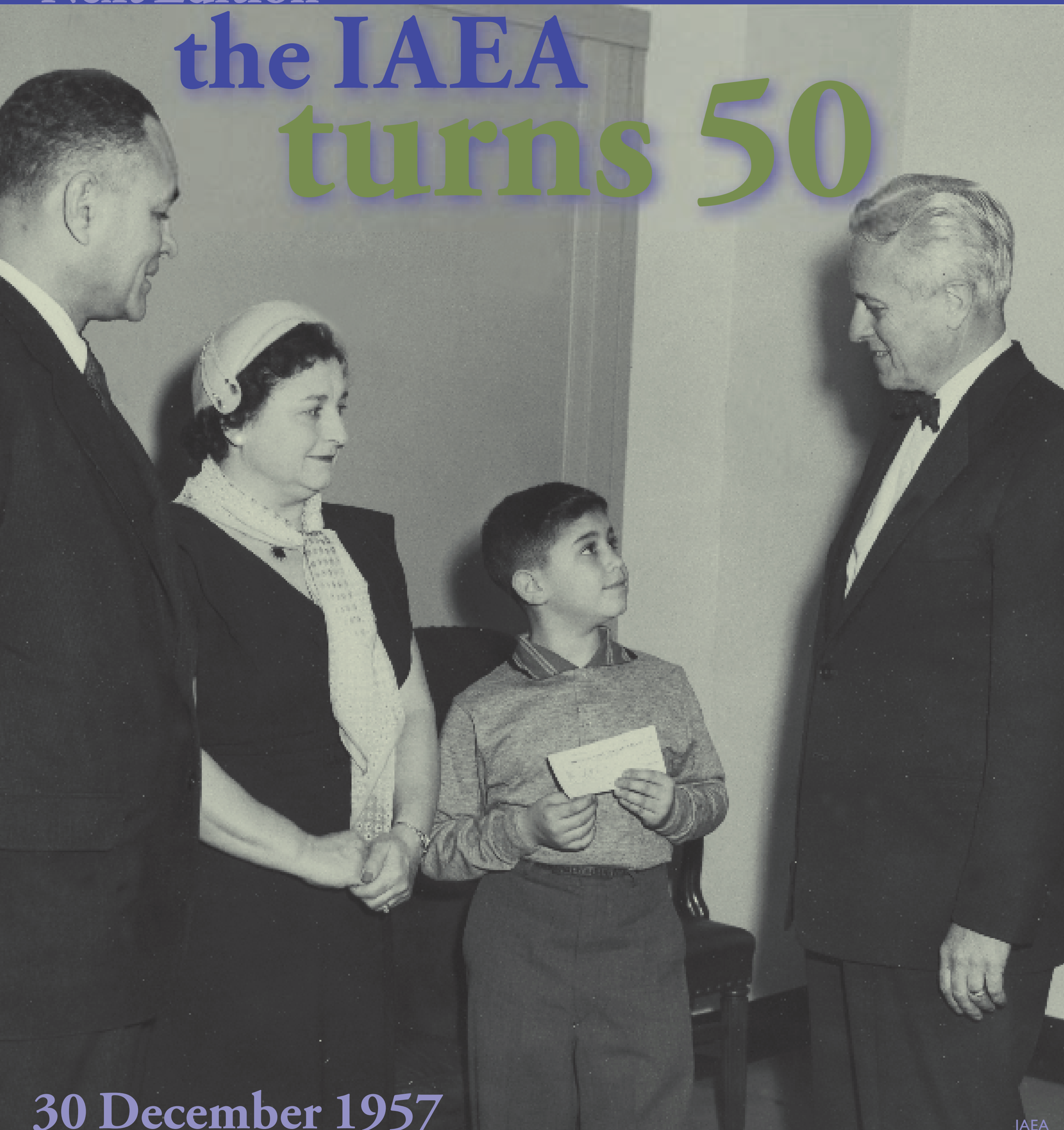

IAEA

30 December 1957

NEARLY A HALF CENTURY AGO, Schoolboy Joe Santore from New Rochelle, New York (USA) hands over the first voluntary contribution to the IAEA—money he collected from classmates—just six months after the Agency officially was born.

From left to right: Dr. Ralph Bunche, Under-Secretary of the United Nations, Mrs. Santore, Joe Santore and Mr. Sterling Cole, the first IAEA Director General.