Annual Report 2003

Article VI.J of the IAEA's Statute requires the Board of Governors to submit "an annual report to the General Conference concerning the affairs of the Agency and any projects approved by the Agency".

This report covers the period 1 January to 31 December 2003.

IAEA
International Atomic Energy Agency

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Member States of the International Atomic Energy Agency

(designation as of 31 December 2003)

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SOUTH AFRICA
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SWEDEN
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SYRIAN ARAB REPUBLIC
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TUNISIA
TURKEY
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UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
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UZBEKISTAN
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ZAMBIA
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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

The Board of Governors

The Board of Governors oversees the ongoing operations of the Agency. It comprises 35 Member States and generally meets five times a year, or more frequently if required for specific situations. Among its functions, the Board adopts the Agency's programme for the incoming biennium and makes recommendations on the Agency's budget to the General Conference.

In 2003, the Board considered the *Nuclear Technology Review 2003* and various activities related to nuclear science, technology and applications. In the area of safety and security, it considered the *Nuclear Safety Review for the Year 2002* and related activities. It also approved action plans for the safety and security of radioactive sources and for occupational radiation protection, as well as a revised Code of Conduct on the safety and security of radioactive sources. It also established as an Agency safety standard a Safety Requirements publication on *Site Evaluation for Nuclear Installations*. As regards verification, the Board considered the *Safeguards Implementation Report for 2002*. It approved a number of safeguards agreements and additional protocols. The Board reported to the Security Council and General Assembly of the United Nations on the non-compliance of the Democratic People's Republic of Korea with its safeguards agreement. The Board passed two resolutions with regard to the implementation of the NPT safeguards agreement in the Islamic Republic of Iran. As a result of the intensive consultations conducted within the framework of its Informal Open-ended Working Group on the Programme and Budget for 2004–2005, the Board approved a package proposal and it recommended to the General Conference a revised level of the Agency's regular budget, representing an increase above zero real growth. The Board also agreed to the introduction of a euro based financial system for the Agency.

Composition of the Board of Governors (2003–2004)

Chairman: H.E. Mr. Antonio NÚÑEZ GARCÍA-SAÚCO
Ambassador, Governor from Spain

Vice-Chairman: H.E. Mr. Javier Manuel PAULINICH VELARDE
Ambassador, Governor from Peru

Vice-Chairman: Ms Dana DRÁBOVÁ
President, State Office for Nuclear Safety
Governor from the Czech Republic

Argentina
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Belgium
Brazil
Canada
China
Cuba
Czech Republic
Denmark
Egypt
France
Germany
Hungary
India
Italy
Japan
Korea, Republic of
Malaysia
Mexico
Netherlands
New Zealand
Nigeria
Pakistan
Panama
Peru
Poland
Russian Federation
Saudi Arabia
South Africa
Spain
Sudan
Tunisia
United Kingdom of
Great Britain and Northern Ireland
United States of America
Vietnam

The General Conference

The General Conference comprises all Member States of the Agency and meets once a year. It considers the annual report of the Board of Governors on the Agency's activities during the previous year; approves the Agency's accounts and the budget; approves any applications for membership; and elects members to the Board of Governors. It also conducts a wide ranging general debate on the Agency's policies and programmes and passes resolutions directing the priorities of the Agency's work.

The IAEA at a Glance

(as of 31 December 2003)

137 Member States.

65 intergovernmental and non-governmental organizations worldwide having formal agreements with the Agency.

46 years of international service by 2003.

2247 professional and support staff.

$249 million total regular budget for 2003, supplemented by extrabudgetary contributions received in 2003 amounting to **$51 million.**

$74.75 million target in 2003 for voluntary contributions to the Agency's Technical Cooperation Fund, supporting projects involving **3121** expert and lecturer assignments, **2848** meeting and workshop participants, **2107** participants in training courses and **1411** fellows and visiting scientists.

2 liaison offices (in New York and Geneva) and **2** safeguards regional offices (in Tokyo and Toronto).

2 international laboratories and research centres.

120 approved Coordinated Research Projects involving **1598** active research contracts and agreements.

232 safeguards agreements in force in **148** States (and with Taiwan, China) involving **2363** safeguards inspections performed in 2003. Safeguards costs in 2003 amounted to **$89.1 million** in regular budget and **$15.1 million** in extrabudgetary resources.

18 national safeguards support programmes and **1** multinational support programme (European Union).

5.5 million monthly visits to the Agency's *WorldAtom* web site.

2.4 million records in the International Nuclear Information System (INIS), the Agency's largest database.

160 publications issued (in print and electronic formats) in 2003.

Notes

- The *Annual Report* reviews the results of the Agency's programme according to the three "pillars" of **technology, safety** and **verification**. The main part of the report, starting on page 9, generally follows the programme structure as it applied in 2003. The introductory chapter, "The Year in Review", seeks to provide a thematic analysis, based on the three pillars, of the Agency's activities within the overall context of notable developments during the year. Additional information on specific issues can be found in the latest editions of the Agency's *Nuclear Safety Review, Nuclear Technology Review* and *Technical Co-operation Report*.

- Additional information covering various aspects of the Agency's programme is provided on the attached CD-ROM. This material is also available on the Agency's *WorldAtom* web site (*http://www.iaea.org/Worldatom/Documents/Anrep/Anrep2003/*).

- All sums of money are expressed in United States dollars.

- The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

- The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the Agency.

- The term "non-nuclear-weapon State" is used as in the Final Document of the 1968 Conference of Non-Nuclear-Weapon States (United Nations document A/7277) and in the NPT.

Abbreviations

ABACC	Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials
ADB	Asian Development Bank
AFRA	African Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
ARCAL	Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
BWR	Boiling water reactor
CRP	Coordinated Research Project
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
ESTRO	European Society of Therapeutic Radiology and Oncology
Euratom	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
FORATOM	Forum Atomique Européen
HWR	Heavy water reactor
IAEA-MEL	IAEA Marine Environment Laboratory
ICAO	International Civil Aviation Organization
IEA	OECD International Energy Agency
ICTP	International Centre for Theoretical Physics
IPCC	Intergovernmental Panel on Climate Change
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organization
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
INIS	International Nuclear Information System
IOC	Intergovernmental Oceanographic Commission (UNESCO)
ISO	International Organization for Standardization
LWR	Light water reactor
NEA	OECD Nuclear Energy Agency
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
OECD	Organisation for Economic Co-operation and Development
OLADE	Organización Latinoamericana de Energía (Latin American Energy Organization)
OPANAL	Organismo para la Proscripción de las Armas Nucleares en América Latina y el Caribe
PAHO	Pan American Health Organization/WHO
PHWR	Pressurized heavy water reactor
PWR	Pressurized water reactor
RAF	Regional Africa
RAS	Regional East Asia and Pacific
RAW	Regional West Asia
RBMK	Light boiling water cooled graphite moderated pressure tube reactor (former USSR)

RCA	Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology
SQ	Significant quantity
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Fund for Population Activities
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNMOVIC	United Nations Monitoring, Verification and Inspection Commission
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UPU	Universal Postal Union
WANO	World Association of Nuclear Operators
WCO	World Customs Organization
WEC	World Energy Council
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization
WWER	Water cooled and moderated energy reactor (former USSR)

Contents

The Year in Review

In the past year a number of world events presented significant challenges for the International Atomic Energy Agency. In the area of nuclear non-proliferation, the Agency has been at the centre of attention and has demonstrated its ability to perform effective and credible inspections. It was also the year of the 50th anniversary of the "Atoms for Peace" speech delivered to the United Nations General Assembly by US President Dwight D. Eisenhower, in which he offered a vision that would enable humanity to make full use of the benefits of nuclear energy while minimizing its risk, a vision that led to the establishment of the Agency. It was a year of notable successes for the Agency in its efforts to ensure that the benefits of nuclear technology were shared globally for economic and social development.

This review highlights some of the major issues and challenges that faced the Agency — and the international community — during the year, while presenting a look forward at emerging trends.

Technology

Maintaining the continuity of nuclear knowledge and skills

Since the late 1980s, nuclear electricity generation has grown at about the same rate as overall global electricity generation, i.e. about 2.5% per year. However, this is well below its rapid expansion in the 1970s and early 1980s, and many universities — and governments — have now reduced or eliminated their support for the study of nuclear science and engineering. The need to manage the large number of existing nuclear facilities including licence extensions, and also introduce a new generation of plant designs has prompted a growing awareness among Member States of the necessity for succession planning in the nuclear industry, to ensure that a new generation of younger people with the proper education and skills can replace the ageing nuclear workforce.

Responding to this situation, the Agency has made the preservation of nuclear knowledge a high priority, cross-cutting activity involving all of its programme areas. For example, a pilot project was set up in 2003 to establish an inventory of fast reactor data and knowledge to support future work in this area. In terms of education, the focus has been on guidance in support of university level nuclear education. The Agency — together with the OECD/NEA, the World Association of Nuclear Operators and the World Nuclear Association — supported the founding of the World Nuclear University (WNU) in September 2003. With time, the WNU should become a coordinating body for studies to assess the nuclear training and education needs of participating countries. The formulation of standardized course content and curricula, and the development of Internet based and other distance learning modes are other areas of future work.

Nuclear energy: A status report

Nuclear power supplied 16% of global electricity generation in 2003. At the end of the year there were 439 nuclear power plants in operation around the world. Their global energy availability factor rose from 74.2% in 1991 to 83.7% in 2002. In 2003, two new plants were connected to the grid, in China and the Republic of Korea, and Canada restarted two units that had been shut down. Construction began on one new power plant, in India. Four units in the United Kingdom were retired, as was one each in Germany and Japan.

Knowledge Management, Education and Networking

The Agency continued to seek creative methods and techniques in education, training and process driven applications to ensure that the knowledge, skills and abilities from the current generation of experienced nuclear professionals are transferred effectively to the work force of the future.

Prominent examples included the setting up, within the framework of the Agency's technical and scientific programmes, of the Asian Network for Education in Nuclear Technology, the Asian Network for Nuclear Safety and the Ibero-American Radiation Safety Network. The first two are entering full operation in 2004 and the third was launched during the General Conference by Spain and will be closely associated with the activities of the Ibero-American Forum of Nuclear Regulators.

Asia continues to be the centre for expansion and growth prospects. Thus, 20 of the 31 reactors under construction are located in this region. In fact, 19 of the last 28 reactors to be connected to the grid are in the Far East and South Asia.

In Western Europe, capacity has remained relatively constant despite nuclear phase-outs in Belgium (which passed a phase-out law in January 2003), Germany and Sweden. The most advanced planning for new nuclear capacity was in Finland, where in 2003 the utility Teollisuuden Voima Oy selected Olkiluoto as the site for a fifth Finnish reactor, and signed a contract for a 1600 MW(e) European PWR.

During 2003, the Russian Federation continued its programme to extend licences at 11 nuclear power plants. Specifically, the Russian nuclear regulatory body, Gosatomnadzor, issued a five-year extension for the Kola-1 plant. Bulgarian regulators issued a new ten-year licence for Kozloduy-4, the first long term licence in Bulgaria, and later issued a similar eight-year extension for Kozloduy-3. Romania, where licence extensions are required every two years, approved an extension for the Cernavoda plant to 2005.

In the USA, the Nuclear Regulatory Commission (NRC) approved nine licence extensions of 20 years each (for a total licensed life of 60 years for each nuclear power plant), bringing the total number of approved licence extensions to 19. It also approved the uprating of eight units. Three companies applied for the NRC's new early site permits, which can be reserved for future use. In Canada, near term expansion has involved the restarting of some of the nuclear units that have been shut in recent years. The first two such restarts took place in 2003. Meanwhile, licences have been extended for four units to 2005, and for eight units until 2008.

Evolutionary and innovative approaches

The future viability of nuclear power is dependent not only on resolving issues of economics, safety and security, waste management and proliferation resistance, but also on the development of innovative technologies that can enhance the positive aspects of this energy source. International efforts on the development of evolutionary and innovative reactor and fuel cycle designs include work by 20 Member States on national and international projects in these areas. To encourage the sharing of information and exchange of experience, the Agency convened an international conference in June on innovative technologies for the nuclear fuel cycle and for nuclear power.

Complementing the many national initiatives are two major international efforts to promote innovation — the Generation IV International Forum (GIF) and the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). In 2002, GIF selected six concepts for international collaborative R&D and, in 2003, made progress on establishing the management and oversight structure for subsequent work and specific cooperative R&D agreements. In June 2003, INPRO published a report defining user requirements in five areas — economics, environmental impacts, safety, waste management and proliferation resistance — for incorporation into nuclear R&D projects. It also provided an assessment method for applying these requirements to specific innovative nuclear concepts and designs; this method is currently being tested by INPRO participants.

Spent fuel storage and waste management

The management and disposal of spent fuel and radioactive waste continue to be a critical issue, not only in terms of the public acceptance of nuclear technology but for any planned expansion of nuclear energy in the future. A number of new issues have also arisen in discussions on waste disposal. For example, at an Agency conference in Vienna in June on the storage of spent fuel from power reactors, a number of Member States expressed the wish to extend spent fuel storage times to 100 years and longer, as a result of delays in repository disposal programmes, lack of resources, uncertainties over whether to treat spent fuel as waste or a resource, lack of public acceptance of disposal, and lack of political will in moving forward on repository siting and construction. These States are also interested in ensuring the future retrievability of waste to ensure that there is a sufficient degree of flexibility in the options available to them.

Progress continued to be made in 2003 on the Yucca Mountain repository in the USA, the Olkiluoto repository in Finland and the site selection process for a final repository in Sweden, all for the disposal of spent fuel and high level waste. In January 2003, the European Commission adopted a set of legislative proposals that included proposed directives on European Union wide nuclear safety and radioactive waste rules, with priority given to geological waste disposal. However, in November the EU Council formally deferred further consideration of these proposals to 2004. In the Russian Federation, legislation was passed to facilitate Russia's cooperation with other countries regarding the storage of spent fuel.

A notable development during the year was the opening of the HABOG storage facility in the Netherlands with a planned 100-year operational life; the involvement of the local population, particularly in the design of the facility, played a large part in the successful inauguration of this facility. The commissioning of the French Morvilliers near surface disposal facility, for the disposal of very low activity radioactive waste primarily from decommissioning activities, was another major development.

Current research reactor concerns

For over 50 years, research reactors have made valuable contributions to the development of nuclear power, basic science, materials development, radioisotope production for medicine and industry, and education and training. Of the total of 671 research reactors built or planned, 272 are still operational in 56 countries, 214 are shut down, 168 have been decommissioned and 17 are planned or under construction. Many of those that are shut down, but not decommissioned, still have fuel — both fresh and spent — at the sites. The proper handling of this spent fuel and the management of radioactive waste continued to be areas of international concern, and Agency emphasis.

A notable international effort was the shipment of fresh high enriched uranium (HEU) research reactor fuel from Romania and Bulgaria to the Russian Federation under the aegis of the tripartite Russian Federation–USA–IAEA agreement. And at an Agency conference on research reactors, held in Santiago, Chile, in November, research reactor designers, users and regulators discussed ways to strengthen physical security, improve the sharing of expertise and enhance the Agency's research reactor safety assistance missions.

The future: Nuclear energy and sustainable development

Global socioeconomic development needs dictate that a large increase in the supply of energy will be required in coming decades. With regard to nuclear energy's role in supplying part of this energy requirement, the Agency in 2003 extended its medium term projections for nuclear energy up to the year 2030. The low projection was revised upward in 2003 and estimates a 20% increase in global nuclear generation until the end of 2020, followed by a decrease, resulting in global nuclear generation in 2030 that will be only 12% higher than in 2002. Nuclear power's share of global electricity generation is projected at 12% in 2030, compared with 16% in 2002.

In the high projection, global nuclear generation will increase steadily by a total of 46% by 2020 and by 70% by 2030. Increases are predicted in all regions, once again led by the Far East. However, overall electricity generation would increase even faster than nuclear power, causing nuclear power's share of overall electricity to decline. By 2030 the nuclear share would be down to 11%.

In general, no progress was made in 2003 on the Kyoto Protocol, which would help make nuclear power's avoidance of greenhouse gas emissions valuable to investors. The next round of major deliberations on energy and sustainable development is not scheduled until the 13th session of the United Nations Commission on Sustainable Development in 2006–2007.

Applications of nuclear technology

A large part of the Agency's work —in both the regular budget and the technical cooperation programme — is concentrated on non-power applications of nuclear technology. Many of these applications are gaining increasing importance as tools for social and economic development.

Nuclear techniques and food production

Induced mutations, created by gamma rays, X rays, fast neutrons or chemicals, have provided some major successes in plant breeding. In many cases new phenotypes have revolutionized the appearance of the crops, enhanced disease and pest resistance, and raised nutritional and processing quality. Important results have been achieved for various commercial crops. One example is the improvement in rice varieties; following trials for mutant varieties of rice in nine Asian Member States, many strains with good yields in different ecological conditions were identified. In Indonesia, Members of Parliament attended a harvesting ceremony to mark the positive economic impact of a rice variety produced using gamma rays that exhibits higher yield and better quality. Seven new varieties of rice are expected to be released in the region over the next three to five years. And in a regional technical cooperation project completed in 2003, new mutated germplasm was introduced in 12 countries in the Asia and Pacific region.

'Atoms for health'

According to WHO, the number of new cancer cases in the developing world will double to ten million annually by 2015 as a result of the increase in

Progress in Ensuring Food Quality

International standards are essential for facilitating trade in food and agricultural products between nations and for promoting food quality and safety within national boundaries. In this regard, the International Consultative Group on Food Irradiation (ICGFI), established under the aegis of the Agency, FAO and WHO in 1984, assists national authorities in harmonizing their national regulations on the basis of the Codex General Standard for Irradiated Foods.

Having fulfilled its mandate in establishing the safety and wholesomeness of irradiated foods and in finalizing international sanitary and phytosanitary standards related to irradiation, members of ICGFI at the 20th meeting in October 2003 in Geneva, decided to discontinue its work from May 2004. Future activities related to irradiation will continue to be undertaken by the Agency and other international organizations through existing mechanisms.

life expectancy and lifestyle changes. However, most developing countries do not have enough health professionals or radiotherapy machines to treat their cancer patients safely and effectively. In response, the Agency — by itself and working with other partners such as WHO — provided training, expert missions and equipment to support national and regional efforts to improve cancer therapy and other human health programmes. Across Africa, the number of cancer patients receiving treatment, often through Agency technical cooperation projects, has increased by approximately 35% over the past five years.

Building capacity is a key aspect of many Agency technical cooperation projects. In West Asia, five nuclear medicine courses were held to provide specialized training for more than 100 physicians and technologists. In addition, the first technetium-99m radiopharmaceutical kits, for use in Albanian hospitals, were produced locally in 2003. This was an important example of cost sharing and greater self-reliance, carried out under the auspices and support of the Agency's technical cooperation programme. At another level, information and communication tools were used to establish a 'tele-nuclear-medicine' link between Namibia, South Africa and Zambia that will facilitate remote diagnosis and treatment; another such link is being established among 15 countries in Latin America.

Managing the world's scarce resources of fresh water

More than one sixth of the world's population lives in areas without adequate access to safe drinking water — a situation that is expected to worsen significantly unless the international community takes prompt and effective action. Moreover, improving the availability of the world's water resources is of crucial importance for sustainable development. The use of isotopes in hydrology, based on the natural occurrence of isotopes in water, helps to provide rapid hydrological information for large areas at low cost.

The Agency has made substantive contributions to the 3rd World Water Forum held in Kyoto and chaired the session to launch the UN's first World Water Development Report. It has more than 80 technical cooperation projects, covering the mapping of underground aquifers, managing surface water and groundwater, detecting and controlling pollution, and monitoring dam leakage and safety. For example, a regional project in Latin America brought together more than 30 water institutes to address water shortages for seven aquifers in Chile, Colombia, Costa Rica, Ecuador and Peru. In Yemen, the Agency assisted with the assessment of the groundwater system in the region of the Sana'a Basin. African Member States have requested a number of projects related to shared aquifers, such as the sustainable development and equitable use of the common water resources of the Nile Basin, the Nubian Sandstone Aquifer, the Iullemeden Aquifer and the North Western Sahara Aquifer.

Member State efforts to explore the desalination of seawater using nuclear energy are also being supported by the Agency. At the Karachi Nuclear Power Plant in Pakistan, a reverse osmosis facility in service since 2000 has been producing about 450 cubic metres of fresh water per day. In India, at the Kalpakkam nuclear power plant, a desalination plant designed to produce 6300 cubic metres of fresh water per day is undergoing commissioning. And in the Republic of Korea a design has been developed for a nuclear desalination plant which would supply 40 000 cubic metres of fresh water per day and 90 MW of electricity.

Technical cooperation in developing countries: Sharing the costs of development

Promoting the scientific, technological and regulatory capabilities of developing countries through

technology transfer and capacity building, with special emphasis on technical cooperation between developing countries, is among the main tasks of the Agency's technical cooperation programme. In 2003, a major emphasis in the programme was on promoting cost sharing of development projects, and revenue generation, by governments.

For example, through an RCA project, national nuclear institutes in East Asia and the Pacific have developed capabilities to provide services to end-users. In particular, China, Indonesia and Vietnam have been awarded contracts by the petrochemical industry in the region. Under an AFRA project on strengthening waste management infrastructure, African specialized teams have over the past few years cleared spent sealed radioactive sources in Angola, Côte d'Ivoire, Ethiopia, Ghana, Mauritius, Sudan, Tunisia, the United Republic of Tanzania and Zimbabwe.

In Europe, Albania made a substantial contribution in 2003 towards the purchase of a new cobalt-60 teletherapy machine for the Hospital Mother Theresa in Tirana, working out a cost effective solution with the Agency to meet project objectives. It also secured assistance from the World Bank to further upgrade the hospital's radiotherapy department. The new teletherapy machine and other improvements will facilitate the treatment of 1000 cancer cases per year.

Many Latin American countries, among them El Salvador, Nicaragua, Bolivia, Guatemala and Colombia, were also involved in cost sharing schemes. The main focus of many of these schemes is on improving national capabilities in the treatment of cancer.

Safety

Nuclear safety in 2003

Any increased role for nuclear energy in the future requires assurances that current nuclear installations are being operated safely, that there is a viable international safety regime and that nuclear material is secure. With regard to the safety of current nuclear power plants and related facilities, there was continued improvement overall around the world in 2003. According to the joint IAEA–OECD/NEA International Nuclear Event Scale, the number of significant events remained negligible. The Agency and other international organizations, such as the World Association of Nuclear Operators, continued to conduct expert missions, design reviews and peer reviews of safety.

Application of international safety standards

One of the key requirements for the establishment of a global safety regime is a set of standards governing the safe operation of nuclear installations. In 2003, the revision and updating of Agency safety standards continued to make good progress; the ultimate aim is to complete this revision process by the end of 2004. Two safety requirements publications were published, on site evaluation for nuclear installations and remediation of areas contaminated by past activities and accidents.

A strategy to enhance the safety standards and their global application was prepared in consultation with the various safety standards committees. It was submitted to the Board of Governors and the General Conference in September 2003. The wider application of the standards continues to be an area of emphasis.

International conventions

In addition to a comprehensive set of safety standards, legally binding international agreements are a vital part of a global safety regime. The first Review meeting of the Contracting Parties of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (the Joint Convention) was held in Vienna in November 2003. The participants noted that it was important for all States to have a long term strategy for managing spent fuel and radioactive waste, especially since only a few have such plans at the current time. There was also a need to plan for integrated decommissioning and waste management. An issue of general concern was the comparatively small number of Contracting Parties — numbering 33 at the end of 2003.

Safe transport of nuclear and radioactive material

Spent nuclear fuel and other radioactive material have been transported safely for many decades without serious accidents. However, many Member States continue to express concern over the risks involved, especially with regard to maritime transport. The Agency's contribution to the efforts worldwide to ensure that radioactive material is transported safely includes safety standards (the Transport Regulations) and review services. In 2003, Transport Safety Appraisal Service (TranSAS) missions visited Panama and Turkey and a pre-TranSAS visit was made to France.

To promote greater dialogue among Member States, the Agency — together with IATA, ICAO,

Civil Liability for Nuclear Damage

An International Expert Group on Nuclear Liability (INLEX) was established during the year. INLEX serves three major functions: it is an expert body to explore and advise on issues related to nuclear liability; it should recommend measures to enhance global adherence to an effective nuclear liability regime, including possible changes to fill any identified serious gaps in the regime, inter alia, on the basis of the Convention on Supplementary Compensation for Nuclear Damage and the annex thereto, the Vienna Convention on Civil Liability for Nuclear Damage, the Paris Convention on Third Party Liability in the Field of Nuclear Energy, and the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention and the amendments thereto; and it will assist in the development and strengthening of the national nuclear liability legal frameworks in Agency Member States.

There are 20 members of INLEX, comprising nuclear and non-nuclear-power States, as well as shipping and non-shipping States. The first meeting of the group was held in Vienna in October 2003.

IMO, ISO and UPU — convened a conference in Vienna in July on the 'Safety of Transport of Radioactive Material'. In addition to discussions on radiation protection, compliance, quality assurance and regulatory issues, there were discussions on liability and on communication with the public and between governments.

Nuclear security

The events of 11 September 2001 gave rise to a thorough review of Agency programmes related to the prevention of acts of nuclear and radiological terrorism, and resulted in the adoption of a plan of activities to protect against such acts. Work continued according to this plan during the year, and the pace of activities continued to increase. A new type of service, the International Nuclear Security Advisory Service (INSServ), was developed. Under this service, missions were organized during the year to identify measures for additional or improved security for nuclear related activities.

Member States have also received assistance in evaluating their national physical protection systems, mainly through International Physical Protection Advisory Service (IPPAS) missions and follow-up visits. Moreover, the Agency delivered an extensive programme of physical protection related training courses, workshops and seminars, as well as border evaluation missions for customs and other personnel.

New courses, including one on combating both nuclear terrorism and incidents involving illicit trafficking in nuclear material, were organized. The membership of the Illicit Trafficking Database (ITDB) continued to increase. In this regard, a meeting of the ITDB national contact points was held in 2003 to identify ways to improve the effectiveness of the database.

Verification

Comprehensive safeguards agreements and additional protocols

In 2003, the Agency continued its efforts to implement a strengthened safeguards system. The number of States that have yet to bring into force their comprehensive safeguards agreements, in accordance with their obligations under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), decreased from 48 at the end of 2002 to 45 at the end of 2003; this included the addition of one new NPT State party. Despite this decrease, the number remains undesirably high. The number of States having brought into force additional protocols to their safeguards agreements increased substantially, from 28 to 38, over the same period. However, as the wider application of the strengthened safeguards system continues to be a priority, the total number of States with additional protocols in force remains disappointing. As a means to address this challenge, the Secretariat, supported by a number of Member States, is implementing an enhanced action plan — which was updated in 2003 — designed to expand adherence to the strengthened safeguards system.

Challenges to the safeguards regime

The events of the past year have indicated quite clearly that the nuclear non-proliferation regime is under stress on multiple fronts and requires urgent steps to strengthen it. The Agency once again had to respond to both ongoing and new challenges to the safeguards system. For example, the situation in the Democratic People's Republic of Korea (DPRK) continued to be a serious cause for concern. Meeting the verification challenges in the Islamic Republic of Iran (Iran) and the Libyan Arab Jamahiriya (Libya) were also the focus of the Agency's effort and attention.

And as a result of the changing situation in Iraq, the Agency has not been able to implement important parts of its broader verification mandates.

Democratic People's Republic of Korea

As in 2002, the Agency continued to be unable to verify the correctness and completeness of the initial declaration by the DPRK of nuclear material subject to safeguards in accordance with its NPT safeguards agreement with the Agency. The Agency was not able to carry out any verification activities in the DPRK in 2003, leaving the Agency unable to provide any assurance about the non-diversion of nuclear material in that State.

The Board passed two resolutions with regard to the DPRK, in January and February 2003. At its February 2003 meeting, the Board decided to report to all Member States of the Agency and to the Security Council and General Assembly of the United Nations the DPRK's further non-compliance and the Agency's inability to verify non-diversion of nuclear material subject to safeguards.

Iraq

Agency inspections in Iraq resumed in November 2002, pursuant to UN Security Council (UNSC) resolution 687 (1991) and subsequent resolutions. When Agency inspectors withdrew on 17 March 2003, 237 inspections had been carried out at 148 locations, including 27 new locations. No evidence was found of the revival of nuclear activities prohibited under resolutions 687 (1991) and 707 (1991). Since 17 March 2003, the Agency has not been in a position to implement its mandate in Iraq under the relevant UNSC resolutions, which remained valid.

In June 2003, the Agency's inspectors returned to Iraq to verify, under the NPT safeguards agreement between Iraq and the Agency, the nuclear material subject to safeguards stored at the Location C Nuclear Material Storage Facility near the Tuwaitha complex south of Baghdad. The inspectors found that some dispersal of natural uranium compounds, not sensitive from the standpoint of proliferation, had occurred due to looting. The Agency recovered and verified the presence of nuclear material subject to safeguards at the site.

Islamic Republic of Iran

The Agency had extensive discussions with Iran in 2003 on safeguards issues to be clarified, and carried out a range of verification activities in the context of Iran's NPT safeguards agreement. Reports by the Director General were made to the Board of Governors in June, August and November 2003. The report in June noted that Iran had failed to meet its obligations under its safeguards agreement with respect to the reporting of nuclear material, the subsequent processing and use of that material and the declaration of facilities where the material was stored and processed. The report also noted corrective actions that had been taken. In response, the Board shared the Director General's concern at the number of Iran's past failures, and welcomed Iran's reaffirmed commitment to full transparency.

The report to the September Board noted an increased degree of cooperation with the Agency by Iran, although it also stated that information and access were at times slow in coming and incremental, observing that a number of important outstanding issues remained, particularly with regard to Iran's enrichment programme. In its resolution of 12 September, the Board expressed grave concern that Iran had still not enabled the Agency to provide the required assurances that all nuclear material had been declared and submitted to safeguards and that there were no undeclared nuclear activities in Iran. The Board also decided that a number of actions on Iran's part were essential and urgent for Agency verification of the non-diversion of nuclear material.

The November report reiterated that Iran had in a number of instances over an extended period of time breached its obligation to comply with its safeguards agreement. However, it was noted that, given the past pattern of concealment, it would take some time before the Agency would be able to conclude that Iran's nuclear programme was exclusively for peaceful purposes. The Board responded in its resolution of 26 November by welcoming Iran's offer of active cooperation and openness and its positive response to the Board's previous demands, but also by strongly deploring Iran's past failures and breaches of its obligation to comply with its safeguards agreement.

Iran signed an Additional Protocol on 18 December 2003. However, as of the date of publication of this report, there remain outstanding issues requiring resolution; the Agency's ongoing verification activities continue to require Iran's active cooperation.

Libyan Arab Jamahiriya

On 19 December 2003, Libya announced its decision to eliminate all materials, equipment and programmes leading to the production of internationally proscribed weapons — including nuclear weapons. The Agency began a process of working with the Libyan authorities to ascertain the extent of Libya's nuclear programme. Libya informed the Agency that

it had been engaged in activities that should have been (but were not) reported to the Agency under Libya's NPT safeguards agreement. It also stated that its nuclear enrichment programme was at an early stage of development and that no industrial scale facility had been built, nor had any enriched uranium been produced.

In December 2003, an Agency team of technical and legal experts visited locations related to undeclared nuclear activities and initiated a process of verifying the previously undeclared nuclear material, equipment, facilities and activities. Since then, Agency inspectors, including nuclear weapon and centrifuge technology experts, have visited Libya to continue the verification process. Libya also confirmed its intention to sign the Additional Protocol and — pending entry into force — to act as of 29 December 2003 as if the protocol was in force.

As part of its continuing verification process with Libya and Iran, the Agency is also investigating, with the support of Member States, the supply routes and the sources of sensitive nuclear technology and related equipment and nuclear and non-nuclear material. It is continuing such investigations with a view to ensuring that the sensitive nuclear technologies and equipment found in Libya have not proliferated further.

Outreach and Management Issues

Events over the past year brought the Agency's activities, on an almost daily basis, to the attention of the media, and public interest in the Agency's work remained high throughout the year. The importance of verification in helping to prevent the proliferation of nuclear weapons was widely discussed and explained in a variety of forums. At the same time, the Secretariat provided commentaries on the importance of the other side of the 'nuclear coin' and of the Agency's programme — the peaceful applications of nuclear techniques for the benefit of humanity. Information campaigns were launched dealing with the radiation treatment of cancer and the search for sustainable water resources.

In 2003, the first biennium in which a full results based management approach was applied to the formulation, implementation and the initial stages of the assessment of the programme was completed. The experience gained is already being applied to the 2004–2005 and 2006–2007 cycles. In this connection, emphasis was placed on consolidating the many process changes introduced over recent years and ensuring that they became part of an overall 'one-house' culture.

After a decade and a half of zero real growth, the Board of Governors agreed to a 'package proposal' that included an increase of some 10% in the regular budget over a period of four years. The part of the increase recommended for 2004 received the approval of the General Conference in September and will make it possible to undertake a more extensive programme aimed at meeting the expressed priorities, needs and interests of Member States.

Conclusion

This review of activities in 2003 makes it clear that the scope of the Agency's work has continued to expand, and that its agenda remains very full. There have been significant challenges in all the areas of activities of the Agency — technology, safety and security, and verification. The Agency has responded appropriately to all of these challenges, guided by the principle that only through international cooperation and mutual accommodation can there be progress in dealing with the pressing issues of poverty, maintaining and enhancing peace and security, and protecting the environment. ■

Technology

Nuclear Power

Objective

To increase the capability of interested Member States to implement and maintain competitive and sustainable nuclear power programmes.

Engineering and Management Support for Competitive Nuclear Power

To support the operation of nuclear power plants, the Agency provides Member States with information, assistance and training on productivity, quality management and life cycle planning, including possible licence extension, uprating and/or decommissioning. In this connection, four publications were completed in 2003 on various aspects of improving nuclear power plant performance and management. The first (IAEA-TECDOC-1358) seeks to assist training professionals in defining the inputs and outputs of their training systems, and in determining the timing, scope and extent of evaluations. Another publication (IAEA-TECDOC-1364) provides nuclear power plant managers with proven approaches to improving the performance of their organizations. Guidance is provided in IAEA-TECDOC-1383 on optimizing nuclear power plant maintenance programmes using internationally recognized good practices, while IAEA-TECDOC-1335 offers guidance on establishing and improving configuration management programmes to support engineering and operational change processes at existing nuclear power plants.

An important output of a CRP was the compilation of the lessons learned and development of guidance for maintaining and upgrading management information in SAT (systematic approach to training) programmes in Member States. The CRP also focused on effective use of computer based information management systems to improve operational efficiency and increase safety.

Quality assurance (QA) and quality management (QM) are essential to the efficient and safe operation of nuclear power plants. In 2003, particular effort was devoted to cooperation with FORATOM and the ISO to harmonize relevant QA and QM documentation. This included updates to the Agency's safety standards in the area of QA.

An increasing number of nuclear power plants are reaching the point where choices must be made between licence extension and decommissioning (Fig. 1). The Agency provides assistance to Member States interested in improving nuclear power plant life management (PLIM), i.e. the cost effective scheduling of replacements, improvements, upgrades, licence extensions and decommissioning, given the state of the equipment and the market conditions for electricity. Several national and regional programmes on the modernization of instrumentation and control systems were conducted in 2003. In addition, a number of CRPs and national and regional technical cooperation projects developed and disseminated documents on equipment monitoring and upgrades.

Together with the OECD/NEA and the European Commission, the Agency published a study entitled *Decommissioning: Policies, Strategies and Costs*. The study covers the full range of issues associated with the decommissioning of commercial nuclear power plants, with an emphasis on the factors likely to most influence costs. Aimed principally at policy makers and regulators, this study is also intended to benefit the decommissioning industry.

As a service to the nuclear and energy industries, the Agency provides a range of information on the world's nuclear power plants. One example is *Country Nuclear Power Profiles*, which was published in 2003 and is one of the most authoritative international surveys available. Another example is the *Power Reactor Information System* (PRIS), an on-line database

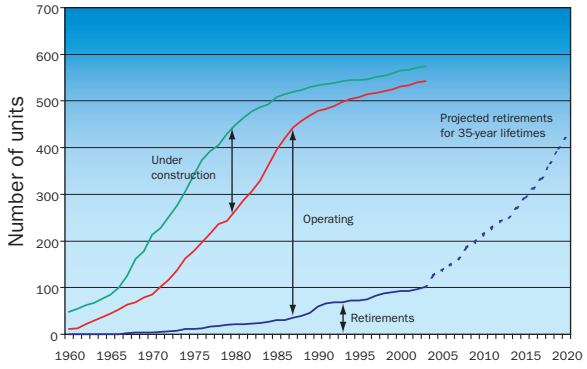


FIG. 1. Projected retirements of nuclear power plants (dashed blue line) assuming all reactors retire after 35 years of operation. The solid lines represent cumulative historical data for retired reactors (blue), retired reactors plus operating reactors (red), and retired reactors plus operating reactors under construction (green).

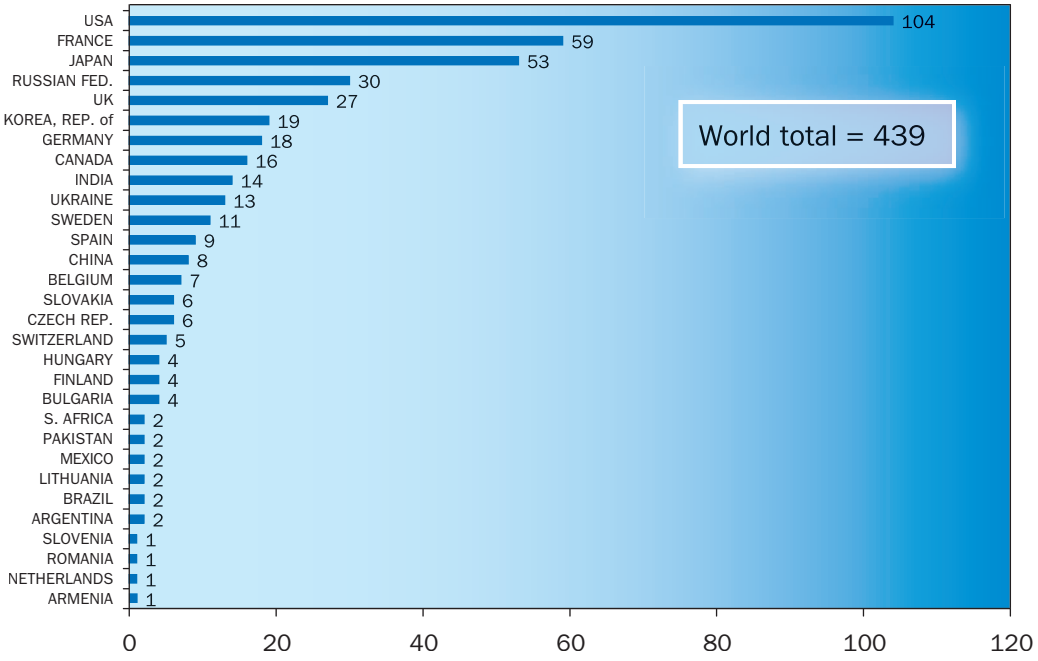


FIG. 2. Summary from PRIS of nuclear power reactors in operation worldwide (as of 31 December 2003).

(Fig. 2). The number of organizations accessing PRIS products and services has increased, from 500 in 1999 to about 600 in 2003. Moreover, the PRIS web site (*http://www.iaea.org/programmes/a2/index.html*) continues to be among the most visited of the Agency's web pages. There has also been a significant increase in networking among experts through the use of a new web based system (WeDAS) to collect data for PRIS over the Internet.

Another information source is the *Nuclear Economic Performance Information System* (NEPIS), which contains data and statistics on functional and activity based costs, and operation and maintenance costs. It also includes safety and operational indicators. The database, currently gathering information from nuclear operators in 12 States, was set up and is being developed in cooperation with the US Electric Utility Cost Group (EUCG). In 2003, the Agency and EUCG signed a new agreement to continue sharing operation and maintenance data, and to develop requirements for data collection and dissemination.

Nuclear Power Technology Development and Applications

The future utilization of nuclear power by Member States depends primarily on the ability of designers and operators to improve the competitiveness of nuclear power plants while meeting increasingly stringent safety requirements. Phase 1A of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), an Agency initiative to ensure that nuclear energy is available to contribute, in a sustainable manner, to the energy needs of States in the 21st century, was completed with the publication of *Guidance for the Evaluation of Innovative Nuclear Reactors and Fuel Cycles* (IAEA-TECDOC-1362). This publication provides basic principles, user requirements, criteria and a methodology for assessing innovative nuclear energy systems. These are being tested, and improved, through case studies in Phase 1B, which began in July 2003. Other activities related to innovation included the convening of an international conference in Vienna on innovative technologies for nuclear fuel cycles and nuclear power, and a session on innovative approaches in nuclear power at the Scientific Forum during the Agency's General Conference in September 2003.

The Agency's Technical Working Groups (TWGs) on advanced LWR and HWR technologies promote the continuous improvement of water cooled reactors. With their assistance, the Agency prepared two publications covering the status of advanced LWR designs (IAEA-TECDOC-1391) and validation of HWR thermohydraulic codes (IAEA-TECDOC-1395).

A CRP dealing with the establishment of a thermo-physical properties database for LWR and HWR materials was completed. New measurements of the thermo-physical properties of a number of compounds were completed, as were property assessments of a range of other compounds. A web based version of the database is under construction at Hanyang University, in the Republic of Korea. In

addition, a new CRP was started on natural circulation phenomena, modelling and reliability of passive systems utilizing natural circulation.

The Agency and its Member States have in recent years been keenly aware of the problem of nuclear workforce ageing. One proactive response from the Agency has been to sponsor the development of nuclear reactor simulators, using PC platforms, for education covering PWRs, BWRs, CANDUs and WWERs. An important activity in 2003 was a workshop at the ICTP, in Trieste, that focused on the development and application of advanced nuclear reactor simulators.

With the assistance of the TWG on fast reactors, the Agency completed status and review reports on: core physics and engineering aspects of transmutation systems; national programmes on accelerator driven systems for partitioning and transmutation; power reactors and subcritical blanket systems with heavy liquid metal cooling and/or target material; and the potential of thorium based fuel cycles to limit plutonium and reduce long lived waste toxicity. The Agency also provided training on accelerator driven systems technology and applications at an ICTP workshop and initiated a CRP to conduct benchmark exercises on the kinetic and dynamic properties of transmutation systems.

As part of the Agency's new initiative on nuclear knowledge preservation and management, a pilot project on fast reactor data retrieval and knowledge preservation was started. This project (described more fully in the 'Nuclear Science' chapter) provides a framework for programmes in Member States aimed at preventing data and information loss, ensuring retrievability and establishing software and hardware standards for data preservation over the next 30–40 years.

Agency work in the area of high temperature gas cooled reactors (HTGRs) included benchmarking HTGR core physics and thermal-hydraulics, and studies on HTGR coated fuel particle technology. A technical document (IAEA-TECDOC-1382) published in 2003 describes the results of the first set of core physics and thermal-hydraulic benchmarks. They include both code to code and code to experiment comparisons using operational data from the Japanese High Temperature Test Reactor and Chinese HTR-10.

Part of the Agency's work in the field of nuclear power technology development and its applications covers the non-electric uses of nuclear energy. In this connection, the Agency completed a CRP on the 'Optimization of the Coupling of Nuclear Reactors and Desalination Systems', covering a range of desalination systems and small and medium size reactors (PWRs, HWRs, fast reactors, heating reactors and floating reactors). The CRP identified the optimal coupling configuration, evaluated the performance of these systems and identified technical features likely to require further assessment before development of detailed specifications for large scale nuclear desalination plants.

The Agency's interregional technical cooperation project on nuclear desalination included several major activities in 2003. For example, within the tripartite BATAN–KAERI–IAEA framework, a final draft of a preliminary economic feasibility study of nuclear desalination on Madura Island, Indonesia, was prepared and is being evaluated; progress was made on a report for the Tundesal project between France and Tunisia for the site at La Skhira; and three expert missions provided assistance to Pakistan's national project for a nuclear desalination demonstration plant at KANUPP. ■

Nuclear Fuel Cycle and Material Technologies

Objective

To strengthen the capabilities of interested Member States for policy making and strategic planning, technology development and implementation of safe, reliable, economically efficient, proliferation resistant and environmentally sound nuclear fuel cycle programmes.

Uranium Production Cycle and Environment

The Agency and the OECD/NEA finalized the latest update of the biennial "Red Book", *Uranium 2003: Resources, Production and Demand,* containing data from 44 countries. In 2002, uranium production totalled 36 042 t U (tonnes uranium), down from 37 022 t U in 2001. Of 20 countries reporting output, two (Canada and Australia) accounted for over 51% of world production, and seven (Australia, Canada, Kazakhstan, Namibia, Niger, Russian Federation and Uzbekistan) accounted for 87% of world production. Newly mined and processed uranium provided 54% of world reactor requirements (66 815 t U), the remainder being met by secondary sources including civilian and military stockpiles, reprocessed uranium, and re-enriched depleted uranium. The uranium market remains uncertain in the medium term due to the limited information available on secondary supplies, which are expected to decline in importance. After 2015, in particular, reactor requirements will have to be increasingly met by the expansion of existing production capacity, the development of additional production centres or the introduction of alternative fuel cycles. Market uncertainty has fuelled the recent increase in spot market prices, which have increased more than 70% since the end of 2002.

Nuclear Fuel Performance and Technology

To assist Member States in enhancing the predictive capabilities of codes used in fuel behaviour modelling for extended burnup, the Agency initiated a CRP on fuel thermal performance, fission gas release and pellet to clad interaction at burnups above 50 MW d/kg HM (heavy metal). The CRP will also address the performance of codes used for transient analysis such as for reactivity initiated accidents and for loss of coolant accidents at extended burnup. Idealized fuel histories were prepared in 2003, including histories supplied by two fuel vendors, and 16 teams of fuel modellers are currently working on the priority cases identified at the first Research Coordination Meeting. In related work, the Agency supported a conference in Bulgaria in September on fuel performance and modelling with particular reference to WWER fuel.

A summary of the present status of mixed oxide (MOX) fuel technology was published as Technical Reports Series No. 415. The topics covered: design; fabrication; performance; in-core fuel management; transport; spent MOX fuel management; decommissioning; waste treatment; safeguards; and alternative approaches for both civil and ex-weapons plutonium recycling. The main focus was on MOX fuel for thermal power, although several aspects of fast reactor MOX fuel were also addressed.

Spent Fuel Management

In June the Agency hosted an international conference on the storage of spent fuel from power reactors to identify the most important directions for national efforts (Figs 1 and 2) and international cooperation. Potential Agency initiatives emphasized at the conference included assistance to Member States in coordinating research on the long term behaviour of spent fuel, and the continuing exchange of information on related technology and public acceptance matters. The proceedings of this conference, as well as details on related Agency activities, are available at *http://www.iaea.org/OurWork/ST/NE/index.html*. Other technical documents on spent fuel management issued in 2003 included the final report of the CRP on spent fuel performance assessment and research (SPAR) (IAEA-TECDOC-1343) and the proceedings of a technical meeting on burnup credit (IAEA-TECDOC-1378).

Nuclear Fuel Cycle Issues and Information Systems

At an international conference on innovative technologies for nuclear fuel cycles and nuclear

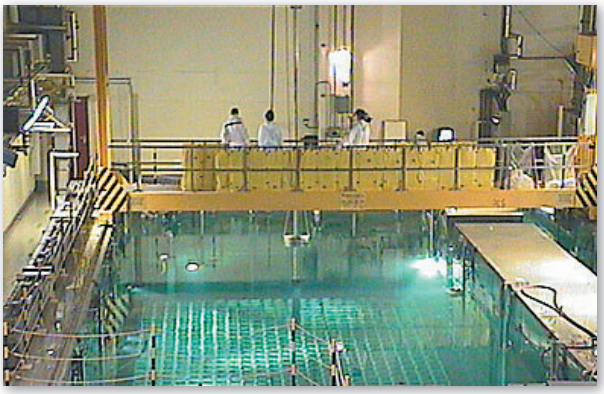


FIG. 1. Spent fuel pool after re-racking was completed at the Krško nuclear power plant, in Slovenia.

FIG. 2. Interim storage and transport casks at ZWILAG, in Switzerland.

power, held in Vienna in June, discussions of future nuclear fuel cycles ranged from an emphasis on national energy security through a closed thorium fuel cycle to growth in mature markets based on regional energy security, limited or small waste volumes and environmental impacts, and a balance between the supply and demand of raw materials at the front end of the fuel cycle. A number of conference participants noted that many innovative fuel cycle concepts focus explicitly on the back end and aim especially at dealing with the remaining waste. Many also favoured the introduction of additional waste management options, such as partitioning and transmutation, to reduce the mass and radioactivity of wastes requiring disposal.

The development and maintenance of databases and information systems are important aspects of the Agency's nuclear fuel cycle programme. Recognizing that data sources, when regularly updated and revised to meet changing needs, provide essential technical support for fuel cycle activities in Member States, the Agency updated and expanded its nuclear fuel cycle databases. For example, the web site devoted to nuclear fuel cycle information (*http://www-nfcis.iaea.org*) was completely redesigned and now includes three databases and one simulation system: the Nuclear Fuel Cycle Information System; World Distribution of Uranium Deposits; Post-Irradiation Examination Facilities; and the Nuclear Fuel Cycle Simulation System. ■

Analysis for Sustainable Energy Development

Objective

To increase the capability of Member States to carry out their own energy and electricity sector analyses and investment planning, including the objective analysis of nuclear technologies and their alternatives for the purposes of sustainable energy development, and to ensure that Member States and various international organizations have access to state of the art information on nuclear power in the context of Agenda 21 (the action plan of the 1992 United Nations Conference on Environment and Development) and mitigation of climate change.

Energy Modelling, Databanks and Capacity Building

Capacity building activities for sustainable energy development and planning in Member States, particularly developing countries and transition economies, received further impetus in 2003 following the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002, which emphasized the need for such activities to accelerate the implementation of *Agenda 21*. The Agency organized nine regional and national training courses and workshops to enhance the planning and analytical skills of experts from developing countries. Fellowships were offered and scientific visits for energy analysts were arranged (Fig. 1). Collaborating in some of the training sessions were the ICTP in Trieste, Argonne National Laboratories in the USA, and the Korea Atomic Energy Research Institute.

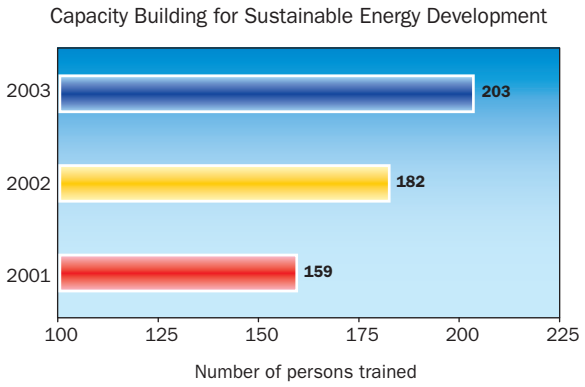


FIG. 1. The Agency provides training to professionals in Member States in energy system planning and analysis and in the use of its models (2001–2003).

The Agency received over 150 requests for its energy models and related databases. About 90 Member States are now using these models to analyse technology choices and policy options for the development of their energy sectors. Some Member States (for example, Belarus, Croatia, Tunisia, the Russian Federation and the United Arab Emirates) are also using the models for research and teaching at their universities. Three national energy studies — for Armenia, Mexico and the Syrian Arab Republic — were conducted through the Agency's technical cooperation programme. In related work, a multi-language user interface for the SIMPACTS[1] model for assessing the external costs of electricity generation was added at the request of Member States.

The medium term nuclear energy projections published annually by the Agency were extended to 2030 (Table 1).[2] The low projection essentially assumes no new nuclear power plants beyond those already being built or firmly planned today, plus the retirement of old plants. The projection was revised upwards in 2003 and estimates a 20% increase in global nuclear generation up until the end of 2020, followed by a decrease, resulting in global nuclear generation in 2030 that will be only 12% higher than in 2002. Nuclear power's share of global electricity generation decreases after 2010 to 12% in 2030, compared with 16% in 2002. Increases are most substantial in the Far East, and decreases are greatest in Western Europe.

The high projection shown in the table takes into account additional reasonable nuclear proposals, even if there is currently no firm commitment. It shows global nuclear power generation steadily increasing by 46% through 2020 and by 70% through 2030, as compared with 2002. There are increases in all regions, again led by the Far East. However, overall electricity generation is projected to increase even faster than nuclear power, causing nuclear power's share of overall electricity to decline. By 2030, the nuclear share is down to 11%.

[1] SIMPACTS: Simplified Approach for Estimating Environmental Impacts and External Costs of Electricity Generation.

[2] Published in *Energy, Electricity and Nuclear Power Estimates for the Period up to 2030, July 2003 Edition*, Reference Data Series No. 1, IAEA, Vienna (2003).

Table 1. Low and High Estimates of Total Electricity Generation and Contribution by Nuclear Power (low estimate: first row in each region; high estimate: second row)

Region	2002			2010			2020			2030		
	Total Elect. TW·h	Nuclear TW·h	%	Total Elect. TW·h	Nuclear TW·h	%	Total Elect. TW·h	Nuclear TW·h	%	Total Elect. TW·h	Nuclear TW·h	%
North America	4779	851.1	17.8	5034	874	17.0	5784	870	15.0	6451	844	13.0
				5444	894	16.0	6709	939	14.0	8146	944	12.0
Latin America	1078	28.6	2.7	1178	29	2.5	1628	47	2.9	2227	30	1.3
				1427	38	2.7	2291	50	2.2	3758	92	2.4
Western Europe	3084	880.2	28.5	3352	858	26.0	3634	823	23.0	3942	564	14.0
				3609	893	25.0	4687	961	20.0	6061	1090	18.0
Eastern Europe	1758	298.5	17.0	1884	319	17.0	2174	423	19.0	2463	378	15.0
				2074	399	19.0	2867	552	19.0	4133	611	15.0
Africa	459	12.0	2.6	538	13	2.5	699	14	2.0	876	14	1.6
				612	14	2.3	973	24	2.4	1530	60	3.9
Middle East and South Asia	1176	19.6	1.7	1342	41	3.1	1805	53	3.0	2327	70	3.0
				1626	47	2.9	2596	100	3.9	3946	194	4.9
South East Asia and the Pacific	600			736			934			1162		
				786			1119	5.5	0.5	1584	18	1.2
Far East	3157	484.3	15.3	3399	695	20.0	4199	855	20.0	5073	981	19.0
				4296	702	16.0	6605	1125	17.0	9830	1361	14.0
World total (Low estimate)	16 090	2574.2	16.0	17 463	2830	16.0	20 857	3085	15.0	24 520	2881	12.0
World total (High estimate)				19 873	2987	15.0	27 848	3756	13.0	38 989	4369	11.0

Energy–Economy–Environment

The two international meetings in 2003 that were most relevant to energy use and sustainable development were the World Climate Change Conference (WCCC) in Moscow in August and September and the Ninth Session of the Conference of the Parties to the UNFCCC (CoP-9) in Milan in December. The Agency was a member of the WCCC organizing committee and provided an invited address to the opening plenary, the first time such attention has been given to the role of nuclear energy. While nuclear energy was not an issue at the CoP-9 negotiations, the Agency was part of a "side event" organized specifically on nuclear power.

Both of the Agency led "Type-2 Partnerships" are conducted in cooperation with UNDESA, which leads the overall UN effort to develop a full range of sustainable development indicators. The immediate objective of one of the partnerships is to produce a report on energy indicators comparable to UNDESA's *Indicators of Sustainable Development: Guidelines and Methodologies* and EUROSTAT's *Measuring Progress Towards a more Sustainable Europe: Proposed Indicators for Sustainable Development.* In 2003, the Agency completed a draft of this report with contributions from the OECD/IEA, UNDESA, the European Environment Agency and EUROSTAT. Under the Type 2 Partnership on Designing Country Profiles on Sustainable Energy Development (CPSED), two new studies were begun in cooperation with UNDESA — for South Africa and Cuba.

Other related international initiatives in which the Agency participated included the 2003 update of the *World Energy Assessment* (to be published by UNDP, the United Nations Department for Economic and Social Affairs and WEC), and a special report by the IPCC on carbon capture and storage.

Increased Agency participation in international endeavours was mirrored by a large number of requests from Member States and international organizations to participate directly in its work. These included three requests for topical studies (in Belgium, Haiti and Lithuania), six requests to participate in cost–benefit studies and three requests for assistance in regional assessments.

Beginning in 2003, the Agency placed special emphasis on using its own planning and analytical tools in energy–economic–environment analyses. The aim is to demonstrate their applicability to Member State analyses of current and topical issues. Use of Agency tools in preparing country profiles in the CPSED partnership is one example. Another is the development of templates for incorporating

the Indicators for Sustainable Energy Development directly into the Agency's own Energy and Economic Data Base. This is a prelude to the broader use of these templates in Member States and by other international organizations.

The extension of topical analytical studies, or analytical approaches, to new applications in areas of interest to Member States was another new focus. An example was a study of the costs and benefits of risk reduction from nuclear power plant modifications that was expanded to an approach for quantifying the full economic, engineering and risk related costs and benefits of upgrades, life extensions and safety enhancements for a variety of reactor types. ■

Nuclear Science

Objective

To increase Member State capabilities in the development and application of nuclear science as a tool for their economic development.

Atomic and Nuclear Data

Well defined atomic and nuclear data are extremely important for the safe design and operation of nuclear facilities, and to advance nuclear applications in medicine, industrial monitoring techniques and scientific research. In this connection, the Agency's major nuclear databases were being converted during 2003 to a form that would make them freely available to all operating and database management systems.

Technical input to specific multinational databases is organized through three networks: the Atomic and Molecular (A+M) Data Centres and ALADDIN Network, the Network of Nuclear Reaction Data Centres, and the Nuclear Structure and Decay Data Evaluators' Network. New initiatives in 2003 to make calculational tools available through the Internet included a preliminary interface to run a set of codes developed at Los Alamos National Laboratory in the USA, and an interface for a heavy particle collision code. In addition, all atomic and nuclear databases were updated; this included the introduction and testing of new actinide cross-section files. As shown in Table 1, use of the Agency's data services continued to increase on both the Internet and through regular postal communications.

Two new CRPs were initiated in 2003, one on nuclear data for the thorium–uranium fuel cycle and the other on nuclear data for the production of therapeutic radioisotopes. A new dosimetry library (IRDF-2002) was finalized, and advances were made in the creation of a common cross-section database for ion beam analysis.

There was a significant increase in training activities on atomic and nuclear data during 2003. A total of 83 students took part in workshops dealing with materials analysis, A+M data for fusion research, nuclear structure and decay data, and relational databases for nuclear data.

Research Reactors

The Russian Research Reactor Fuel Return Programme of the Agency, the Russian Federation and the USA facilitates the return of Russian origin research reactor fuel to the Russian Federation. In 2003, fact-finding missions visited sites in a number of Member States, starting with Latvia and followed by the Czech Republic, Romania, Kazakhstan, Poland, Bulgaria and Hungary, to assess the feasibility of returning their fuel. All Russian origin fresh HEU was returned from Romania in September and from Bulgaria in December under this initiative. In November, a contract was concluded to provide the 14 MW TRIGA reactor in Piteşti, Romania, with sufficient LEU to complete its conversion from HEU to LEU.

The Agency developed material for a training course for facilities wishing to convert from HEU to new, high density LEU fuels based on uranium–molybdenum alloys. In related work, the Agency conducted a series of workshops and training courses under a regional technical cooperation project on research reactor spent fuel options in Latin America and: (a) produced a catalogue of pictures showing typical forms of corrosion degradation of research reactor fuel cladding; (b) set up a web site containing relevant documents to facilitate communication; (c) produced a brochure in Spanish on research reactors for public outreach; and (d) prepared a draft study of regional options for the long term management and disposition of spent fuel.

Table 1. User Requests for Nuclear Data: 2000–2003

User requests	2000	2001	2002	2003
Internet retrievals from the main Agency nuclear databases	9642	12 894	20 773	29 913
Access through the Internet to other Agency files and information	11 472	16 153	18 135	20 752
Information on CD-ROMs	648	883	1108	852
Off-line retrievals	2557	2231	2548	2340

Current Issues in the Operation of Research Reactors

Several challenges currently facing the research reactor community were addressed at an Agency conference in Santiago, Chile, in November. Focusing on such topical issues as utilization, safety, decommissioning, fuel and waste management, the conference made the following recommendations:

- All countries with a research reactor should adopt the 'Code of Conduct on the Safety of Research Reactors' for the operation and utilization of such reactors;
- Operators should have a strong, independent regulatory body and the relevant legal framework;
- Physical security at research reactors and associated fuel cycle facilities should be strengthened;
- Consideration should be given to life cycle issues and the question of how to improve the utilization of research reactors through the formulation (and periodic updating) of:
  - Strategic plans for utilization;
  - Fuel management plans;
  - Ageing management plans;
  - Refurbishment or modernization plans;
  - Decommissioning plans;
  - Operational, utilization and decommissioning waste management plans.
- Strategic planning should be carried out for the utilization and promotion of regional centres of excellence;
- Resource sharing should be considered for regional self-sufficiency (e.g. in radioisotopes).

To counter the underutilization of research reactors, the Agency organized a regional workshop in Latin America on strategic planning for research reactor utilization. One outcome was a proposal for a project focusing initially on medical radioisotope production, but also providing a framework for regional cooperation in research reactor utilization.

A CRP on small angle neutron scattering (SANS) was completed. In addition to the initiation of a technical cooperation project on a SANS centre, new devices to guide neutron beams and special detectors were the main outputs of this CRP. A new CRP on neutron radiography, a powerful tool for the non-destructive testing of materials, was launched to improve source and detection systems.

Nuclear Research Facilities and Instrumentation

In fusion research, much of the current experimental and theoretical work is focused on the International Thermonuclear Experimental Reactor (ITER). In 2003, ITER gained three new members (China, the Republic of Korea and the USA), while Canada ceased being a member. There are three continuing members — the European Union, Japan and the Russian Federation. The expanded membership of six, together with the Agency, will participate in the next phase, the ITER Transitional Arrangements. The ITER site selection process made progress in 2003, with the final choice now between locations in France and Japan.

To support developments on ITER, the Agency organized eight technical meetings in 2003 focusing mainly on magnetic confinement. In addition, CRPs investigating alternative approaches, such as inertial confinement, created opportunities for developing countries to work on plasma physics and fusion with countries with well established fusion communities.

The Agency conducts regional training courses and workshops to promote better use of available nuclear instrumentation, better maintenance, regular modernization, and improved quality assurance. Courses were conducted in East Asia and Latin America on an application known as 'LabView' using universal serial bus (USB) connections for data acquisition and control. This application helps trainees to modernize and refurbish nuclear instruments. Participants were provided with kits to train their colleagues in their home countries. Finally, nine distance learning modules for nuclear instrumentation maintenance were developed and field tests have begun.

There is a growing demand for new knowledge on and access to accelerator based nuclear analytical

techniques, as evidenced by 20 active technical cooperation projects in 2003. Two CRPs were completed, one on the use of ion beam techniques for the analysis of light elements in thin films, including depth profiling, and the other on the development of alpha particle spectrometry, instrumentation, methods and applications. Both established successful synergies among diverse research laboratories involved in the study of accelerator based nuclear techniques of analysis and nuclear instrumentation. A computer code (WinAlpha) for the analysis of alpha particle spectra was developed *(http://www.iaea.org/programmes/ripc/physics/index.html).*

Maintenance of Knowledge in Nuclear Science and Technology

The maintenance and preservation of nuclear knowledge has been a key objective of the Agency's activities in the area of nuclear science and technology, with a focus on designing policy and guidance, supporting university level nuclear education and preserving important information and skills. In particular, the preservation of nuclear knowledge is a cross-cutting activity involving all programme areas of the Agency. For example, a pilot project began in 2003 to establish a comprehensive, international inventory of fast reactor data and knowledge to support fast reactor development 30–40 years from now. This involved the retrieval and preservation of data from the German KNK II experimental fast reactor. Documents are being scanned and converted into electronic form, and bibliographical records will be produced using the Agency's International Nuclear Information System (INIS). The Agency also began construction of a knowledge base on high temperature gas cooled reactors incorporating technical information publicly available for selected projects, including the DRAGON reactor in the United Kingdom and the AVR in Germany.

The Agency supported networking of education and training activities through coordination with the European Nuclear Engineering Network and through the establishment of the Asian Network for Higher Education in Nuclear Technology, the Asian Network for Nuclear Safety and the Ibero-American Radiation Safety Network. Together with the OECD/NEA, the World Association of Nuclear Operators and the World Nuclear Association, the Agency supported the founding in September of the World Nuclear University (WNU).

INIS has been incorporated as an integral part of the Agency's new nuclear knowledge initiative. In 2003, its membership grew to 129. The number of bibliographic records added increased by 23%, and the number of subscribers grew by 37%. ■

Food and Agriculture

Objective

To enhance capabilities within Member States for alleviating constraints to sustainable food security by the application of nuclear techniques.

Soil and Water Management and Crop Nutrition

Water is becoming an increasingly scarce resource in many developing countries and the agricultural sector, as its biggest user, needs to become more efficient in irrigation practices. Accurate measurements are therefore crucial for the better management of irrigation water and rainfall captured for crop production. To help Member States choose the best techniques, the Agency assessed currently available methods to measure soil water. The soil moisture neutron probe (SMNP), based on neutron scattering by the hydrogen atoms of water, proved to be the most popular device for surface and subsurface soil water content measurement since it is the most accurate and efficient, and is free from interferences. Following this assessment, training manuals and guidelines on the practical use of soil water measuring devices were prepared and widely disseminated to Member States. In addition, an interregional training course was held at the Agency's Laboratories at Seibersdorf, and ten Member States were supplied with soil moisture sensing equipment. Increases in water use efficiency of up to 30% have been demonstrated.

Phosphorus deficiency is widespread in tropical acid soils and a major constraint to efficient crop production. Attempts by farmers in many Member States in Africa, Asia and Latin America to enhance productivity and sustain soil fertility are frustrated by the high cost and limited availability of manufactured, water soluble phosphate fertilizers. A database of the chemical and physical properties of 135 phosphate rocks from all regions and the first version of an FAO–IAEA–IFDC[1] decision support system were posted on the Internet in 2003. The support system integrates phosphate rock properties with measurable soil and climatic variables to predict the effectiveness of phosphate rocks compared with water soluble superphosphate fertilizer. Using these resources, as well as information in the FAO's *Fertilizer and Plant Nutrition Bulletin No. 13, Use of Phosphate Rocks for Sustainable Agriculture*, policy makers, farm managers and extension workers are now able to make informed decisions for improved fertilizer and nutrient management practices.

Plant Breeding and Genetics

Substantial progress was made in developing improved crop varieties through mutation induction, particularly in relation to rice — the basic source of nourishment, employment and income for one billion households in Asia, Africa and Latin America. In Indonesia, a harvesting ceremony, attended by Members of Parliament, marked the positive economic impact of a variety of rice produced using gamma rays, with higher yield and better quality. This variety has been introduced in 20 provinces. In addition, 45 rice mutant trials were conducted through a regional technical cooperation project completed last year in nine countries. The trials identified 17 lines that performed well in different ecological conditions and which are now being used in the breeding programmes of the participating countries. Another 17 mutants were judged as being suitable for cross-breeding programmes. Taking into consideration both the very high yield potential and the expression of other desired characters, it is expected that at least five to seven new, high yielding rice varieties will be released during the next three to five years in the region, bringing significant additional income to rice farmers.

In a collaborative effort between the Agency and the International Rice Research Institute in the Philippines, four salt tolerant mutants were developed from the high quality rice cultivar IR29. This cultivar was mutated by gamma rays and the resulting progeny tested for tolerance to salt (Fig. 1). The mutant lines, in addition to exhibiting greater tolerance to salt, showed no obvious adverse characteristics, and consequently have been well received by rice breeders. The lines have now been crossed onto elite breeding stocks as a first step in breeding new salt tolerant rice cultivars.

[1] International Fertilizer Development Center, now called the International Center for Soil Fertility and Agricultural Development, but with the same acronym.

FIG. 1. Left: Hydroponics seedling test of putative rice mutants for salinity tolerance at the Agency's Laboratories at Seibersdorf. Right: Other varieties in field trials for salt tolerance on the coastal plains of Ajuy, Philippines. Susceptible (dead) plots are surrounded by tolerant mutants (green plots)(photo courtesy of the International Rice Research Institute).

Finger millet (*Eleusine coracana* (L.) Gaertn.) is an important traditional food crop in Zambia because its grains are rich in essential minerals and sulphur containing amino acids. Existing varieties, however, have limited yields and are often susceptible to pests and diseases. The Agency assisted the Misamfu Regional Research Centre in Kasama and the National Institute for Scientific and Industrial Research in Lusaka in identifying two mutant lines with an average of 10 fingers per head and yields of 6–8 tonnes per hectare. These lines were then tested through on-farm trials and feedback was obtained from farmers and other interested groups from the region. One of the selected lines (FMM 165) is now undergoing seed multiplication for distribution to farmers.

Agency support to the Agricultural Research Corporation in Wad Medani, Sudan, for banana improvement resulted in the identification of a clone with a potential yield of 53 tonnes per hectare. This is 37–46% higher compared with the yield of the standard cultivars 'Dwarf Cavendish' and 'Williams'. The clone, which also shows favourable quality characters, was released as 'Elbeili' and is now being mass propagated and disseminated to farmers.

Animal Production and Health

To help farmers choose the best diets and feeding strategies for their cattle, buffalo and camels, an Agency CRP developed models based on infusions of carbon-14 labelled allantoin, uric acid and purine bases that allow farmers and feed manufacturers to estimate the supply of rumen microbial proteins to animals from spot urine samples. Use of this procedure in Malaysia and Thailand led to a drop in feeding costs and a concomitant increase in animal productivity, as well as more effective use of locally available feed resources.

In many developing countries a major constraint on livestock productivity is the low production of milk and meat. To help increase production, and the associated economic benefits, the Agency developed a computer based management and decision support database, a manual with guidelines and recommendations for professionals engaged in artificial insemination (AI) and a CD-ROM for continued education and training of field AI technicians for improving the delivery of AI services to farmers. These tools were transferred to over 4000 livestock personnel and farmers through national training and education programmes in Asia and Africa.

Agency support to Member States and the international community for controlling transboundary animal diseases included assistance to a number of African and Asian countries in diagnosis and surveillance for the Global Rinderpest Eradication Programme (GREP). As a consequence, six West African countries were officially declared free from rinderpest by the Office International des épizooties (OIE). Pakistan, the last Asian country with rinderpest, and where a rinderpest workshop was held in 2003, stopped all vaccination and declared provisional freedom from rinderpest. In Mongolia, a similar workshop was held and the country submitted a national dossier to the OIE for a declaration of freedom from rinderpest.

In other activities related to animal disease control, the Agency provided recommendations to the OIE to improve the validation of diagnostic tests, based on data generated through research and technical

The Road to Freedom from Rinderpest in Pakistan

In 2003, Pakistan declared itself "provisionally free" from the deadly cattle plague rinderpest. The last cases of this highly infectious viral disease that can destroy entire populations of cattle and buffalo were detected in October 2000. For a country to declare itself provisionally free from rinderpest it must prove that there has been no outbreak for at least two years, that it has stopped vaccination and that a surveillance system is in place according to the rules of the OIE. Pakistan's success story is a major milestone in the Global Rinderpest Eradication Campaign and a major step nearer to the goal of rinderpest eradication by 2010. The Agency was an important part of this effort through the supply of essential laboratory equipment and kits to allow diagnosis of the disease, training and the provision of experts.

cooperation activities. Additionally, the OIE accepted, for regulatory purposes, a new diagnostic test for contagious bovine pleuropneumonia — the most important transboundary animal disease in Africa. This test was validated through a CRP involving 12 African countries. The Agency also developed kits for the detection of antibodies against the non-structural proteins of the foot and mouth disease virus to discriminate between vaccinated and field infected cases, and Senegal has now acquired the capability for the sustainable production and distribution of kits for the detection of antibodies to the African swine fever virus.

Insect Pest Control

In Central America, governments have promoted the production and export of tropical fruit crops as a viable alternative to coffee, sugarcane and banana, whose prices have fallen sharply in the past ten years due to worldwide surplus production. Fruit fly pests, however, limit production and commercialization of tropical fruits. Under an Agency regional project for application of the sterile insect technique (SIT), FAO, the Inter-American Institute for Cooperation on Agriculture, the International Regional Organization for Plant and Animal Health (OIRSA) and the US Department of Agriculture formed an alliance to assist Central American countries in establishing areas that are free from or have a low prevalence of fruit flies. One area, in Quetzaltenango, Guatemala, where peaches and apples are commercially produced, was officially certified as fruit fly free in 2003, thus allowing the export of fresh fruit from this area to Mexico without quarantine restrictions. In addition, two areas in Guanacaste, Costa Rica, were also officially declared free from the Mediterranean Fruit Fly.

Invasive insect pests are increasingly threatening agriculture and the environment in many parts of the world. One example is the cactus moth, *Cactoblastis cactorum*, which has the potential to affect subsistence farmers who depend on *Opuntia* (cactus) cultivation for food and income from its products in Central and South America and in North Africa. The Agency supported the development of SIT and other complementary technologies through research contracts. In addition, a technical cooperation project in Mexico to prevent the introduction and establishment of this pest sought to raise awareness of the problem through training sessions and the preparation of promotional material.

A CRP on the application of genetics to improve SIT for tsetse control/eradication was concluded; the results will be published in the journal *Genome*. The CRP has led to the development of genetic tools for studying tsetse flies and to the finding that tsetse populations show an unexpectedly high degree of genetic differentiation, facilitating SIT intervention.

A mosquito rearing facility at the FAO/IAEA Agriculture and Biotechnology Laboratory in Seibersdorf was completed and inaugurated in June 2003. As a result, a good basis has been created to initiate the first phase of the mosquito SIT R&D programme, which can now commence with the successful establishment of a colony of the African malaria vector *Anopheles arabiensis* and the identification of potential field sites in northern Sudan and Reunion Island.

Food Quality and Safety

Significant inputs provided by the International Consultative Group on Food Irradiation (ICGFI), of which the Agency is a key member, led to the adoption of a newly revised 'Codex General Standard for Irradiated Foods', as well as a newly revised Codex Recommended International Code of Practice for Radiation Processing of Food, at the 26th Session of the Codex Alimentarius Commission. Partly as a result of research in a CRP and on the basis of discussions at ICGFI, the 5th Session of the Interim

Commission on Phytosanitary Measures adopted *Guidelines for the Use of Irradiation as a Phytosanitary Measure* as part of the International Standards for Phytosanitary Measures series.

Critical elements in the establishment of international standards related to food quality and safety include the elaboration and validation of methods of analysis and sampling for the determination and control of contaminants in foods, water and soil, such as radionuclides, mycotoxins, toxic metals and pesticides. Such methods are necessary to ensure the reliability and international acceptance of food contaminant analyses, thereby minimizing the distorting effects of technical barriers to trade, especially for developing countries. Work by the FAO/IAEA Agriculture and Biotechnology Laboratory at Seibersdorf led to the successful adoption of 'Guidelines for Single-Laboratory Validation of Methods of Analysis' as a final Codex text. ■

Responding to Nuclear and Radiological Emergencies Affecting the Food Chain

Nuclear and radiological emergencies can affect the quality and safety of foods, as well as the production and export of agricultural commodities over long periods of time. Cooperative arrangements between the Agency and FAO for notification, information exchange and technical support in relation to food and agriculture in the case of a nuclear or radiological emergency were agreed in April 2003. FAO's Emergency Coordination Group oversees the implementation of the arrangements and is responsible for an integrated FAO response, including interdisciplinary action on disaster prevention, mitigation and preparedness, and post-emergency relief and rehabilitation, or REHA. A network of technical experts was formed to develop and implement the relevant REHA tasks. The centrepiece of the 2003 work plan was an FAO/IAEA workshop on practical agricultural countermeasures, organized in Greece. Information is being distributed on CD-ROM and on the Internet to assist those Member States that do not have a basic emergency response plan for food and agriculture.

Human Health

Objective

To enhance capabilities in developing Member States to address needs related to the prevention, diagnosis and treatment of health problems through the development and application of nuclear techniques.

Nuclear Medicine

Nuclear medicine procedures have been widely recognized in clinical practice as indispensable tools for the diagnosis and management of a number of benign and malignant disorders. A new radiopharmaceutical for the treatment of liver cancer, rhenium-188 Lipiodol, was developed within the framework of an Agency CRP. In the clinical phase study, 133 patients were treated at eight participating centres, with encouraging results so far. The median survival of patients treated with Lipiodol is 12 months (with a range of 7–32 months), compared with the typical 3–4 month survival obtained with current treatments. Seven post-graduate students are participating in this CRP as part of their doctoral theses.

Another new therapeutic nuclear medicine procedure, intravascular radionuclide therapy using liquid rhenium-188 Perrhenate inside an angioplasty balloon catheter, was developed and tested on 178 patients. The procedure has produced results that are similar to those obtained using commercial procedures, but at considerably less cost.

Technologies related to in vivo and in vitro molecular nuclear medicine procedures for the diagnosis and prediction of treatment response in patients suffering from breast cancer and hepatitis B and C were transferred to several Member States. Imaging with the radiopharmaceutical technetium-99m Sestamibi (which is traditionally used for studying heart perfusion) was used as a predictor of response to treatment with chemotherapeutic agents in breast cancer by eight participating centres. Image processing showed excellent correlation with a clinical response evaluated on the basis of WHO criteria. The results of genotyping using in vitro molecular methods have provided guidelines for the management of patients suffering from hepatitis B and C, especially with regard to their diagnosis, transmission pattern and treatment. These Agency initiatives have resulted in an increased acceptance of molecular diagnostic technology. Further, a CRP on radioimmunoassay successfully raised polyclonal antibodies to alpha fetoprotein (a tumour marker for liver cancer) in research centres in developing countries.

The Agency's efforts to promote nuclear medicine techniques and procedures are complemented by the use of information technology and communication tools. These tools were developed and disseminated for the promotion and use of 'tele-nuclear medicine' in developing countries. The associated software has also been developed and is being tested in Latin America, where the Agency supports a tele-nuclear medicine network connecting 15 countries. Twelve modules for distance assisted training for nuclear medicine technologists were completed and will be published in 2004. In addition, a session on tele-nuclear medicine was held at the scientific forum on innovative nuclear approaches during the regular session of the Agency's General Conference in 2003.

Applied Radiation Biology and Radiotherapy

As a result of increasing life expectancy, cancer is expected to increase worldwide from the current 10 million new cases per year to 15 million new cases in 2015. With the aim of developing more effective cancer treatment strategies by Member States, two new CRPs were started in 2003. One seeks to improve the results of radiotherapy for treating nasopharynx cancer, which is a major problem in developing countries, particularly in South East Asia and northern Africa. The other CRP focuses on the radiotherapy of cancer of the cervix in AIDS patients. While treatments of AIDS are improving, the survivors can suffer from an increased frequency of certain types of cancers, including cancer of the cervix. While radiotherapy is a primary means of treatment of this disease, there is evidence that the radiation side effects in many AIDS patients are more severe, and new protocols need to be devised to meet the growing need for better treatment. Associated laboratory studies are also planned to elucidate the mechanism of this increased sensitivity.

Radiotherapy is a proven and accepted treatment for cancer (Fig. 1). However, many developing countries are extremely short of equipment and qualified staff. The Agency's activities in ameliorating this situation included the provision of equipment and training of staff under more than 60 national and

FIG. 1. Patient set-up for radiotherapy.

regional technical cooperation projects. Support was also given to the development of a trial distance learning course for trainee radiation oncologists. The shortage of trained therapy radiographers is another major problem, leading to underutilization of even the existing scarce radiotherapy equipment — a syllabus to help developing countries establish programmes for the training of therapy radiographers was prepared.

Tissue allografts (grafts from one person to another) are usually sterilized by very high doses of radiation to kill microbial contaminants. A Code of Practice for the dose and the conditions of irradiation was finalized by a group of experts assembled by the Agency from hospitals, academic institutions and industry. Subsequently, the Agency started an interregional project for Europe, Latin America and South East Asia.

Dosimetry and Medical Radiation Physics

The Agency provides a dosimetry calibration service, linked to the SI system of measurements, for the safe and effective use of radiation for the diagnosis and treatment of diseases. In this connection, the Agency's Dosimetry Laboratory participated in two comparisons with regional metrology organizations in Europe and Asia to demonstrate the quality of its calibration services. The Agency also maintains the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories (the IAEA/WHO SSDL Network), providing substantial development and operational support through training and the provision of expertise. This network was expanded in 2003 by adding laboratories in Albania, Croatia, Georgia and Kuwait through the Agency's technical cooperation programme.

The development and dissemination of national dosimetry standards for mammography were important components of the work carried out by the Agency's Dosimetry Laboratory in the field of diagnostic radiology. This was in addition to work on the development of a calibration facility for use in general and dental radiography, computed tomography and fluoroscopy, with standardization and calibration procedures also being developed and tested.

Conducting dosimetry audits through the IAEA–WHO Thermoluminescent Dosimetry (TLD) postal dose quality audit service is an important part of a quality assurance (QA) programme offered to Member States (Fig. 2). The TLD audit service checked the calibration of about 100 radiotherapy beams in SSDLs and almost 500 hospital beams. This represents a growth of approximately 25% compared with previous years. In addition, more than 100 new hospitals, mainly from the western Pacific region, joined the TLD network. The scientific and organizational aspects of this service were given special attention, including development of new electronic data sheets to facilitate data processing. Follow-up procedures were implemented for 32 hospitals having TLD results outside the 5% acceptance limit, leading to clarification of the reasons for dose discrepancies and improvement of dosimetry practices.

A total of 41 cobalt-60 beams from industrial facilities and research institutes were checked for the measurement of the high doses that are used in product sterilization, food irradiation and radiation processing by the International Dose Assurance Service. Approximately 80% of the checks were found to be within the acceptance level of 5%, and those outside were contacted by the Agency to resolve the discrepancies.

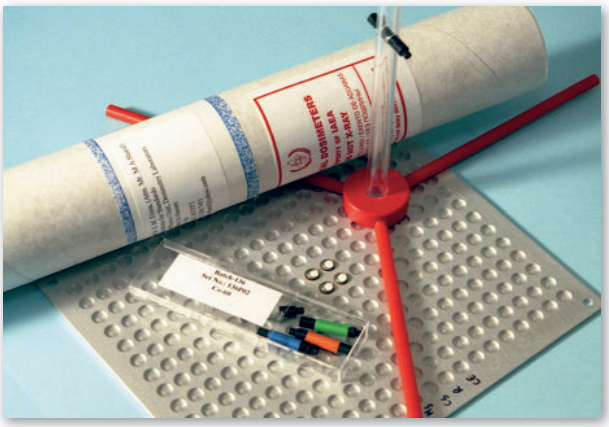


FIG. 2. The TLD service for dosimetry audits in radiotherapy.

Nutrition and Effects of Contaminants on Human Health

Nuclear based and related techniques are widely recognized as critical tools in seeking solutions for malnutrition, because of their specificity and high sensitivity and the possibility of introducing less invasive procedures. Three CRPs addressing infant growth monitoring, the significance of infection in children, and body compositional changes leading to obesity were completed. The use of deuterium labelled water for measuring the breast milk intakes by infants provided valuable information on the nutrient requirements of healthy breast fed babies, who were assessed according to WHO standard protocols. Using carbon-13 labelled urea and a breath test (carbon-13–UBT), procedures were established in Argentina, Bangladesh, Benin, Chile, the Democratic Republic of the Congo, Cuba, India, Indonesia, Mexico, Pakistan and Senegal to track down *Helicobacter pylori* and its impact on the nutritional status and growth of children. Brazil, Chile, China, Cuba, India, Jamaica, Mexico and Nigeria were assisted using doubly labelled water to develop methods to study body compositional changes related to obesity and non-insulin dependent diabetes mellitus in high risk populations. These CRPs are linked to the United Nations global strategy on human nutrition. Continuing this linkage, the Agency has implemented two new CRPs dealing with low birthweight babies and physical activity and lifestyles, in support of its collaborative activities with WHO.

The impact of mercury in aquatic ecosystems on the health of people living nearby was investigated using nuclear and isotopic techniques for the measurement of methylation and de-methylation rates of mercury. Mercury levels (including the more potent organic form of mercury) in fish and vegetables, and in the urine and hair of subjects consuming the contaminated foods, were evaluated to trace the uptake routes. The results confirmed that the major uptake in vegetables was from the air, while uptake in fish was due to pollution from mining activities. With regard to other contaminants such as arsenic, cadmium and lead, Bangladesh, Brazil, Chile, China, India, Kenya, the Republic of Korea, Morocco, Peru and Vietnam have validated methodologies for a better understanding of nutrition–pollution interactions.

At an international conference on 'Isotope and Nuclear Analytical Techniques for Health and Environment', organized by the Agency in June in Vienna, participants sought to identify potential opportunities for developing countries to apply a broad range of isotopic and nuclear analytical techniques in health and environmental studies, and to consider the promotion and transfer of such technology. International developments and trends in health care, nutrition and environmental monitoring were also reviewed. The conference participants concluded that the Agency's efforts in supporting innovative applications of nuclear and related techniques for problem solving in the areas of health and environment have been significant and timely. These applications will receive greater dissemination with the publication of a selection of conference papers in the *Journal of Analytical and Bioanalytical Chemistry*.

Water Resources

Objective

To increase the capability of Member States to improve the integrated management of water resources and geothermal resources, as well as specific water supply infrastructures, through the use of isotope technology.

Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources

At the Agency's 11th international symposium on isotope hydrology and integrated water resources management, held in Vienna in May 2003, the state of the art in isotope techniques and their application to water resources management were reviewed, confirming that groundwater sustainability issues remain the mainstay for isotope applications, while application in climate modelling and watershed management has also become increasingly important. The Agency's global isotope databases for precipitation, and those planned for rivers and groundwater, were considered to be critical. The symposium concluded that there was a need to further expand efforts in global data collection in all environments.

A better understanding of the Earth's water cycle is one of the key elements of the Johannesburg Plan of Implementation resulting from the 2002 World Summit on Sustainable Development. Several initiatives were taken to help develop a better scientific basis for isotope applications in water cycle research. As a result of the Agency's efforts since 2001, isotopes are now well integrated in the WMO/World Climate Research Programme GEWEX (Global Energy and Water Cycle Experiment) project. An IAEA–GEWEX workshop evaluated the potential means of integrating precipitation isotope data in moisture source tracing models and, as a first step, initiated an international intercomparison of the isotopic modules in different global circulation models.

Two new CRPs were formulated to develop isotope applications in water cycle studies. One of the proposed CRPs will develop methods for the study of water and carbon cycle dynamics, focusing on the isotope analysis of atmospheric, leaf and soil moisture to characterize water and carbon exchange between the land surface and atmosphere. Improved understanding of moisture fluxes will lead to better models of present and future climate conditions. The second CRP aims to develop a basis for the assessment of groundwater sustainability by using the residence time and flow paths of base flow (groundwater discharge) in large river basins. This CRP will complement research being conducted in an ongoing CRP on the isotopic monitoring of river discharge. In addition, the re-orientation and strengthening of the Global Network for Isotopes in Precipitation, through monthly and/or daily sampling at 170 stations in 53 countries, is expected to increase use of the network in climate and hydrological research.

Partnerships with other international agencies and programmes were further strengthened. A strong link was established with the UNEP–Global Environment Monitoring System–Water Programme (GEMS/Water) through a joint project on interlaboratory comparison exercises for water chemistry aimed at improving the quality of chemical data worldwide. In collaboration with UNESCO, the Agency organized a meeting on indicators of groundwater resource sustainability. The working group focused on identification and review of groundwater indicators and produced a draft document which will be included in the next edition of the *World Water Development Report* of the United Nations. Another partnership effort featured a regional training course on isotope hydrogeology in Panama in October 2003 under the Joint International Isotopes in Hydrology Programme between the Agency and UNESCO.

The Agency implemented two projects within AFRA and RCA on isotope techniques in dam safety and sustainability. The projects enhanced Member State capacities for isotope applications and led to increased awareness of these techniques among scientists and dam managers through a variety of case studies where naturally occurring environmental isotopes were used to identify the origin of water downstream of a dam reservoir.

More than 70 technical cooperation projects in water resources development and management were implemented in Africa, the Middle East, Asia and Latin America. In Uganda, a project implemented together with the Austrian Development Cooperation led to the delineation of recharge areas

Using Isotopes to Characterize Groundwater Salinity

Increased pressure on freshwater resources comes partly through an increased demand for irrigated food production, which in turn may lead to a loss of available water resources as a result of pollution and salinization. A technical meeting highlighted the role of isotope techniques in the development of improved management practices to minimize deleterious impacts of irrigation return water on groundwater. In addition to the return of irrigation water with elevated salt content, groundwater salinization may also result from present-day or ancient seawater intrusion or dissolution of salt deposits. Isotope methods for investigating the origins of salinity were the subject of a CRP initiated in 2000 with research groups from Australia, China, France, Israel, Italy, Jordan, Republic of Korea, Morocco, Pakistan, Sweden and the United Kingdom. Results now show that isotopes provide unique and cost effective means to investigate the cause of groundwater salinization.

of Chuho Springs, near Kisoro town. These springs are being developed as a source of freshwater for the township and surroundings. The results of isotope investigations provided unique information critical for the sustainability of the source of water. In Vietnam, isotope hydrochemical investigations revealed the causes of groundwater salinization in Ho Chi Minh City.

Reference Isotope Data and Analysis for Hydrological Applications

The Agency continued to improve analytical services and training to Member State scientists. For instance, analytical support was provided for 30 different technical cooperation projects, with the services being co-ordinated through a network of Member State laboratories. The aim is to provide timely data for projects and improve the quality of analysis. The results of interlaboratory comparisons for isotopes of water and boron were disseminated to the participating laboratories for maintaining quality control in their measurements. Nearly 700 stable isotope reference materials were supplied to the various laboratories across the world.

Building and developing human resources in the field of isotope hydrology is an important activity for the Agency. Nearly 20 training courses, workshops and seminars were organized for developing Member States. In addition, human resource development is being implemented through computer aided self-learning tools and the appropriate printed material. ■

FIG. 1. Participants at an Agency training course in Indonesia learn how to collect water samples for determining the age of groundwater by carbon-14 analysis.

Protection of the Marine and Terrestrial Environments

Objective

To increase the capability of Member States in the identification and mitigation of marine and terrestrial environmental problems due to radioactive and non-radioactive pollutants.

Measurement and Assessment of Radionuclides in the Marine Environment

The first global expedition for marine isotope studies in the Southern Hemisphere oceans (BEAGLE–Blue Earth Global Expedition), organized by the Japan Marine Science and Technology Centre with the participation of the Agency's Marine Environment Laboratory (IAEA-MEL), has the objective of studying water and heat transport from the equatorial regions to the Antarctic Ocean. This programme is relevant to general global climate change studies. Seawater profile samples down to 6000 metres were collected for isotopic analysis. Preliminary results from the Pacific leg of the expedition indicate that Antarctic bottom waters are cooling and the Antarctic surface water temperature has been increasing over recent years.

A joint IAEA–UNESCO expedition involving six Member States was undertaken off the coast of Brazil to trace submarine groundwater discharge in coastal zones using nuclear and isotopic techniques. The investigations by IAEA-MEL confirmed that this area has been strongly influenced by such discharges transporting nutrients and contaminants to coastal waters.

Natural radiotracers were used on several cruises to study oceanic processes and the ocean's role in climate change. IAEA-MEL participated in fieldwork supported by the US National Science Foundation to understand the biological processes involved in carbon sequestration in surface waters, and to assess the influence of minerals on carbon export to the deep ocean. Cruises in the northwest Mediterranean quantified fluxes using particle traps (Fig. 1), and estimated carbon fluxes from uranium-238:thorium-234 disequilibria measurements in water. Organic to inorganic carbon ratios in sinking particles varied with their settling velocity, and were generally higher in the more slowly settling material. In a related project with France, measurements from four cruises using the uranium-238 : thoron-234 disequilibria method were employed to determine the relationship between barite formation in the water column and carbon removal from the biosphere. Since the ocean contains 50 times more carbon dioxide than the atmosphere, these studies yield crucial information on rates, mechanisms, locations and the capacity of the ocean to act as a global carbon sink for atmospheric carbon dioxide.

Assistance was provided to Member State laboratories within the framework of the Agency's Analytical Quality Control Services programme for the analysis of radionuclides in the marine environment. An evaluation of a worldwide intercomparison exercise on a mixed fish sample from the Irish and North Seas was completed, showing improved radionuclide measurements from over 130 laboratories. Reference materials for non-nuclear contaminants were also provided; a fish sample was distributed for metals and methylmercury analyses, with results received from 105 laboratories in 47 countries. Finally, a mussel sample for organic pollutant analyses drew results from 89 laboratories in 44 countries.

Transfer of Radionuclides in the Marine Environment

IAEA-MEL assessed local marine organisms in experimental and field studies as potential bio-indicators of metal contamination in the lagoon of French

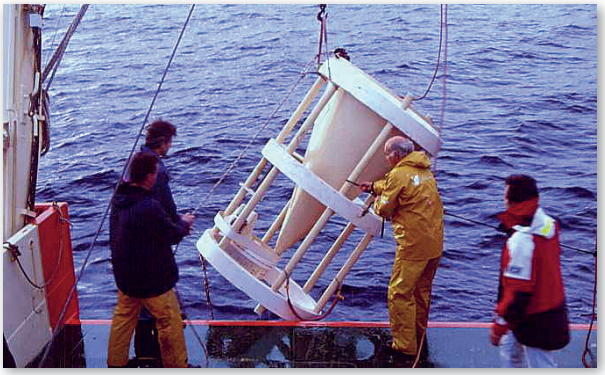


FIG. 1. Deployment of particle traps for measuring ocean carbon isotopes and sinking.

New Caledonia, in the southwestern Pacific Ocean. This lagoon is an excellent model for studying contamination in tropical coastal ecosystems because it is subjected to large inputs of metals from land based mining activities. Metal bioaccumulation and retention was determined in organisms following experimental exposure to metal radiotracers. The results indicated that all the metals tested were incorporated and strongly retained in organisms when exposed to contaminated sea water or food, whereas a very low bioavailability of sediment bound metals was observed. Brown alga and oysters were deemed the most suitable species to furnish reliable information on metal levels in the lagoon.

A new regional technical cooperation project on enhancing the sustainability of the marine coastal environment was initiated. This project will augment the regional database for radionuclides in the marine environment, apply nuclear techniques to track pollutants in heavily contaminated coastal zones, and transfer to Member States the radiolabelled receptor binding assay technology for quantifying algal toxins in shellfish. An interregional technical cooperation project was started on harmful algal blooms following an agreement with the USA to provide a three year supply of tritiated saxitoxin.

Monitoring and Study of Marine Pollution

Contaminant screening provides key information on environmental quality, and IAEA-MEL received external funding to assist Member States and members of UNEP's Regional Seas Programmes in this effort. Collaboration continued with UNEP's Programme for the Assessment and Control of Pollution in the Mediterranean Region (MED POL) and with the Regional Organisation for the Protection of the Marine Environment (ROPME) in the Gulf. A comprehensive marine environmental survey of sediments and biota was conducted along the coastline of the United Arab Emirates as a first step in assessing marine pollution; concurrent training in sampling was provided to 12 scientists. IAEA-MEL field activities included seeking evidence in the Kuwait sediment record of oil pollution from the 1991 Gulf War (Fig. 2), continuing collaboration with the Black Sea Environment Programme on a marine pollution study in the western Black Sea, and designing an environmental monitoring programme on behalf of the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden.

Under a technical cooperation regional project, analyses of sediment samples from North African coastlines for radionuclides, heavy metals and organic compounds showed decreasing concentrations of contaminants. A new project in Angola was established to transfer the capability to assess marine pollution arising from offshore oil related activities.

Measurement and Assessment of Radionuclides and Non-radioactive Pollutants in the Terrestrial Environment

Analytical results for depleted uranium were provided for the Agency's study of the radiological conditions in Kuwait. The Agency also supported two World Bank initiatives in Belarus and Kazakhstan, providing advice on radionuclide and economic issues related to the utilization of radioactively contaminated lands for growing commercial crops.

Instrumentation activities concentrated on improvements in the hardware of the laboratory microbeam X ray fluorescence (XRF) spectrometer, including construction of a multipurpose sample holder and micromanipulator stage. Automatic data acquisition can now be carried out using newly developed software, allowing for simultaneous optical and micro-XRF identification of individual particles or structures as well as for performing accurate micro-tomographic scans. A procedure for the identification and relocation of individual particles was developed and tested. In addition, a quantitative procedure for the analysis of minute samples by using the microbeam XRF spectrometer was developed and applied. ■

FIG. 2. Typical seashore contamination from oil pollution.

Physical and Chemical Applications

Objective

To increase Member State capabilities in the application of radioisotopes and radiation processing as tools for sustainable economic development.

Radiochemical Applications

Assisting Member States in the development of new diagnostic and therapeutic radiopharmaceuticals for local use is one of the major goals of the Agency's activities in the area of physical and chemical applications. In this connection, a CRP on the development of technetium-99m based radiopharmaceuticals for infection imaging was completed. Ubiquicidine (UBI), an anti-microbial peptide, was labelled with technetium-99m and evaluated in vitro and in vivo. Preliminary clinical studies in Mexico using technetium-99m UBI showed that images with intense accumulation of acute infection were obtained using this radiopharmaceutical.

A CRP for optimizing cyclotron radioisotope production by using solid targets and high current irradiation was completed. It has stimulated collaborative research and produced original data for the fabrication of cyclotron solid targets capable of withstanding high beam currents. This will promote increased reliability and better economics of radionuclide production programmes. The results have shown that compact, medium current cyclotrons can produce adequate amounts of radionuclides such as palladium-103 for cancer brachytherapy applications. Practical radionuclide production yields have been increased by up to 30% in some instances, contributing to an improvement in the efficiency and economics of radionuclide production programmes.

Training in radiochemistry and exploitation of particular applications for nuclear analytical techniques were the focus of radioanalytical activities in 2003. Development began of training modules for radiochemists, comprising training course material, lecture notes and a series of in-depth modules to address subjects such as nuclear analytical techniques, chemical separations, isotopic techniques, radioecology and environmental radioactivity, radiation safety and dosimetry, and quality assurance and quality control.

Under an RCA project for East Asia and the Pacific, the progress of participating Member State laboratories in achieving compliance with ISO/IEC 17025 in the field of nuclear analytical techniques was evaluated. Reports have shown that most have implemented the quality system. Nuclear analytical laboratories in Hungary, Indonesia, Republic of Korea, Romania and Slovenia obtained national accreditation in 2003 towards ISO/IEC 17025.

The Agency's Analytical Quality Control Services (AQCS) web site *(www.iaea.org/programmes/aqcs)* was made fully operational to provide on-line facilities for ordering reference materials and to provide information on AQCS activities for Member States. A total of 208 orders for AQCS products were received in 2003 from approximately 200 customers, and 625 AQCS reference materials valued at $65 430 were sold. The Agency's Laboratories at Seibersdorf produce and distribute reference materials and also provide AQCS services.

Radiation Processing, Radiography and Radiotracer Applications

Investigation is needed into the effects of irradiation on polymers and natural resources that can be made into marketable products, such as biodegradable materials. To further research in this area, the Agency started a new CRP on controlling degradation effects in the radiation processing of polymers. Participants reported on the application of analytical techniques such as synchrotron radiation, positron annihilation methods and electron spin resonance spectroscopy that permit a deeper analysis of radiation induced effects, opening up possibilities for the development of new materials and products.

Following the commercialization of hydrogel wound dressing technology based on natural and synthetic polymers (Fig. 1), R&D on the process was completed in Egypt and the Syrian Arab Republic. Under the RCA programme, hydrogels commercialized in India, Malaysia and Vietnam; research continues in Bangladesh, China, Philippines and Thailand.

A new CRP on industrial process gamma tomography was initiated to test and validate techniques for multiphase flow systems. This CRP will assist specialists in developing countries in introducing this technique for the visualization and optimization of complex industrial processes. Another CRP, on integration of residence time distribution (RTD) tracing with computational fluid dynamics (CFD) simulation

FIG. 1. Burn wound healing of a leg treated with a radiation processed, chitosan based, hydrogel wound dressing.

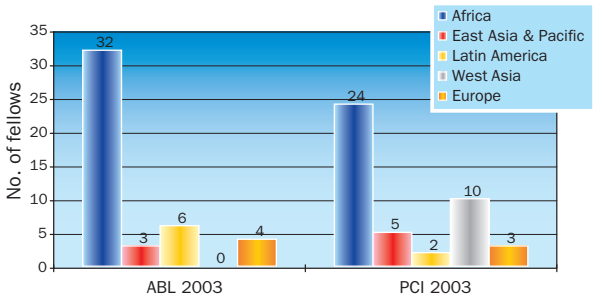


FIG. 2. Number of fellows receiving training in 2003 at the Agency's Laboratories at Seibersdorf, by geographical region (ABL: Agriculture and Biotechnology Laboratory; PCI: Physics, Chemistry and Instrumentation Laboratory).

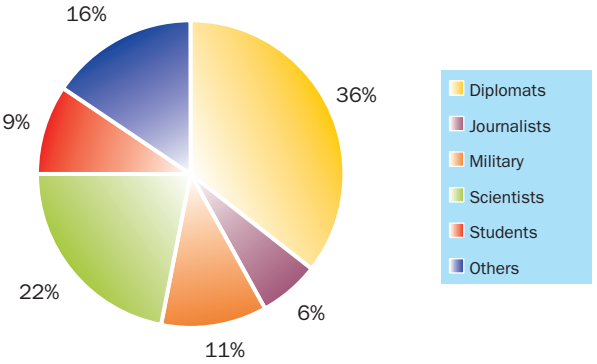


FIG. 3. Profession of visitors who toured the Agency's Laboratories at Seibersdorf in 2003.

for industrial process visualization and optimization was completed. As a result, a CFD–RTD integrated software package was validated for industrial process modelling.

Advances in land mine detection technology were achieved through a CRP on nuclear techniques for the identification of anti-personnel land mines. Specifically, several new prototype instruments for humanitarian demining were developed, as well as a standardized dummy plastic land mine to facilitate intercomparison tests of demining devices. Testing, repair and maintenance of the devices are being performed at the Agency's Laboratories at Seibersdorf. The research has also generated several technical cooperation projects and proposals in and from Member States affected by the presence of land mines. There was also interaction between scientists from Member States with a land mine problem and scientists from other States.

The Agency's Laboratories at Seibersdorf support the implementation of the various scientific and technical programmes of the Agency by providing experimental facilities and services. For example, the Safeguards Analytical Laboratory conducts sample analysis. In 2003, the number of environmental samples analysed in the Clean Laboratory increased from about 400 to 600. The Laboratories also continued to attract many fellows, with 89 receiving training (Fig. 2). The Laboratories received 371 visitors during the year; the percentage breakdown by profession of the visitors is shown in Fig. 3. ■

A Milestone in the Radiation Treatment of Flue Gas

A breakthrough in radiation technology for flue gas purification from sulphur and nitrogen oxides was achieved in 2003. After testing, an industrial plant in Poland with a 1 MW power electron accelerator, the biggest radiation processing facility ever built, commenced full operation in June 2003. The by-product is used as a fertilizer, making the technology very competitive.

Safety

Safety of Nuclear Installations

Objective

To increase the capacity of Member States to achieve and maintain a high level of safety in nuclear installations under design and construction or in operation.

Regulatory Infrastructure for Nuclear Safety

The first phase of an extrabudgetary programme on the safety of nuclear installations in Southeast Asian, Pacific and Far Eastern countries was completed in 2003. This initiative assisted China, Indonesia, Malaysia, Philippines, Thailand and Vietnam in enhancing the safety of their nuclear power plants and research reactors, and in strengthening their legal and governmental safety infrastructures. A pilot project on education and training was also completed and demonstrated the feasibility of sharing safety knowledge through the establishment of a web based regional safety network among participating countries. The network will be implemented in the second phase of the programme, which starts in 2004.

Full scope International Regulatory Review Team (IRRT) missions were carried out in Bulgaria and Pakistan. In addition, four follow-up IRRT missions visited Finland, Hungary, Indonesia and Switzerland. These missions identified four main issues: regulatory body resources, competency and training of staff, succession planning and the need for internal and external regulatory guidance. In some instances, the missions identified a need for introducing a quality management system to assist the regulatory body in improving its overall performance and enhancing the conduct of its regulatory activities. In general, the follow-up IRRT missions noted that regulatory bodies have made significant progress in resolving issues raised during the full scope missions.

The IAEA–OECD/NEA Incident Reporting System (IRS) was set up in 1983 to exchange information on unusual events at nuclear power plants and increase awareness of actual and potential safety problems. In 2003, there were 71 new reports, slightly more than in 2002. Since the reporting rate has been comparatively low over the last few years, the joint Secretariat took steps to increase the awareness in Member States of the need for more proactive participation. The number of countries participating in the Incident Reporting System for Research Reactors (IRSRR) increased from 32 to 38, covering more than 85% of the current operating fleet of research reactors.

Development of Safety Assessment Methods and Tools

Three International Probabilistic Safety Assessment Review Team (IPSART) missions, varying from level 1 to full scope level 2, were conducted to verify the adequacy of modelling data and important methodology issues stemming from the development of PSAs. In general, the overall quality of the PSAs reviewed during these missions was better than that seen in previous missions.

In response to an increasing focus on severe accidents in activities associated with the design and operation of nuclear power plants, the Agency developed a new service, 'Review of Accident Management Programmes' (RAMP). This service will assess the safety status in various phases of accident management programmes and compare that status with international experience and practices.

An extrabudgetary programme on 'Accident Analysis and its Associated Training Programme for the RBMK 1000 Kursk Nuclear Power Plant' was initiated in 2001 to enhance the accident analysis capability at the plant. The second phase of this programme, which focused on the development of a computer based 'Integrated Training and Accident Analysis System' (ITAAS), was completed in 2003. ITAAS provides a software and hardware tool for comprehensive, integrated accident analysis, safety analysis and technical training.

The Agency started a new CRP on 'Assessment of the Interfaces between Neutronic, Thermal–Hydraulic, Structural and Radiological Aspects in Accident Analyses'. This project is devoted to the investigation of various aspects of large leaks from the primary system to the secondary system and includes the analysis of uncertainties. For each of the hazards that could result from this type of accident, comparison of results from best estimate calculations and conservative calculations will be performed.

Engineering Safety of Existing Nuclear Installations

The Agency initiated an extrabudgetary programme on the safety aspects of the long

Progress in Establishing an International Consensus on Nuclear Safety

With the publication of a Safety Requirements document and six Safety Guides, the Agency completed the set of 21 Safety Standards Series documents on design and site evaluation. The seven titles published in 2003 included:

- Site evaluation for nuclear installations (NS-R-3) (Safety Requirements);
- Commissioning for nuclear power plants (NS-G-2.9) (Safety Guide);
- Periodic safety review of nuclear power plants (NS-G-2.10) (Safety Guide);
- External human induced events in site evaluation for nuclear power plants (NS-G-3.1) (Safety Guide);
- Dispersion of radioactive material in air and water and consideration of population distribution in site evaluation for nuclear power plants (NS-G-3.2) (Safety Guide);
- Evaluation of seismic hazards for nuclear power plants (NS-G-3.3) (Safety Guide);
- Meteorological events in site evaluation for nuclear power plants (NS-G-3.4) (Safety Guide).

term operation (LTO) of PWRs. The programme's objectives are to assist Member States in reconciling the multitude of related processes and practices and in establishing a general LTO framework. It will also provide these Member States with a forum for the exchange of information. The programme activities will be implemented through four working groups guided by a programme steering committee.

A CRP on seismic issues was completed in 2003. It addressed hazard, design and operational experience. A final document with the main contributions and conclusions will be issued in 2004.

The seismic evaluation of existing nuclear facilities was the focus of a symposium held in Vienna in August 2003. In addition to providing an important forum for the exchange of experience, the meeting confirmed the need for a safety standard on this issue. It also identified a number of items of concern: seismic considerations in safety assessments, such as the significance of high acceleration records and the treatment of uncertainties; unresolved issues in the assessment of structures and components; preparedness in the case of a seismic event; and scope extension to include nuclear installations other than nuclear power plants.

Operational Safety

Five Operational Safety Review Team (OSART) missions, four OSART follow-up visits and six preparatory meetings were conducted in 2003. Increased emphasis was placed on the promotion of effective self-assessment by operating organizations. A pilot study to review operating experience feedback was carried out during the OSART mission at the Civaux nuclear power plant in France; another pilot study for a more in-depth review of safety culture was carried out in conjunction with the OSART mission at the Krško nuclear power plant in Slovenia. The overall conclusion gathered from OSART missions is that managers are committed to improving the operational safety and reliability of their plants. The rate of resolution of and compliance with the Agency's recommendations at follow-up missions in 2003 remained at approximately 97%. An overall improvement was observed in the areas of safety management, industrial safety and plant material conditions. Improvements were also noted in reporting criteria and the analysis of low level events, standards for quality management systems and expanded use of safety performance indicators.

As part of its Peer Review of Operational Safety Performance Experience (PROSPER) service, the Agency provided assistance to Armenia and France. The Agency also provided assistance to China in developing a national programme on the assessment of operations. In addition, at the request of the Hungarian Government and the Hungarian Atomic Energy Authority (HAEA), the Agency conducted an expert mission to assess the results of HAEA's investigation of a fuel cleaning incident in April 2003 at the Paks nuclear power plant. A follow-up expert mission was also carried out at the facility to assist in safety management improvements.

Research Reactor Safety

In 2001, the General Conference requested the Secretariat to conduct a survey of research reactor safety in Member States. Most of the responses to the survey

were received and analysed in 2002; the additional responses received in 2003 have not had any impact on the conclusions. Overall, the level of concern with regard to the safety of shut down research reactors that will not be restarted or decommissioned was reduced. The survey results and analysis are available at *http://www.iaea.org/worldatom/Programmes/Survey/survey2.html*.

The Code of Conduct on the Safety of Research Reactors was developed to provide guidance to States on the development and harmonization of policies, laws and regulations, and to provide recommendations concerning best practices in the management of research reactor safety. The technical provisions in the Code are based on international consensus documents, primarily the Agency's Safety Fundamentals and Requirements .

Several mechanisms are available to monitor the safety of research reactors. The most extensive is the Integrated Safety Assessment of Research Reactors (INSARR) service, which addresses all aspects of operational safety. Eleven missions were conducted in 2003. The Agency has completed either INSARR or specific type missions to 13 out of the 21 project agreement research reactors that are still in operation, and communication was maintained with the operators of the remaining eight reactors.

National projects on research reactor safety were initiated in Europe (Portugal and Romania), Africa (the Democratic Republic of the Congo, the Libyan Arab Jamahiriya and Nigeria) and West Asia (the Islamic Republic of Iran and Uzbekistan) to address specific safety issues. These included the establishment of competent regulatory and operating bodies, refurbishment of reactor systems and introduction of quality assurance programmes.

The Agency organized an international conference on 'Research Reactor Utilization, Safety, Decommissioning, Fuel and Waste Management', in Santiago, Chile. The major findings of this meeting are summarized in the 'Nuclear Science' chapter of this report.

Fostering Harmonization in Nuclear Safety

The IAEA–OECD/NEA International Nuclear Event Scale (INES) Information Service, with 60 participating Member States, is used to facilitate rapid communication to the media and the public regarding the safety significance of events at all nuclear installations associated with the civil nuclear industry, including events involving the use of radiation sources and the transport of radioactive material. During 2003, guidance for the rating of transport events, radiation events and fuel damage events was prepared for trial use. Twenty-one event ratings using the INES scale were received during the year, one at level 0, nine at level 1, ten at level 2 and one at level 3 (Fig. 1).

Another collaborative service, involving the Agency, OECD/NEA and WANO, is the Nuclear Events Web-based System (NEWS), which provides information on the occurrence of nuclear events. So far, approximately 1000 users are registered in NEWS, and the site at *http://www-news.iaea.org/news/default.asp* has registered about 1500 hits per month. In 2003, NEWS was made available, free of charge, to the general public as an information resource on event descriptions, INES ratings and press releases. ■

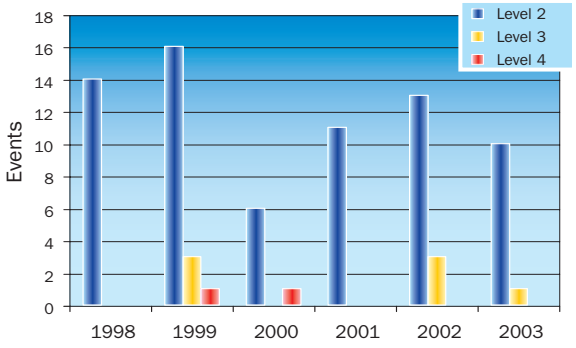


FIG. 1. Reporting of events to INES, 1998–2003.

Radiation Safety

Objective

To achieve global harmonization and raise the levels of protection of people against radiation exposure and of the safety of radiation sources, and to ensure that the Agency properly discharges its health and safety responsibilities with regard to its own operations.

Radiation Safety Standards and Provisions for their Application

The Radiation Safety Standards Committee (RASSC) met twice during the year, including a joint session with the Waste Safety Standards Committee (WASSC), to discuss issues of common interest and review a number of draft safety standards (see Table 1). In connection with safety standards, discussions in Luxembourg of the Inter-Agency Committee on Radiation Safety included consideration of the future revision of the *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources* (BSS) (Safety Series No. 115).

A substantial part of the Agency's assistance in the radiation and waste safety fields continued to be channelled through the technical cooperation model projects on upgrading radiation safety infrastructures. For example, progress on the implementation of the model projects was monitored through a new methodology developed using performance indicators and based on comprehensive information provided by peer review missions, project monitoring, expert missions, and coordination and planning meetings with participating Member States. Peer reviews of the effectiveness of regulatory infrastructures were conducted in 11 countries. Of the 89 Member States currently in the model projects, 44 had been peer reviewed by the end of 2003.

The Agency's activities in the area of education and training focused on: development of an inter-centre network mechanism; creation of training modules; and development of various methods of imparting training (e.g. on the job training, e-learning, appraisal systems). Important milestones in 2003 included the development and provision of train the trainers courses and training packages.

Safety of Transport of Radioactive Material

The 2003 amended edition of *Regulations for the Safe Transport of Radioactive Material* (the Agency's Transport Regulations) was prepared for adoption into the UN Recommendations for the Transport of Dangerous Goods, Model Regulations, and the regulatory documents of IMO and ICAO. In its February 2003 meeting, the Transport Safety Standards Committee (TRANSSC) reviewed the proposed changes in regulations submitted by Member States for the edition to be published in 2005 and approved the publication for comment. Furthermore, it recommended that development of Safety Guides on quality assurance and compliance assurance in support of the Transport Regulations be accelerated.

The appraisal of a State's transport operations has become one of the necessary tools for assisting States in effectively discharging their regulatory responsibilities. During 2003, two Transport Safety Appraisal Service (TranSAS) missions were completed — to Panama and Turkey. A preparatory mission to France was also undertaken as a prelude to a TranSAS

Table 1. Draft Safety Standards Reviewed in 2003

Title	Status
Occupational radiation protection in the mining and processing of raw materials (Safety Guide)	Approved for publication
Regulatory control of radiation sources (Safety Guide)	Approved for publication
Preparedness for nuclear and radiological emergencies (Safety Guide)	Submitted to Member States for comment
Levels of activity concentrations in the application of exclusion, exemption and clearance (Safety Guide)	Submitted to Member States for comment

mission to be carried out in 2004. TranSAS missions have previously visited Brazil, Slovenia and the United Kingdom. The Agency also published a report on the TranSAS mission to Brazil, which took place in April 2002. The 2003 General Conference, in resolution GC(47)/RES/7, commended those States that had already made use of TranSAS and encouraged other States to avail themselves of these missions.

An international conference on the safety of transport of radioactive material was held in Vienna in July 2003. Co-sponsored by ICAO, IMO and UPU, and held in cooperation with the International Air Transport Association and ISO, the conference addressed a range of topics, including radiation protection, compliance and quality assurance, emergency preparedness and response, packaging and transport of radioactive material, and regulatory issues. There were also discussions on liability and on communication with the public and between governments. The summary and findings were submitted to the 47th regular session of the General Conference in September, after which the Conference requested the Agency to draft an international action plan for approval by the Board of Governors.

In 2003, the Agency distributed the third edition of a manual on the *Safe Transport of Radioactive Material* (Training Course Series No. 1), based on the current edition of the Transport Regulations. Following the Agency's standardized approach to transport safety training, it will be used as the basis for all Agency training courses on the subject and is recommended to Member States as a reference for national training programmes.

Occupational Radiation Protection

The Agency routinely monitors the occupational exposure of all staff and external experts who might be exposed to radiation as a result of their work for the Agency. A total of 548 Agency staff members were monitored during 2003, along with 1308 other individuals (including technical cooperation experts and participants in Agency training courses and missions) who were monitored on an ad hoc basis.

The Agency's Radiation Protection Committee conducted a fundamental review of the arrangements relating to radiation safety. The motivation for the review was the need to ensure that the arrangements were fully consistent with the Agency's current safety standards, as required by its Statute. In its review, the committee considered both the organizational aspects and the actual requirements for radiation safety that should apply within the Agency. Its proposals covered the organizational arrangements for safety and the regulations to be followed by users of radiation sources.

An action plan, based on the findings and recommendations of the Agency's international conference on occupational radiation protection held in Geneva in August 2002, was developed in cooperation with ILO, reviewed by the organizations involved in the conference and approved by the Board of Governors in September 2003. The objective of the plan is that the relevant international organizations, in particular the Agency and ILO, assist their Member States in establishing, maintaining and, where necessary, improving programmes for the radiation protection of workers. To ensure the successful implementation of this plan, the Agency and ILO have agreed to establish a steering committee.

Radiological Protection of Patients

In resolution GC(46)/RES/9.A, the General Conference in 2002 endorsed the decision of the Board of Governors to approve an international action plan for the radiological protection of patients. In 2003, the following activities were carried out in support of the action plan:

- Three guidance documents, developed in cooperation with WHO, PAHO and international professional bodies in these areas, were finalized for publication in 2004. They refer to application of the BSS to the three main areas of application of radiation in medicine: diagnostic radiology and interventional procedures using X rays, nuclear medicine and radiotherapy (Fig. 1).

FIG. 1. Catheterization laboratory of a hospital participating in two Agency CRPs.

- Three standard syllabuses and training packages in the application of the BSS were finalized. These modules were used to train trainers in an inter-regional workshop in Antalya, Turkey, and in six regional training courses. In addition, two regional workshops were held for disseminating information on accidental medical exposures in radiotherapy and for using the lessons learned to prevent similar occurrences.
- A document on the methodology of surveying patient doses and image quality for establishing guidance levels for diagnostic examination was prepared; the methodology will be tested in an upcoming project in ten Latin American Member States. Pilot projects on image quality improvement and patient dose reduction were also launched in a number of Member States in Europe and West Asia.

Safety of Radiation Sources

One of the outcomes of the Agency's international conference on the security of radioactive sources, held in Vienna in March 2003, was the updating of the 1999 Action Plan for the Safety of Radiation Sources and the Security of Radioactive Material. The revised version of the plan was thereafter approved by the Board of Governors and endorsed by the General Conference. A revised version of the *Categorization of Radioactive Sources* (originally published as IAEA-TECDOC-1191) was published in July 2003 as IAEA-TECDOC-1344. This formed the basis for the scope of the Code of Conduct on the Safety and Security of Radioactive Sources. Consensus was reached on the scope and the revised text of the Code, after which it was approved by the Board in September. The General Conference endorsed the objectives and principles set out in the Code, while recognizing that it is not a legally binding instrument. The Conference urged every State: to support and endorse the Agency's efforts to enhance the safety and security of radioactive sources; to work towards adopting the Code; and to encourage other States to do the same.

The 'Tripartite Initiative' between the Agency, the Russian Federation and the USA, on securing and managing radioactive sources, completed 15 missions in 11 countries of the former Soviet Union to determine what actions were necessary to secure sources. These missions identified significant numbers of sources that are regarded as vulnerable (Fig. 2). Some of these were secured, but much work still needs to be done.

Nuclear and Radiation Emergencies

In September 2003, the General Conference, in resolution GC(47)/RES/7.A.8, welcomed the decision by the representatives of Competent Authorities to the Convention on Early Notification of a Nuclear Accident (Notification Convention) and the Convention on Assistance in the case of a Nuclear Accident or Radiological Emergency (Assistance Convention) to establish a National Competent Authorities' Co-ordinating Group (NCACG), and supported the Secretariat's intention to facilitate the NCACG's work and develop an action plan. A meeting between the Secretariat and regional representatives of NCACG was held in December 2003 in Vienna at which a draft of the action plan was produced.

Under the Assistance Convention, the Agency collects and disseminates to Member States information on methodologies, techniques and results of research on the response to nuclear emergencies. In this context, the Agency published *Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency* (EPR-Method 2003). This document provides information on response to the full range of foreseeable emergencies, including malevolent acts involving radiological dispersal devices, and a definition of the quantities of radioactive material that should be considered dangerous if not controlled. To facilitate wider dissemination, the report was also made available on the Internet, where it received more than 30 000 visits in one month. Related activities included

FIG. 2. Disused radioactive source (level gauge with caesium-137).

the organization of regional courses at which representatives from 56 countries received training in the application of Agency guidance for response.

Other Agency work under the Assistance and Notification Conventions included the convening of a workshop on the submission of notifications and emergency information through the Early Notification and Assistance Convention web site and the development of new reporting forms. In addition, the second meeting of representatives of the Competent Authorities, identified under the conventions, was convened in June. The representatives agreed to establish the NCACG mentioned above and to develop an action plan.

In 2003, the Assistance Convention was formally invoked in relation to three events involving radiation sources in Nigeria, Qatar and Ecuador. Emergency missions were carried out in response to these events. The first provided assistance to Nigeria in the investigation of the theft of two americium–beryllium radioactive sources from a truck. The second mission assisted Qatar in recovering unidentified buried orphan sources. The third mission provided assistance to Ecuador after the theft of five iridium-192 radioactive sources from a private company and the loss of another similar source.

Building Infrastructures to Support Nuclear Safety

An international conference, entitled 'National Infrastructures for Radiation Safety: Towards Effective and Sustainable Systems', was organized by the Agency in Rabat in September and hosted by the Government of Morocco. Held in co-operation with the European Commission, ILO, OECD/NEA and WHO, the conference focused on such issues as stakeholder involvement in building and maintaining national radiation safety infrastructures, the Agency's model project on upgrading radiation protection infrastructures, education and training, effectiveness and efficiency of the activities of regulatory bodies, security of sources, emergency preparedness and performance evaluation. The 47th regular session of the Agency's General Conference "welcomed the findings" of the conference and requested that a group of experts be convened "to advise the Secretariat on implementation of the findings". ■

Management of Radioactive Waste

Objective

To increase global harmonization in the policies, criteria, standards and provisions for their application, as well as in methods and technologies, for achieving safety in radioactive waste management, in order to protect humans and their environment against potential health effects attributable to actual or potential radiation exposure to radioactive waste.

Radioactive Waste Safety Standards and Provisions for their Application

As a follow-up to a General Conference request in 2000 to develop criteria for long lived radionuclides in commodities (especially foodstuffs and wood), the Secretariat integrated its efforts in this area into current work on the concepts of exclusion, exemption and clearance. Subsequently, the Radiation Safety Standards Committee (RASSC) and the Waste Safety Standards Committee (WASSC) reviewed a draft Safety Guide specifying levels of activity concentrations that can be used in the practical application of these concepts as established in the *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources* (BSS), and approved its circulation to Member States for comment. The committees considered that elaboration of the work on foodstuffs should be done separately in view of the recommendations already made by the FAO/WHO Codex Alimentarius Commission.

A Safety Requirements publication on *Remediation of Areas Contaminated by Past Activities and Accidents* (Safety Standards Series No. WS-R-3) and two Safety Guides on the predisposal management of high level, and low and intermediate level radioactive waste (Safety Standards Series Nos WS-G-2.5 and WS-G-2.6) were published. Status reports on Safety Standards, as well as the full text of published standards, can be found at *http://www-ns.iaea.org/standards/*.

Disposable Radioactive Waste: Managing Non-Reusable Radioactive Materials and Arranging for their Disposal

The first Review Meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management ('Joint Convention') was held in November 2003. All Contracting Parties demonstrated a strong commitment to the objectives of the Convention and to implementing the obligations of the articles. Furthermore, it was agreed that for the safe and successful management of spent fuel and radioactive waste, there needed to be: a clear legal framework; a strong and independent regulatory function; competent licensees or operators; clear lines of responsibility and accountability; public involvement in the decision making process; adequate financial provisions; clear, integrated plans on how spent fuel and radioactive waste will be managed to ensure continued safety into the future, and as this could be for decades, to avoid creating a legacy situation that would impose undue burdens on future generations.

The Action Plan on the Safety of Radioactive Waste Management was approved by the Board of Governors after being modified to take into account the findings of an Agency conference on issues and trends in radioactive waste management, held in Vienna in December 2002. A key output of the action plan was a position paper by international experts on *The Long Term Storage of Radioactive Waste: Safety and Sustainability*, which was published in 2003.

In the project on Application of Safety Assessment Methodology for Near Surface Waste Disposal Facilities (ASAM), launched in 2002, significant advances were made in the areas of: application of safety assessment methodologies for evaluating safety upgrading options; disposal of disused sealed sources; and assessment in relation to the long term safety of mining and mill tailings.

Current information and know-how on liquid waste were collated and disseminated through a CRP that ended in 2003. An important result of this CRP was the development of safe, cost effective techniques as well as techniques tailored to the individual needs of facilities and/or States.

Major outcomes of an Agency conference on geological repositories, held in Stockholm in December,

included endorsement by government organizations in various Member States of the steps required for the development of disposal facilities. The conference also highlighted the importance of international cooperation in research, development and demonstration (RD&D) issues, and of such cooperation in developing and consolidating the scientific and technical basis for safe geological disposal.

In keeping with the increased awareness of Member States and the Agency of the need for greater cooperation in all areas related to waste disposal and the development of geological repositories, the 'Network of Centres of Excellence', organized by the Agency, became operational in 2003. Other work on waste disposal included the publication of a report summarizing the available know-how for the development of near surface disposal facilities for low and intermediate level radioactive waste.

Protection of the Public and the Environment

A project entitled 'Environmental Modelling for Radiation Safety ' commenced in 2003 with the main objectives of enhancing the capabilities of Member States to model radionuclide transfer in the environment, and thereby assessing exposure levels of the public and biota to ensure an appropriate level of protection from the effects of ionizing radiation associated with radionuclide releases and from existing radionuclides in the environment. At the first combined meeting of all six working groups, work began on topics related to the control of radioactive releases to the environment and the restoration of sites with radioactive residues.

Under the UNDP–GEF Dnieper River Basin Environment Programme, the Agency completed a scientific assessment of data on radioactive contamination in the basin, and its radiological consequences. The first major project output was a transboundary diagnostic analysis. The project identified some actual and potential hot spots in the basin, including the Chernobyl exclusion zone, radioactive waste dumps at former uranium mining and milling sites, and inhabited areas in three countries with high levels of radioactive contamination caused by the Chernobyl accident. It was recommended that a detailed, site specific assessment be performed of hot spots in order to develop remediation measures. The project will be completed in 2004 after the development of a 'Strategic Action Plan for the Dnieper River Basin'.

The "United Nations Chernobyl Forum" is the Agency's contribution to the implementation of the UN's new initiative, launched in 2002, on the 'Human Consequences of the Chernobyl Nuclear Accident — A Strategy for Recovery'. The forum held its first organizational meeting in Vienna in February 2003, with the participation of relevant international organizations and representatives of Belarus, the Russian Federation and Ukraine, at which the terms of reference and work plan of the forum were accepted. The Chernobyl Forum also established two international expert groups on 'environment' and 'health' under the aegis of the Agency and WHO, respectively. The first meetings of the environment group were held in July and December 2003 at which the draft technical report on environmental consequences of the Chernobyl accident and remediation activities was prepared. The group on health met in December 2003.

Following an earlier preliminary assessment of the radiological conditions at the former nuclear

Towards a Policy on Protection of the Environment from Ionizing Radiation

In October 2003, the Agency organized an international conference on the 'Protection of the Environment from the Effects of Ionizing Radiation' in Stockholm. Held in cooperation with UNSCEAR, the European Commission and the International Union of Radioecology and hosted by the Government of Sweden through the Swedish Radiation Protection Authority, the conference's primary objective was to promote the development of a coherent international policy on the protection of the environment from effects attributable to ionizing radiation exposure. The conference reviewed recent developments and considered their implications for future work on developing guidance at the national and international levels, and was the culmination of a series of meetings on the subject organized by or held in cooperation with the Agency. The main finding of the conference was that this was an appropriate time to launch international initiatives to consolidate the present approach to controlling radioactive discharges to the environment by taking account of the protection of species other than humans. The conference recommended that an international action plan be prepared, under the aegis of the Agency, on the protection of the environment against the detrimental effects attributable to radiation exposure.

weapons test sites in Algeria, a meeting between an international team of experts and national counterparts in 2003 decided on expanding activities to provide a more comprehensive assessment of the sites.

Residual Radioactive Materials: Termination of Practices, Decommissioning of Installations and Remediation of Sites

Many nuclear facilities, both civilian and military, have now arrived at a stage in their life cycle where decommissioning and remediation of the surrounding environment is required. In this context, an action plan on decommissioning is being developed on the basis of the findings of the 2002 international conference on 'Safe Decommissioning for Nuclear Activities', held in Berlin. The action plan aims to assist Member States in the systematic planning for and safe decommissioning of nuclear facilities in compliance with internationally agreed safety standards and recommendations.

Uranium mining and milling activities and legacies continue to be of international concern. With the support of the World Bank, an Agency project was started on mill tailings in Kyrgyzstan. A remediation plan is being developed through this project. The main focus is on conventional risks arising from tailings impoundments. A monitoring and warning system will also be established to identify potential hazards before they endanger the local population and infrastructure. The specific problems associated with the long term stability of uranium mill tailings were also studied, and technical and managerial recommendations were provided in a CRP that was completed in 2003.

The Agency published a report on *Radiological Conditions in Areas of Kuwait with Residues of Depleted Uranium*. The report states that in all of the cases examined, the estimated radiation doses that could arise from exposure to residues of depleted uranium were found to be very small and well below the annual doses received by the population of Kuwait from natural sources of radiation in the environment.

A draft plan for the decommissioning of the BN-350 nuclear power plant in Aktau was submitted by Kazakhstan to the Agency for an international peer review. A report on the conclusions of the review was submitted to the Kazakhstan Atomic Energy Committee for its consideration.

Recommendations on measures to improve safety were submitted to Tajikistan. In addition, plans for future technical cooperation were developed focusing on: regulatory infrastructure for nuclear and radiological activities; radioactive waste storage and disposal; and decommissioning activities.

In other work, the Agency held two training courses on the decommissioning of the shut down research reactor at the Institute of Nuclear Sciences Vinča in Serbia and Montenegro. One course was on the basics of decommissioning and the other on project management. Assistance was also provided in developing the decommissioning plan and associated safety related documents.

The Agency's Contact Expert Group (CEG) for International Radioactive Waste Projects in the Russian Federation organized two workshops during the year to elaborate specific project proposals for international activities. After the signing of the Framework Agreement on Multilateral Nuclear Environmental Programme in Russia (MNEPR) in May in Stockholm, the Northern Dimensions Environmental Partnership (NDEP) support fund, administered by the European Bank for Reconstruction and Development, became operational. Preparatory activities for specific contracts under this fund are now under way. The first contracts have been signed under the Global Partnership Programme of the G-8 countries, and more cooperative activities are expected to start soon. The CEG will be serving as a technical advisor and project facilitator for these activities.

Management of Disused Sealed Radioactive Sources

The proper management of sealed radioactive sources has received considerable international attention in recent years, with large sources coming within the scope of the Agency's activities. In 2003, the largest single operation to recover a caesium source took place in Côte d'Ivoire. Neutron sources were recovered from Sudan and Côte d'Ivoire, while large cobalt sources were recovered from Angola. Technical preparations are under way for similar operations in Haiti, Mozambique, the Islamic Republic of Iran, Thailand and The Former Yugoslav Republic of Macedonia.

Other Agency efforts in this area included publication of a technical document, *Management of Disused Long Lived Sealed Radioactive Sources*, the development of generic procedures for source conditioning, and a conceptual design for a mobile infrastructure. These will allow the handling and

conditioning of any existing type of source in Member States that lack the necessary infrastructure.

Radioactive Waste Management Information

Facilitating the exchange of information is one of the main tasks of the Agency. Web based and other services include: the *Net Enabled Waste Management Database* (NEWMDB-II) Version II (*http://www-newmdb.iaea.org/reports.asp*); *Directory of Radioactively Contaminated Sites* (DRCS) (*http://www-drcs.iaea.org*); and the third report in the series *Radioactive Waste Management: Status and Trends (http://www-pub.iaea.org/MTCD/publications/publications.asp)*.

A notable development was the inclusion by the UN Department of Economic and Social Affairs of the Agency's 'Indicator of Sustainable Development for Radioactive Waste Management' in its list of core indicators *(http://www.un.org/esa/sustdev/natlinfo/indicators/isdms2001/isdms2001economicB.htm#radioactivewaste)*.

The Agency's *International Catalogue of Sealed Radioactive Sources and Devices* underwent a comprehensive review and update. The database currently contains 4695 records on sources and 4328 records on devices and information on 1141 source manufacturers to help in instances of identification when there is limited information. A simplified, printed version for use at border control points as well as a poster for industrial, medical and agricultural facilities will aid in recognizing radioactive sources. ■

Security of Material

Objective

To increase Member States' awareness and ability to control, account for and protect nuclear and other radioactive materials and nuclear installations from subnational terrorist or other illegal activities, and to detect and respond to such activities.

Technical, Administrative and Regulatory Arrangements in Member States to Protect and Control Nuclear Material

To help operators identify vulnerabilities in safety systems that are of security relevance for protection against sabotage, the Agency developed *Guidelines for the Self-assessment of Safety and Security Vulnerabilities of Nuclear Installations*. These guidelines identify important synergies between nuclear safety and security.

The Agency supported Member States in evaluating their national physical protection systems by conducting International Physical Protection Advisory Service (IPPAS) missions and follow-up activities in Armenia, Bulgaria, Chile, Mexico, Norway, Peru, Philippines, Poland, Romania, Turkey and Ukraine. As a result of these missions, upgrades of physical protection systems were initiated. In addition, the Agency offered an extensive programme of physical protection related training courses, workshops and seminars in Algeria, Argentina, Czech Republic, Ghana, Hungary, India, Mexico, the Russian Federation and the USA.

The Agency reviewed and updated the design basis threat (DBT) methodology, which provides the essential foundation for State systems of physical protection, and completed a document entitled *Guidance for Development and Maintenance of a DBT*. Together with DBT workshops in South Africa and Brazil, these efforts assisted State authorities in managing their DBTs.

Effective State Systems of Accounting for and Control of Nuclear Material (SSACs) are essential for ensuring the security of such material. Training courses and evaluation missions focusing on SSACs were held in eight Member States, and guidelines for SSACs, including those for the establishment, improvement and maintenance of an effective SSAC and for a State's self-assessment of its SSAC, are being developed. In addition, the Agency started work on the promotion of an enhanced 'security culture', one of the fundamental principles of physical protection.

Addressing Illegal Activities Involving Nuclear and other Radioactive Material

If the protection and control of nuclear or other radioactive material are deficient, States need to have effective capabilities to detect, interdict and respond to the theft of and illicit trafficking in these materials, as well as to sabotage and other such threats. The Agency's efforts to assist Member States in enhancing these capabilities included border evaluation missions for customs and other 'front-line' personnel (Fig. 1). As a result of these activities, upgrades are being implemented in Belarus, Bosnia and Herzegovina, Croatia, Georgia, The Former Yugoslav Republic of Macedonia and Ukraine.

The Agency has intensified its efforts to strengthen response measures in Member States. A pilot regional course on combating nuclear terrorism and incidents involving illicit trafficking in nuclear material was held in Romania, and a national course on the same subject was held in Albania. In addition, incident response missions visited Ecuador, Nigeria and Uganda. Other work included the completion of a

FIG. 1. An Agency expert demonstrates the use of a radiation detection 'pager' to border guards in Uzbekistan.

technical document on *Preparedness and Response for Malevolent Acts involving Radioactive Material*.

In the process of implementing national strategies for regaining control over radioactive sources, the Agency conducted missions to a number of Member States. A publication entitled *Strengthening Control Over Radioactive Sources in Authorized Use and Regaining Control over Orphan Sources: National Strategies* (IAEA-TECDOC-1388) was completed. The Agency also conducted several missions under the umbrella of the "Tripartite Initiative", which focuses on securing vulnerable, high activity radioactive sources within the former Soviet Union. All of these missions had the goal of providing assistance in the investigation of nuclear material theft and in efforts to locate the material.

To help States identify the best means of strengthening their nuclear security, the Agency initiated the International Nuclear Security Advisory Service (INSServ), aimed at identifying measures for additional or improved security for nuclear related activities. The recommendations generated from this service are expected to facilitate subsequent, more specific, nuclear security assistance, either through Agency programmes or through bilateral assistance. Such support includes technical advice, legislative and regulatory assistance, training, and equipment. INSServ missions were carried out in Azerbaijan, the Democratic Republic of the Congo, the United Republic of Tanzania, Uganda, Uzbekistan and Yemen.

The Agency provided assistance to Member States in drafting national legislation in the field of nuclear security, including a legislative framework containing the basic requirements and procedures for the control of radioactive sources and for the physical protection of nuclear material. This also involved revision of *Categorization of Radioactive Sources,* issued as IAEA-TECDOC-1344, which contributes to risk informed decision making in dealing with the security of radioactive sources.

The Illicit Trafficking Database (ITDB) continued to expand in terms of both the number of participating States and reported incidents. In 2003, membership in the ITDB reached 75 States. A total of 75 new incidents have been reported by Member States, 60 of which occurred in 2003. A new format for the *ITDB Quarterly Report* was introduced, and an expanded *ITDB Annual Report* was issued to Member States. In October, the Agency organized a meeting of the national contact points for the ITDB at which actions to improve the effectiveness of the ITDB were identified.

Convention on the Physical Protection of Nuclear Material: Status of the Amendment

In 2003, a total of 15 additional States became parties to the 1979 Convention on the Physical Protection of Nuclear Material (CPPNM), making a total of 97 States Parties. This increase reflects the importance given to the CPPNM as part of the international nuclear security regime.

The open-ended group of legal and technical experts convened by the Director General to prepare a draft amendment aimed at strengthening the CPPNM (the Group) completed the task for which it was established at its final meeting in March 2003. On 14 March 2003, the Group adopted by consensus its final report, after which the Secretariat distributed the report to all States Parties to the CPPNM for their consideration. The report sets out possible amendments to the CPPNM that reflect an extension of the scope of the CPPNM to cover: the physical protection of nuclear material used for peaceful purposes, in domestic use, storage and transport and the protection of nuclear material and nuclear facilities used for peaceful purposes against sabotage; the importance of national responsibility for the establishment, implementation and maintenance of a physical protection regime; the Physical Protection Objectives and Fundamental Principles; the basis for cooperation in the case of a credible threat of sabotage of nuclear material and nuclear facilities or in the case of sabotage thereof; and new offences relating to sabotage, nuclear smuggling, and offences that are contributing to, and organizing or directing, the commission of an offence. The text prepared by the Group does, however, contain a number of clauses on which it was not able to reach agreement.

At the 47th regular session of the General Conference, the Director General urged States Parties to the CPPNM to work rapidly towards consensus on the remaining outstanding issues so that a diplomatic conference could be convened to adopt the proposed amendments at an early date. In this context, the General Conference, in resolution GC(47)/RES/8, welcomed the finalization of the work of the Group and urged Member States to act on that basis with a view to achieving a well defined amendment of the CPPNM as soon as possible. ■

Verification

Safeguards

Objective

To provide the international community, in the most effective and efficient manner, with credible assurance that States are complying with their safeguards commitments.

The Safeguards Statement for 2003

The Secretariat's findings and conclusions for 2003 are based upon an evaluation of all the information available to the Agency in exercising its rights and fulfilling its safeguards obligations for that year.

Safeguards activities were implemented for 40 States[1] with both comprehensive safeguards agreements in force and additional protocols in force or being otherwise applied. Only for such States are Agency safeguards able to provide credible assurance not only regarding the non-diversion of nuclear material but also regarding the absence of undeclared nuclear material and activities.

- For 19 of those States, the Secretariat completed sufficient activities and evaluation and found no indication of the diversion of nuclear material placed under safeguards and no indication of undeclared nuclear material or activities for the State as a whole. On this basis, the Secretariat concluded that all nuclear material within the territories of those States, under their jurisdiction or under their control anywhere had been placed under safeguards and remained in peaceful nuclear activities or was otherwise adequately accounted for.
- For 19 States (and for Taiwan, China), the Secretariat found no indication of the diversion of nuclear material placed under safeguards. Evaluations aimed at drawing a conclusion regarding the absence of undeclared nuclear material and activities for each of these States (and for Taiwan, China) as a whole remain in progress. On this basis, the Secretariat concluded for these States (and for Taiwan, China) that the nuclear material placed under safeguards remained in peaceful nuclear activities or was otherwise adequately accounted for.
- The Islamic Republic of Iran and the Libyan Arab Jamahiriya, having been engaged in undeclared nuclear activities, were in breach of their obligations to comply with their respective safeguards agreements.

Safeguards activities were implemented for 98 States with comprehensive safeguards agreements in force but without additional protocols in force or being otherwise applied. For those States, the Secretariat found no indication of the diversion of nuclear material placed under safeguards. On this basis, the Secretariat concluded that for these States, the nuclear material placed under safeguards remained in peaceful nuclear activities or was otherwise adequately accounted for. As a result of the unilateral actions of the Democratic People's Republic of Korea (DPRK) to terminate the Agency's safeguards activities in late 2002, the Secretariat was not able to implement safeguards inspections in the DPRK in 2003 and could not, therefore, draw any safeguards conclusions in respect of nuclear material in that State.

Safeguards activities were implemented in four States with INFCIRC/66/Rev.2-type safeguards agreements in force. For those States, the Secretariat found no indication of the diversion of nuclear material or of the misuse of facilities, equipment or non-nuclear material placed under safeguards. On this basis, the Secretariat concluded that the nuclear material and other items placed under safeguards remained in peaceful nuclear activities or were otherwise adequately accounted for.

Safeguards activities were implemented in selected facilities in four of the five nuclear weapon States with voluntary offer safeguards agreements in force. For those States, the Secretariat found no indication of the diversion of nuclear material under safeguards. On this basis, the Secretariat concluded that the nuclear material under safeguards remained in peaceful nuclear activities or was otherwise adequately accounted for.

As of the end of 2003, 45 non-nuclear-weapon States party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) had not yet brought into force comprehensive safeguards agreements with the Agency as required by Article III of that treaty.

[1] In addition, the Agency applies safeguards, including the measures foreseen in the Model Additional Protocol (INFCIRC/540(Corr.)), in Taiwan, China.

For 44 of those States[2], the Secretariat could not implement safeguards and could not, therefore, draw any safeguards conclusions.

In Iraq, the Agency was able to implement its United Nations Security Council resolution-related mandate in 2003 until 17 March and, as of that time, had not found any evidence or plausible indication of the revival of a nuclear programme. Under its comprehensive safeguards agreement with Iraq, the Agency verified in June 2003 that, in spite of the looting that took place in April 2003, the amount of uranium that may have been dispersed was not of proliferation concern.

State Specific Issues

In 2003, a number of discoveries, disclosures, and political developments highlighted important challenges to the Agency's verification regime.

Democratic People's Republic of Korea. The DPRK has been in non-compliance with its safeguards agreement since 1993. Since 31 December 2002, when at the request of the DPRK the Agency's inspection activities were suspended, the Agency has not been able to verify that there has been no diversion of nuclear material in the DPRK. In January and February 2003, the Agency's Board of Governors adopted two resolutions which encouraged the DPRK to reconsider its decisions and comply with its safeguards agreement. In February 2003, the Agency informed all its Member States, the Security Council and the General Assembly of the United Nations about the DPRK's further non-compliance and the Agency's inability to verify the non-diversion of nuclear material subject to safeguards in the DPRK.

There are reports, which the Agency is not in a position to confirm, that the DPRK: may have reactivated its research reactor at Nyongbyong; may have completed the reprocessing of the 8000 spent fuel rods which had previously been under Agency safeguards; and may have an undeclared uranium enrichment programme. The Agency has requested clarification from the DPRK on the issue of the uranium enrichment programme, but no response was received as of the end of 2003.

Iraq. After the resumption of inspections in November 2002, the Agency was able to conduct field activities related to its United Nations Security Council (UNSC) mandate in Iraq for only two and a half months in 2003 (see the next chapter, Verification in Iraq Pursuant to UNSC Resolutions). Since 17 March 2003, the Agency has been unable to perform its inspection activities in Iraq pursuant to its Security Council mandate, which remained valid.

Nuclear material stored at Location C at Tuwaitha is subject to safeguards under the comprehensive safeguards agreement between the Agency and Iraq. The material inventory consists of low enriched, natural and depleted uranium in various chemical forms; some of the material was reported as having been looted in April 2003. In June 2003, the Agency conducted an inspection, recovered and verified the nuclear material subject to safeguards at Location C and estimated that at least 10 kg of uranium compounds could have been dispersed as a result of the looting. The quantity and type of uranium compounds dispersed are not sensitive from the point of view of nuclear proliferation. Nonetheless, the Agency requested the Coalition Provisional Authority to make every effort to recover this material and place it once again under safeguards.

Islamic Republic of Iran (Iran). The Agency had extensive discussions with Iran in 2003 on safeguards issues to be clarified, and carried out a range of verification activities in the context of Iran's NPT safeguards agreement. Reports by the Director General were made to the Board of Governors in June, September and November 2003. The report in June noted that Iran had failed to meet its obligations under its safeguards agreement with respect to the reporting of nuclear material, the subsequent processing and use of that material, and the declaration of facilities where the material was stored and processed. The report also noted corrective actions that had been taken. In response, the Board shared the Director General's concern at the number of Iran's past failures, and welcomed its reaffirmed commitment to full transparency.

The report to the September Board noted an increased degree of cooperation with the Agency by Iran, although it also stated that information and access were at times slow in coming and incremental, observing that a number of important outstanding issues remained, particularly with regard to Iran's enrichment programme. In its resolution of 12 September, the Board expressed grave concern that Iran had still not enabled the Agency to provide the required assurances that all nuclear material had been declared and submitted to safeguards and that there were no undeclared nuclear activities in Iran. The Board also decided that a number of actions on Iran's part were essential and urgent for

[2] Cuba acceded to the NPT on 4 November 2002. However, in 2003 safeguards were still being applied under INFCIRC/66/Rev.2-type safeguards agreements.

Agency verification of the non-diversion of nuclear material.

The November report, while reiterating that Iran had in a number of instances over an extended period of time breached its obligation to comply with its safeguards agreement, stated that there was to date no proof that the previously undeclared nuclear material and activities were related to a nuclear weapons programme. However, it was noted that, given the past pattern of concealment, it would take some time before the Agency would be able to conclude that Iran's nuclear programme was exclusively for peaceful purposes. The Board responded in its resolution of 26 November by welcoming Iran's offer of active cooperation and openness and its positive response to the Board's previous demands, but also by strongly deploring Iran's past failures and breaches of its obligation to comply with its safeguards agreement.

On 10 November 2003, Iran conveyed its acceptance of the text of a protocol additional to its safeguards agreement, and it agreed to cooperate with the Agency in accordance with the provisions of the additional protocol pending its entry into force. On 18 December 2003, Iran signed a protocol additional to its safeguards agreement. Iran also informed the Director General that it had decided to voluntarily suspend, with effect from 10 November 2003, all enrichment and reprocessing activities as a confidence building measure. The Agency is continuing its efforts to verify the correctness and completeness of Iran's declarations on nuclear material and facilities. The remaining outstanding issues that need resolution in this regard continue to require Iran's active cooperation.

Libyan Arab Jamahiriya (Libya). On 19 December 2003, Libya announced its decision to eliminate all materials, equipments and programmes which lead to the production of internationally proscribed weapons, including nuclear weapons. Subsequently, Libya informed the Director General that it had been engaged for a number of years in the development of a uranium enrichment capability; however, to date, no industrial scale facility had been built, nor had any enriched uranium been produced. Libya's clandestine nuclear activities included the import of natural uranium, centrifuges and conversion equipment as well as drawings related to nuclear weapon fabrication. Under Libya's safeguards agreement some of these activities should have been reported to the Agency, but were not.

The Agency started an in-depth verification of Libya's undeclared nuclear activities with an initial verification mission led by the Director General from 27 December 2003 to 1 January 2004. The Agency began the process of placing the previously undeclared nuclear material, along with the most sensitive equipment, under Agency seal.

Libya announced that as of 29 December 2003 it would act as if an additional protocol to its safeguards agreement were in force; it also stated its intention to pursue a policy of full transparency and active cooperation with the Agency. The Agency continues in its efforts to verify the correctness and completeness of Libya's declaration on nuclear material and facilities.

As part of its continuing verification process with Libya and Iran, the Agency is also investigating, with the support of Member States, the supply routes and the sources of sensitive nuclear technology and related equipment, and nuclear and non-nuclear material. It is continuing such investigations with a view to ensuring that the sensitive nuclear technologies and equipment found in Libya have not proliferated further.

Conclusion of Comprehensive Safeguards Agreements and Additional Protocols

Comprehensive Safeguards Agreements (CSAs). In the course of 2003, CSAs entered into force with Burkina Faso, Georgia and the United Arab Emirates, while the validity of Panama's Treaty of Tlatelolco CSA in the context of the NPT was confirmed through an exchange of letters, and CSAs were signed by Burkina Faso, Cuba, Mauritania and Tajikistan.

Additional protocols. Additional protocols entered into force for Burkina Faso, Chile, Cyprus, Democratic Republic of the Congo, Georgia, Iceland, Jamaica, Kuwait, Madagascar, and Mongolia. Denmark, France, Ireland and Italy informed the Agency of the ratification regarding their respective protocols in the course of 2003. By the end of the year, all of the 15 States that were Members of the European Union (13 non-nuclear-weapon States and 2 nuclear-weapon States) had provided such notifications.[3]

In addition, Burkina Faso, Cuba, Democratic Republic of the Congo, El Salvador, Iceland, Iran, Jamaica, Madagascar, Malta, Mauritania, Paraguay,

[3] The additional protocols for 15 States of the European Union — France, the United Kingdom and the then 13 non-nuclear-weapon States of the European Union — and Euratom entered into force on 30 April 2004.

Tajikistan, and Togo signed additional protocols. As of the end of 2003, out of 71 States with significant nuclear activities, 46 States had not brought an additional protocol into force.

Towards More Effective and Efficient Verification

Recognizing the lack of sufficient resources, Member States increased the regular budget of the Agency's verification programme, which had been operating for more than 15 years under conditions of a zero real growth budget. For 2004, the budget was increased by 12.4%, with a further 3.3% increase foreseen for 2005. In 2003, the Agency carried out many activities aimed at strengthening safeguards, the most important of which are elaborated below.

Verification activities in the field. The Agency carried out 2363 inspections at 644 facilities and locations outside facilities, representing 9260 person-days of inspections. This included 1773 person-days carried out to verify the transfer of spent fuel to storage facilities in 13 States, representing an increase of 29% over 2002. In addition, 272 days of inspection effort were carried out for verifying the design of facilities with nuclear material, or under construction or being decommissioned.

Complementary access. Complementary access was conducted in 21 States in 2003. Performed under additional protocols, complementary access plays an important role in the drawing and maintenance of conclusions of the absence of undeclared nuclear material and activities, and is specifically reflected in State evaluations. Field trials were carried out in the Netherlands and in Finland to test practical arrangements between the State authorities, Euratom and the Agency for advance notification and implementation of complementary access.

Sample taking. Environmental sampling is a powerful tool for detecting undeclared nuclear material and activities. Compared with 2002, the number of environmental samples collected during inspections and complementary access increased by more than 100%.

Sample analysis. The Agency improved the application of the X ray fluorescence technique for screening cotton environmental swipe samples. The use of thermal ionization mass spectrometry for measuring extremely small quantities of uranium and plutonium in environmental samples was also improved. In addition, the Agency upgraded the application of secondary ion mass spectrometry for the analysis of uranium particles on swipe samples.

The Agency published procedures for qualifying candidate laboratories in the Agency's Network of Analytical Laboratories (NWAL) with regard to nuclear material and environmental sample analysis. In this regard, the acceptance of a Japanese laboratory into the NWAL will enable the Agency to increase its analytical capacity.

The Safeguards State Evaluation Process

In 2003, the Agency continued to refine its process of evaluating State nuclear activities and plans to provide the basis for drawing safeguards conclusions, resulting in more consistent and comprehensive State evaluations. The number of State Evaluation Reports (SERs) that the Agency prepared and reviewed in 2003 continued to grow: 59 were prepared and reviewed, 29 of which took account of declarations submitted by States pursuant to Article 2 of their additional protocols. An evaluation was also carried out for Taiwan, China.

Information analysis. The Agency developed new ways to analyse safeguards relevant information from open sources. Such analyses are integral to assessing a State's ability to carry out nuclear activities, including those involving proliferation sensitive technologies. Analysis of commercial satellite imagery, a further open source of information, was enhanced; further processing of such information can significantly improve the accuracy of information on nuclear sites.

Safeguards Approaches

In 2003, the Agency revised its policy and model safeguards approach for natural uranium conversion facilities in order to strengthen safeguards at such plants. Traditional practice had been to apply all safeguards measures specified in a comprehensive safeguards agreement only to the product of such plants, and not to the bulk of the material processed in them. The new policy foresees that safeguards measures are applied to all material in natural uranium conversion plants as soon as the material reaches a stage where it is "suitable for fuel fabrication or for being isotopically enriched" (para. 34(c) of INFCIRC/153). It also confirms that the Agency must receive design information for the entire plant. Preparations have begun for the implementation of the revised approach at natural uranium conversion plants.

The development and implementation of the facility specific safeguards approach[4] for the Rokkasho Reprocessing Plant in Japan (RRP) proceeded according to schedule. The main achievements of this project included: submission of the proposed Facility Attachment to the Japanese Government for approval; development and near complete installation of the solution measurement and monitoring system; installation of the On-Site Laboratory infrastructure, including hot cells, glove boxes and utilities; and commencement of acceptance tests.

Another facility specific safeguards approach developed in 2003 for a hot cell at a nuclear facility in Switzerland takes into account the facility's specific design and uses both non-destructive analysis (NDA) and additional containment/surveillance measures. The Agency also adapted an existing fork detector NDA system to operate in unattended mode when measuring spent fuel assemblies in the hot cell. Also, a new facility specific safeguards approach based on surveillance cameras, including underwater cameras, was developed for a spent fuel storage facility in India. Both of these new approaches will reduce the need for inspector presence. The Agency also rehearsed enhanced inspection procedures at LEU fuel fabrication facilities in Japan.

Safeguards approaches developed for the spent fuel conditioning and dry storage facilities at the Chernobyl Nuclear Power Plant in Ukraine required the development of application specific monitoring equipment. In 2003, the prototype of a mobile monitoring system for container transport was installed at the spent fuel conditioning facility and, in collaboration with the facility operator, underwent cold and hot tests. The monitoring system for the spent fuel conditioning facility was assembled and tested at Agency Headquarters.

Procedures for design information verification were significantly improved. More specifically, facility specific design information verification plans were drafted. New tools to assist in design verification were introduced in 2003, such as a three dimensional scanning laser range finder — a tool that can produce a three dimensional image of a facility area or of equipment. The image can be stored and the system enables the Agency to electronically compare the original images with later images of the same facility area or equipment, and thus to identify design modifications over time.

Integrated Safeguards

Integrated safeguards are the optimum combination of all safeguards measures available to the Agency under comprehensive safeguards agreements and additional protocols that achieve the maximum effectiveness and efficiency within available resources. The Agency focused on several aspects related to integrated safeguards, which continued to be implemented at the State level in Australia and Norway and began in Indonesia. State specific integrated safeguards approaches are under development for Canada, Hungary, Japan, Poland, Slovenia and Uzbekistan. The Agency tested the unannounced inspection component of the integrated safeguards approach for Hungary.

Facility specific integrated safeguards approaches for Japan were further developed and refined. Throughout the year, there were trials of such approaches involving random interim inspections, particularly for LWRs without mixed oxide (MOX) fuel, research reactors and critical assemblies (RRCAs), and spent fuel storage facilities.

In order to facilitate the implementation of integrated safeguards, the Agency drew up guidelines for unannounced and short notice inspections and for dealing with anomalies, questions and inconsistencies. The Agency also formulated provisional implementation criteria for RRCAs, spent fuel storage facilities and LWRs without MOX.

Information Technology

The IAEA Safeguards Information System (ISIS), established in the mid-1970s, is now not only outdated but difficult and costly to maintain. Moreover, it limits the Agency's ability to integrate other IT applications. In recognition of this situation, a project was launched in 2002 to re-engineer the current information system. The development and implementation of the new system is expected to start in 2004 and be completed in three to four years. By the end of the year, extrabudgetary funding envisaged for the project over the period 2005–2007 was still short by some $16 million of the resources needed for its completion.

The Agency introduced new IT tools in 2003. The 'Nuclear Accounting Data Warehouse', under development since 1997, will improve both the storage

[4] A set of technical measures (such as verification measurements and containment/surveillance devices) chosen for the implementation of safeguards in a given facility. The approach takes into account the specific features of the facility and provides a capability to detect the diversion and undeclared production of nuclear material.

and processing of information about nuclear material. More specifically, authorized Agency staff will be able to query nuclear material accounting data with more flexibility, i.e. at different levels of aggregation or detail. It also permits the visualization of nuclear material transfers within and between facilities.

Usually, nuclear facilities have their own electronic formats for nuclear material accounting data. A new tool allows inspectors to record these large data files electronically during inspections and obviates the need to input the data manually upon return to Headquarters. The Agency configured this software tool for seven additional facilities during 2003, thereby increasing the available number of facility-specific configurations to 47.

Verification Equipment

The Agency continuously seeks to upgrade or develop reliable and effective safeguards equipment for monitoring, containment, surveillance, NDA and other tasks to increase the efficiency of its verification measures. Following positive cost–benefit analyses, the Agency installed further unattended and remote monitoring systems in nuclear facilities to maintain continuity of knowledge and verify the movements of nuclear material. These systems, in particular new, unattended monitoring systems using radiation detection and other types of sensors, reduce the need for inspector presence in the field.

Ten new unattended monitoring systems were installed and five obsolete systems were replaced by newer units, bringing the total to 88 unattended monitoring systems installed at 44 facilities in 22 States. Five remote monitoring systems, operating a total of 14 cameras, were installed. At the end of 2003, the Agency had a total of 44 remote monitoring systems in place, in 8 States, operating a total of 109 cameras.

The cost efficiency of unattended and remote monitoring systems depends on various factors, including installation, maintenance and communication costs. For that reason, the Agency began to implement a technology called Virtual Private Network, which allows for secure data transmission over the Internet and has the potential to reduce data transmission costs by up to 75%.

Spent fuel at an on-load reactor of unique design in Argentina is stored in two layers in the spent fuel pond. The lower level of the pond has so far been difficult to access, which is why the Agency developed a new method to allow the verification of spent fuel at the lower level. Specifically, digital surveillance and radiation monitoring instruments were integrated and deployed underwater for the first time in combination. This monitoring system is an example for the integration of non-destructive analysis and surveillance measures, which increases the effectiveness and efficiency of verification equipment.

Throughout 2003, the Agency implemented new safeguards approaches, with unattended monitoring systems as an integral part, for LWRs, storage facilities and transfers of spent fuel to dry storage. Unattended monitoring systems were installed at a hot cell and related dry storage facility in Canada to monitor transfers of uranium waste generated in the hot cell.

Table 1. Verification Activities

	2001	2002	2003
Person-days of inspection	10 314	10 084	9260
Number of new or revised Subsidiary Arrangements negotiated			
— General Parts	9	3	5
— Facility Attachments	10	12	17
Number of nuclear material samples analysed	831	736	678
Number of nuclear material analytical results reported	1747	1593	1426
Number of environmental samples screened	308	426	887
Nuclear material under safeguards (tonnes)			
Plutonium contained in irradiated fuel (including recycled plutonium in fuel elements in reactor cores)	690	731.6	770.3
Separated plutonium outside the reactor core	77.5	82.0	85.5
High enriched uranium	20.9	31.8	31.8
Low enriched uranium	50 079	51 226	52 972
Source material	94 940	96 410	102 252

Advanced thermo-hydraulic power monitors are used to monitor the power output of a research reactor and can verify that the output is consistent with the power level declared by the operator. More specifically, this system measures the water flow and temperatures in the primary coolant loop. The Agency improved its security features and reliability by means of sensor redundancy. The upgraded equipment was installed at a research reactor in Belgium and replaced older power monitor systems at research reactors in Indonesia, Japan and the Republic of Korea.

A new type of uranium enrichment monitoring system was installed at a uranium down-blending facility in the USA. This system comprises unattended measurement systems in the facility, which transmits the data to an accessible location. Furthermore, software was developed to interpret the data. This system reduces the duration and intrusiveness of inspections.

The Agency authorized upgraded NDA equipment for inspectors to verify the enrichment level and isotopic composition of both heavily shielded nuclear material and fuel assemblies at materials testing reactors during routine inspections. The Agency also developed new, more efficient software for core discharge monitor systems (used for unattended monitoring of fuel assembly transfers), which can count the numbers of spent fuel bundles discharged from the reactor. With Member State support, the Agency completed the development of a digital Cerenkov viewing device, which will permit verification in a non-intrusive way of spent fuel assemblies with a long cooling time, and/or low burnup, in spent fuel storage ponds.

A new measurement approach was developed, based on numerical simulation and NDA measurement, for difficult-to-access nuclear material at an Italian facility. This enabled the re-establishment of inventory.

The Agency built and tested and is now routinely using a specialized detector system to measure HEU fresh fuel assemblies at a research reactor facility in Germany. The system was developed in 2002 in co-operation with the European Union's Joint Research Centre in Ispra.

A new generation of electronic seal was developed incorporating advanced optics, electronics and cryptography. Evaluation of the new seal's performance began in early 2003.

The Agency completed the replacement of analog single camera surveillance systems with digital surveillance systems. The systematic replacement of analog multi-camera surveillance systems continued.

Training

A variety of training courses was provided to Agency staff and State personnel. With the support of a Member State, the Agency carried out a feasibility study on establishing a certification programme for training safeguards inspectors. The Agency also developed a training course specifically for inspection support staff to give them additional in-depth knowledge and skills to more effectively carry out their work. The course incorporates new responsibilities stemming from the implementation of additional protocols.

The training curriculum on additional protocol measures was consolidated and harmonized. In addition, the introductory course for Agency safeguards was revised to include topics from advanced training courses.

Interaction with States and Outreach

Member State Support Programmes. Substantial contributions to Agency safeguards continued to be made through Member State Support Programmes, with overall contributions in 2003 exceeding $21.3 million. Additionally, the Czech Republic and South Africa established support programmes.[5] At the beginning of the year, 212 Member State Support Programme tasks were under way addressing such needs as: the development and/or refinement of safeguards concepts; the development of equipment and techniques; training; and improved information technology. Thirty-one such tasks were completed and five were terminated in 2003. Following a review of the remaining tasks and the launch of 43 new ones, there were 219 ongoing Member State Support Programme tasks at the end of 2003.

Consultation and outreach. The Agency again gave high priority to explaining the significance of and encouraging States to bring into force comprehensive safeguards agreements and additional protocols. In

[5] States and organizations representing groups of States having formal support programmes: Argentina, Australia, Belgium, Canada, Czech Republic, EC, Finland, France, Germany, Hungary, Japan, Republic of Korea, Netherlands, Russian Federation, South Africa, Sweden, UK and USA. States having R&D contracts and test programmes: Austria, Israel, Latvia and Pakistan.

connection with four regional and one interregional outreach seminars hosted by the Agency, Malaysia, Romania and Uzbekistan, bilateral consultations on the conclusion and implementation of safeguards agreements and additional protocols were held with representatives of 47 States from all regions who participated in those seminars. National seminars were held in Colombia, Cuba, Haiti, the Islamic Republic of Iran, Malaysia and Thailand, while teams from Albania, Belarus, Cuba and Ukraine visited Vienna for consultations to expedite the entry into force of additional protocols.

Guidance for States. Shortly after the Board of Governors approved the Model Additional Protocol in 1997, guidelines were issued to help States prepare and submit their declarations to the Agency, under Articles 2 and 3 of the additional protocol, in a correct and timely manner. In 2003, the Agency revised the guidelines in the light of practical implementation experience and comments from States. In April, the Agency presented the proposed revision to representatives of 29 States at a technical meeting in London hosted by the United Kingdom Support Programme. The revised guidelines will be issued to States in 2004. A further refinement of the process was the possibility for States to transmit declarations electronically to the Agency over secure lines.

Other events. The Agency organized a technical meeting to review current and future needs for the verification of spent fuel in wet and dry storage facilities, to examine the status of existing spent fuel measurement technologies and to explore methodologies to improve existing capabilities. The recommendations of these experts regarding the refinement of spent fuel measurement methods were taken into account in the Agency's safeguards R&D programme for 2004.

A workshop was organized under the United States Support Programme on the 'Next Generation Surveillance System'. Participants discussed the role of surveillance as a verification tool, including current and future surveillance needs for safeguards. They also reviewed user and critical system requirements for the future surveillance system and, in addition, identified appropriate technologies to be employed which will be considered in the Agency's long term safeguards R&D programme.

Assistance to and cooperation with State Systems of Accounting and Control (SSACs). Throughout 2003, the Agency provided assistance to Member States, at both State and facility levels, to help them strengthen their SSACs. This assistance included technical advice, training and guidance. For example, the Agency co-ordinated the upgrading of the nuclear material accounting and control system at the Ulba fuel fabrication facility in Kazakhstan. The parties involved have agreed on an action plan for this purpose and on providing equipment for material measurements. Further SSAC evaluation missions visited Armenia, Azerbaijan, Kyrgyzstan and Tajikistan. The Agency also provided computer hardware and software systems to three Member States to enhance the operation of their SSACs.

The Agency and Euratom agreed to implement safeguards in the non-nuclear-weapon States of Euratom following an approach which includes the common use of equipment, joint scheduling of inspections and special arrangements for inspection work and data sharing. The ongoing restructuring of Euratom has affected the Agency's verification implementation; for example, participation in inspections by Euratom has become irregular. Some practical arrangements of the 'New Partnership Approach' may need to be reviewed after Euratom's future role has been clarified. With regard to the expansion of the European Union, following the accession of ten States in May 2004, the Agency and Euratom have established a working group to introduce similarly cooperative measures for applying safeguards in accession States, and to address important issues associated with the implementation of additional protocols in the relevant States.

Twenty-two procedures for the common use of equipment are now being implemented by the Agency and by ABACC. A procedure has also been implemented for submitting official correspondence via encrypted e-mail.

The Agency's cooperation with the SSAC in the Republic of Korea was further enhanced through the use of remote monitoring systems. With regard to Japan, the joint use of equipment as well as the joint verification of spent fuel from LWRs has resulted in savings. An IAEA–Japan Task Force Group recommended further cooperative measures under both traditional and integrated safeguards.

During the General Conference in September 2003, one session of the Scientific Forum was held on 'Safeguards Technology: Challenges and Limitations'. The main topics for discussion were safeguards effectiveness through the use of new methods and equipment, such as open source information, including satellite imagery, and environmental sampling. An NGO forum was held in Vienna in February 2003, where the Agency's strengthened safeguards system was the focus of discussion with experts and research centres. ■

Verification in Iraq Pursuant to UNSC Resolutions

Objective

To provide credible assurance that Iraq is complying with the provisions of United Nations Security Council (UNSC) resolution 687 (1991) and other relevant resolutions.

Status of Verification Activities

After the resumption of activities in Iraq under its UNSC mandate on 27 November 2002, the Agency was able to conduct field activities until 17 March 2003, when its activities were suspended in view of the impending military action (Fig. 1). As of 17 March 2003, the Agency did not find in Iraq any evidence of the revival of a nuclear programme prohibited under United Nations resolutions 687 (1991) and 707 (1991). However, the time available to the Agency before inspections were suspended was not sufficient to permit it to complete its overall review and assessment.

On 22 May 2003, the UNSC adopted resolution 1483, in which it expressed its intention to revisit the mandate of the Agency under relevant resolutions. However, the Council did not take up the matter in 2003.

Operations

During the three and a half months of operation, Agency teams carried out 237 inspections at some 148 locations, including 27 new locations. More than 1600 different buildings were inspected. Inspections were undertaken at State run and private industrial facilities, research centres, trading companies and universities. These were locations where Iraq's significant technical capabilities were known to have existed in the past or new sites suggested by remote monitoring and analysis or identified by other States. The Agency sought to determine if anything relevant to the revival of nuclear capabilities had occurred

FIG. 1. Briefing on Iraq for the United Nations Security Council in New York, 7 March 2003. Participating in the debate are (from left): Mr. Jack Straw, Foreign Secretary, United Kingdom; Mr. Colin Powell, Secretary of State, USA; Dr. Mohamed ElBaradei, Director General, IAEA; and Dr. Hans Blix, Executive Chairman, UNMOVIC.

in Iraq over the past four years during which inspections were interrupted. Important special activities included verifying the use of aluminium tubes in rockets and the disposition of certain high explosives, and clarifying the purpose of construction work at former sites of interest.

A broad variety of nuclear and non-nuclear material, environmental, soil and swipe samples (85 in total) were collected from various locations across Iraq. Previously installed air particulate samplers, removed from Iraq in December 2002, were refurbished and reintroduced in January 2003. Land and vehicle based surveys, as well as hand-held radiometric (gamma) screening, commenced in early December 2002, and over a period of 75 days the Agency conducted 125 surveys (separate from inspections) at State, industrial and military locations as well as in urban areas.

The Agency also implemented a programme aimed at understanding Iraq's procurement patterns. In addition to ad hoc inspections related to procurement activities, an Agency team of technical experts, customs investigators and computer forensic specialists conducted a series of inspections at private and government owned trading companies and at procurement departments within government manufacturing facilities. During these inspections, approximately 4000 pages were copied and 100 gigabytes of computer data retrieved.

Analysis

During the first half of 2003, the Agency's activities were focused on the analysis and assessment of inspection findings, the generation of new inspection priorities and the consolidation of all information made available to the Agency, including that provided by Member States (the nature and extent of which remained limited).

Although the time available before inspections were suspended was not sufficient to permit it to complete its overall review and assessment, the Agency was able to significantly update its understanding of Iraq's remaining nuclear capabilities. It did not find any evidence or plausible indication of the revival of a nuclear programme prohibited under UNSC resolutions 687 (1991) and 707 (1991).

In the second half of the year, the Secretariat office responsible for the implementation of the Agency's resolution-related mandate focused its activities on: analysing the wealth of additional information collected during inspections; consolidating its information assets and collecting and analysing a variety of new information, including satellite imagery, updating its knowledge of the formerly relevant facilities in Iraq; refining its plan for resumed verification activities in view of the many uncertainties of the evolving situation in Iraq; and evaluating lessons learnt through its past experience in Iraq.

Export–Import Operations

Starting in May 2002 with the adoption of resolution 1409, the UNSC requested the Agency to evaluate applications submitted to the Office of the Iraq Programme (OIP) related to the export of products and commodities to Iraq. The Agency was responsible for identifying nuclear related items referred to in paragraph 24 of resolution 687 (1991) or in Section D (Nuclear) of the Goods Review List (GRL)[1], to determine whether such items were either prohibited or required prior approval by the Security Council Committee established by resolution 661 (1990) (the "Sanctions Committee"). Over 3200 applications were processed between January and May 2003, when the Council decided, in resolution 1483 (2003), to lift the sanctions, terminating that part of the Agency mandate. ■

[1] The Goods Review List (GRL) (S/2002/515) is referred to in resolution 1409 (2002). Section D of the GRL identifies the relevant nuclear related items. This section is identical to the list of nuclear related items to which the export–import mechanism, approved in UNSC resolution 1051 (1996), applies, as well as to Annex 3 of the Agency's Ongoing Monitoring and Verification (OMV) Plan approved in UNSC resolution 715 (1991), as updated in 2001 (S/2001/561).

Technical Cooperation

Management of Technical Cooperation for Development

Objective

To further strengthen the technical cooperation programme, and ensure relevance, transparency, effectiveness and efficiency in contributing to tangible social and economic benefits and to the scientific advancement of Member States.

Programme Planning and Coordination

The third meeting of the Standing Advisory Group on Technical Assistance and Cooperation (SAGTAC) was held in July 2003. The group made recommendations and observations on strengthening the Country Programme Framework (CPF) process, possible improvements for the project approval process and partnership building with non-conventional donors.

As a follow-up to evaluations of the technical cooperation programme, in-depth reviews were carried out of internal processes and programming tools to ensure greater performance and efficiency and better linkage with international development priorities. One review, for example, focused on optimizing existing processes and on identifying the necessary levels of human resources to carry out programme planning and implementation. Another review, responding to a request from SAGTAC, involved an assessment of the process for approving programmes.

Upstream work for the 2005–2006 programme included a greater emphasis on fewer, but better, projects in Member States. Importance was also given to ensuring, through the application of the central criterion, that the projects selected receive strong commitment from the recipient government. In this regard, a key tool in programme planning for technical cooperation is the development of CPFs, a major feature of which is direct dialogue and engagement with central authorities in Member States when planning national technical cooperation strategies. There are now 93 countries with CPFs in place or awaiting final signature, 32 more than in 2002.

To increase the efficiency of implementation, a new interactive intranet system was developed to support fellowship evaluations and placements. The system helps to find hosting institutions and introduces a fully electronic workflow and approval process in technical cooperation and technical divisions. Similar systems were started for expert missions and meetings and for updating project budgets. In addition, the internet system TC-PRIDE (Technical Cooperation Project Information Dissemination Environment; *http://www-tc.iaea.org/tcpride/*) has been enhanced with country level information, including contacts, historical, financial, and statistical information, and the status of individual fellowships.

Delivery under the technical cooperation programme in 2003 was greater than in 2002, with net new obligations totalling $76.1 million, up from $74.6 million the previous year. While resources for 2003 were also higher than they had been in 2002, resources for the Technical Cooperation Fund (TCF) actually available at 31 December 2003 were well below resource projections on which the technical cooperation programme for 2003 had been based, which resulted in a reduction of the programme for both 2003 and 2004.

New resources from extrabudgetary donors reached a record high of $11.8 million, up from $5.7 million in 2002. This indicates a willingness on the part of a broad range of donors to work in partnership with the Agency to support activities under the technical cooperation programme. As Fig. 1 indicates, $4.3 million were contributed as government cost sharing by Member States to support project activities in their own country. The remaining $7.5 million were received from Member States and organizations for use in specific projects approved under the technical cooperation programme. In total, just under $8.5 million of the total $11.8 million were used to upgrade approved 'footnote-a/' projects and components.

Programme Formulation and Implementation

One of the longest running technical cooperation projects is the 'Model Project on Upgrading Radiation Protection Infrastructures'. The Secretariat presented a progress report on the implementation of the project to the November meeting of the Board of Governors.

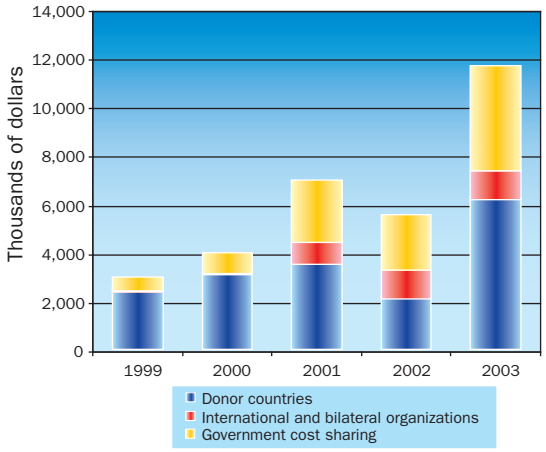


FIG. 1. Member State support to the Agency's technical cooperation programme. Much of the growth is based largely on extrabudgetary resources.

Currently, 88 Member States are participating in the project, which is now being implemented in the form of ten regional projects, with two projects for each region. The report concluded that 41 participating countries have achieved essential parameters signifying compliance with the requirements for attaining milestones 1 and 2. Substantial parts of activities related to milestones 3, 4 and 5 are still to be implemented by most of the participating countries.

Harnessing the growing capabilities of Member States is a new initiative that the Agency is pursuing as part of its technical cooperation activities. One example was a meeting held in Athens, supported by the Greek Government, to identify possible Mediterranean subregional projects on environmental and safety related issues. The main feature of this initiative is the emphasis on technical cooperation *among* developing countries (TCDC), cost sharing and self-reliance. The Agency's role in this project will be more that of a technical advisor and a facilitator rather than an organization providing financial assistance.

Under a regional East Asia and the Pacific project on self-reliance and the sustainability of national nuclear institutions, a guideline in project costing and pricing was provided to the 12 participating countries. Nuclear institutions in four of these countries (China, India, Malaysia and Pakistan) are generating considerable revenue through products and services and have the infrastructure to support such work. These institutions provide expertise to an additional six countries (Bangladesh, Indonesia, Philippines, Sri Lanka, Thailand and Vietnam) that would like to increase their self-reliance capabilities, but have inadequate management skills and infrastructure.

In the Africa region, guidance, training and advisory assistance provided to Member States since 2000 has led ten African national nuclear institutions to integrate their activities into national development objectives by refocusing on programmes that are needs-driven and which can be sustained through income generation and improved management practices. Some of these national nuclear institutions were able to earn up to 60% of their budget through the realignment of core activities and priorities.

Other efforts to build self-reliance and sustainability included steps to increase the role of ARCAL's 34 regional designated centres in support of regional projects in Latin America and the Caribbean and to integrate them as full partners in project implementation. ARCAL Member States also initiated discussions to establish a goal for the future, in agreement with national development plans, to benefit countries with less advanced nuclear development through partnerships with countries that are more advanced in each of the different areas of mutual interest.

The Agency assisted Member States in the establishment of appropriate legislative and regulatory frameworks for upgrading radiation safety, nuclear liability, safeguards and the physical protection of nuclear material. This assistance included activities to further empower the national regulatory authority and support to 13 Member States in their development of national nuclear and radiation safety legislation. ■

Annex

Note: Tables A4–A28 are available on the attached CD-ROM.

Table A1. Allocation and Utilization of Regular Budget Resources in 2003

Programme	2003 budget GC(46)/7 (at € 0.9229) (1)	2003 adjusted budget [a] (at € 0.8938) (2)	2003 total expenditure		Unused (overexpended) budget (5)
			Amount (3)	% of adjusted budget (4)	
Overall Management, Coordination and Common Activities	688 000	706 798	703 665	99.56	3 133
Nuclear Power	4 787 000	4 906 000	4 906 474	100.01	(474)
Nuclear Fuel Cycle and Material Technologies	2 318 000	2 375 000	2 424 547	102.09	(49 547)
Analysis for Sustainable Energy Development	2 738 000	2 805 000	2 822 797	100.63	(17 797)
Nuclear Sciences	8 364 000	8 514 664	8 447 535	99.21	67 129
Subtotal	**18 895 000**	**19 307 462**	**19 305 018**	**99.99**	**2 444**
Overall Management, Coordination and Common Activities	676 000	694 886	683 981	98.43	10 905
Food and Agriculture	11 312 000	11 558 846	11 544 118	99.87	14 728
Human Health	6 410 000	6 542 000	6 545 036	100.05	(3 036)
Water Resources	3 051 000	3 124 000	3 128 460	100.14	(4 460)
Protection of the Marine and Terrestrial Environments	3 780 000	3 881 000	3 907 402	100.68	(26 402)
Physical and Chemical Applications	2 582 000	2 640 911	2 632 453	99.68	8 458
Subtotal	**27 811 000**	**28 441 643**	**28 441 450**	**100.00**	**193**
Overall Management, Coordination and Common Activities	766 000	786 000	790 647	100.59	(4 647)
Safety of Nuclear Installations	8 013 000	8 225 000	8 221 246	99.95	3 754
Radiation Safety	5 324 000	5 479 368	5 454 031	99.54	25 337
Management of Radioactive Waste	6 309 000	6 469 000	6 493 444	100.38	(24 444)
Subtotal	**20 412 000**	**20 959 368**	**20 959 368**	**100.00**	**0**
Overall Management, Coordination and Common Activities	1 021 000	1 049 536	1 006 164	95.87	43 372
Safeguards	88 311 000	90 732 766	90 524 213	99.77	208 553
Security of Material	880 000	903 000	1 153 472	127.74	(250 472)
Verification in Iraq Pursuant to UNSC Resolutions (extrabudgetary funding only)					
Subtotal	**90 212 000**	**92 685 302**	**92 683 849**	**100.00**	**1 453**
Public Information	3 356 000	3 447 846	3 436 574	99.67	11 272
Information Technology Infrastructure and Services	5 897 000	6 068 000	6 084 145	100.27	(16 145)
Nuclear Information Resources	6 702 000	6 887 000	6 887 060	100.00	(60)
Conference, Translation and Publishing Services	4 166 000	4 283 398	4 277 519	99.86	5 879
Subtotal	**20 121 000**	**20 686 244**	**20 685 298**	**100.00**	**946**
Management of Technical Cooperation for Development	15 065 000	15 488 684	15 486 359	99.98	2 325
Subtotal	**15 065 000**	**15 488 684**	**15 486 359**	**99.98**	**2 325**
Executive Management, Policy-Making and Coordination	13 938 000	14 282 297	13 700 663	95.93	581 634
Administration and General Services	36 619 000	37 703 000	38 254 001	101.46	(551 001)
Oversight and Evaluation	1 964 000	2 018 000	2 046 100	101.39	(28 100)
Subtotal	**52 521 000**	**54 003 297**	**54 000 764**	**100.00**	**2 533**
Total – Agency programmes	**245 037 000**	**251 572 000**	**251 562 106**	**100.00**	**9 894**
Reimbursable work for others	3 838 000	3 942 000	3 329 176	84.45	612 824
Total	**248 875 000**	**255 514 000**	**254 891 282**	**99.76**	**622 718**

[a] Based on the decision of the Board of Governors in document GOV/1999/15 an amount of $18 368 was transferred to the nuclear safety area (protection against radiation) to cover the cost of emergency assistance to Ecuador, Georgia, Nigeria and Qatar. To recover this advance, year-end unencumbered balances in the regular rudget appropriation sections were used.

Table A2. Extrabudgetary Funds in 2003

Programme	Extra-budgetary figures GC(45)/8 & GC(46)/7 (1)	Resources			Total resources 31 Dec 2003 (2)+(3)+(4) (5)	Expenditure 31 Dec 2003 (6)	Unused balance 31 Dec 2003 (5)-(6) (7)
		Unused balance 1 Jan 2003 (2)	Receipts [a] 31 Dec 2003 (3)	Adjustments 31 Dec 2003 (4)			
Overall Management, Coordination and Common Activities	110 000	0	153	0	153	0	153
Nuclear Power	1 568 000	1 095 157	1 480 581	5 695	2 581 433	1 760 841	820 592
Nuclear Fuel Cycle and Material Technologies	447 000	283 677	464 470	0	748 147	354 536	393 611
Analysis for Sustainable Energy Development	250 000	0	0	0	0	0	0
Nuclear Science	13 000	296 746	(41 350)	0	255 396	16 745	238 651
Total	2 388 000	1 675 580	1 903 854	5 695	3 585 129	2 132 122	1 453 007
Overall Management, Coordination and Common Activities	0	162 516	216 854	1 880	381 250	342 135	39 115
Food and Agriculture (excl. FAO)	391 000	325 554	71 439	68	397 061	303 939	93 122
FAO	2 834 000[b]	239 773	2 165 500	0	2 405 273	2 283 234	122 039
Total Food and Agriculture	3 225 000	565 327	2 236 939	68	2 802 334	2 587 173	215 161
Human Health	0	115 064	0	235	115 299	34 385	80 914
Water Resources	0	0	0	0	0	0	0
Protection of the Marine and Terrestrial Environments	630 000	527 235	724 197	1 004	1 252 436	708 019	544 417
Physical and Chemical Applications	0	8 500	0	0	8 500	0	8 500
Total	3 855 000	1 378 642	3 177 990	3 187	4 559 819	3 671 712	888 107
Overall Management, Coordination and Common Activities	0	0	162 631	0	162 631	17 129	145 502
Safety of Nuclear Installations	3 137 000	4 015 523	3 797 211	17 343	7 830 077	3 438 260	4 391 817
Radiation Safety	248 000	3 536 918	1 736 489	2 167	5 275 574	2 407 373	2 868 201
Management of Radioactive Waste	230 000	508 818	935 671	1 059	1 445 548	755 074	690 474
Total	3 615 000	8 061 259	6 632 002	20 569	14 713 830	6 617 836	8 095 994
Overall Management, Coordination and Common Activities	0	0	728 744	0	728 744	0	728 744
Safeguards	7 553 000	14 906 043	21 333 644	244 098	36 483 785	15 109 503	21 374 282
Security of Material	597 000	5 110 525	8 208 430	78 436	13 397 391	4 215 628	9 181 763
Verification in Iraq Pursuant to UNSC Resolutions	10 650 000	8 104	6 500 000	37 114	6 545 218	5 643 641	901 577
Total	18 800 000	20 024 672	36 770 818	359 648	57 155 138	24 968 772	32 186 366
Public Information	620 000	959 481	913 680	19 904	1 893 065	1 155 686	737 379
Information Technology, Infrastructure and Services	0	18 278	0	0	18 278	6 836	11 442
Nuclear Information Resources	12 000	729	232 911	169	233 809	55 456	178 353
Conf. Transl. and Publishing Services	0	0	0	0	0	0	0
Total	632 000	978 488	1 146 591	20 073	2 145 152	1 217 978	927 174
Management of Technical Cooperation for Development	300 000	225 805	334 138	0	559 943	446 503	113 440
Total	300 000	225 805	334 138	0	559 943	446 503	113 440
Executive Management, Policy-Making and Coordination	0	194 815	561 473	9 599	765 887	216 910	548 977
Administration and General Services	0	0	330 683	0	330 683	162 818	167 865
Oversight and Evaluation	100 000	29 887	179 113	(3 354)	205 646	64 068	141 578
Total	100 000	224 702	1 071 269	6 245	1 302 216	443 796	858 420
Total extrabudgetary	**29 690 000**	**32 569 148**	**51 036 662**	**415 417**	**84 021 227**	**39 498 719**	**44 522 508**

[a] The column "Receipts" includes cash contributions received as well as budget contributions from FAO, UNEP and the United Nations Office for Project Services for approved activities.

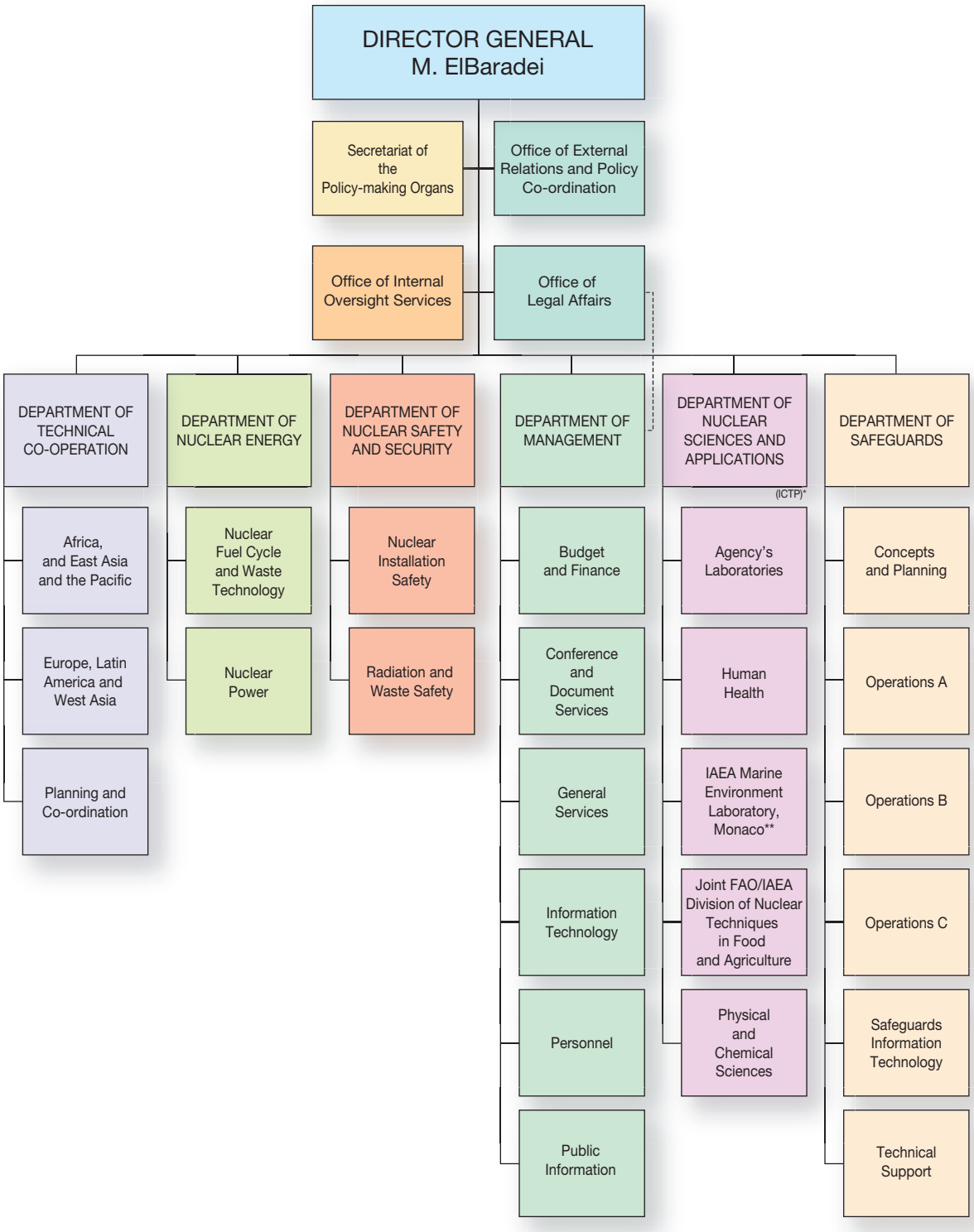
[b] The FAO budget includes $1 057 176 estimated costs for FAO professional staff working in the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. The salaries of these staff members are paid by FAO and, therefore, are not included under the column of the Agency's resources and expenditure.

Table A3. Technical Cooperation Disbursements by Agency Programme and Region in 2003
(in thousands of dollars)

Programme	Africa	East Asia and the Pacific	Europe	Latin America	West Asia	Global/ inter-regional	Total
Nuclear Power	230.2	462.4	1 516.5	763.3	602.0	103.6	3 678.1
Nuclear Fuel Cycle and Material Technologies	247.9	135.4	639.5	389.0	0.0	0.0	1 411.9
Analysis for Sustainable Energy Development	314.4	123.2	40.3	149.5	4.2	0.0	631.6
Nuclear Science	818.9	341.3	477.9	693.7	833.6	83.8	3 249.2
Food and Agriculture	6 236.1	1 644.3	424.5	2 011.3	1 046.0	677.6	12 039.7
Human Health	4 826.9	1 776.4	3 983.5	3 916.4	805.0	361.0	15 669.1
Water Resources	1 912.2	997.0	196.4	883.1	63.6	41.0	4 093.3
Protection of the Marine and Terrestrial Environments	494.7	512.4	539.2	521.3	340.8	122.2	2 530.6
Physical and Chemical Applications	1 639.9	1 382.0	1 735.6	1 185.6	1 057.2	6.5	7 006.8
Safety of Nuclear Installations	268.9	647.1	2 717.8	215.0	271.4	49.6	4 169.8
Radiation Safety	1 173.3	1 093.1	3 049.8	1 583.1	1 827.6	117.6	8 844.5
Management of Radioactive Waste	374.5	395.1	2 348.9	513.9	322.2	184.9	4 139.5
Security of Material	150.2	22.1	541.6	0.0	91.4	20.0	825.3
Public Information	0.0	0.0	2.0	37.7	0.0	0.0	39.8
Nuclear Information Resources	0.0	0.0	29.1	0.0	26.4	0.0	55.5
Management of Technical Cooperation for Development	825.9	843.6	756.6	953.3	157.5	1 195.3	4 732.3
Executive Management, Policy-Making and Coordination	55.1	9.3	31.7	3.6	0.0	0.0	99.6
Total	**19 569.1**	**10 384.8**	**19 030.9**	**13 819.9**	**7 449.0**	**2 962.9**	**73 216.6**

ORGANIZATIONAL CHART

(as of 31 December 2003)



* The Abdus Salam International Centre for Theoretical Physics (Abdus Salam ICTP), legally referred to as "International Centre for Theoretical Physics", is operated as a joint programme by UNESCO and the Agency. Administration is carried out by UNESCO on behalf of both organizations. The Agency's involvement in the Centre is managed by the Department of Nuclear Sciences and Applications.

** With the participation of UNEP and IOC.

"The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world."

Article II of the IAEA Statute

IAEA

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