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End User Needs for Enhanced IAEA Safeguards Information Management Capabilities

R. Badalamente[a]
G. Anzelon[b]
S. Deland[c]
R. Whiteson[d]

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(a) Pacific Northwest Laboratory.
(b) Lawrence Livermore National Laboratory.
(c) Sandia National Laboratory.
(d) Los Alamos National Laboratory.

Executive Summary

The International Atomic Energy Agency is undertaking a program for strengthening its safeguards system based on the recognition that safeguards must give assurance not only of the non-diversion of declared material or that declared facilities are not being misused, but also of the absence of any undeclared nuclear activities in States which have signed comprehensive safeguards agreements with the Agency.

The IAEA has determined that the detection of undeclared nuclear activities and the creation of confidence in the continuing peaceful use of declared material and facilities is largely dependent on *more information* being made available to the Agency and on the capability of the Agency to make *more effective use* of this additional information, as well as existing information.

The IAEA expects to obtain through expanded reporting and its own collection measures a much greater volume of information than it is currently required to manage. Furthermore, the information being obtained is fundamentally different in several respects from that it has experience dealing with under conventional safeguards. The vastly increased amount of data that the Agency must deal with and its essentially qualitative nature and other characteristics demand new and innovative information management systems and techniques by the Agency in order for it to make effective use of the information in meeting its expanded safeguards mission.

It is essential that development efforts by the U.S. Support Program addressing IAEA information management needs be guided by a set of "umbrella" guidelines and/or specifications including a definition of user needs (the purpose of this document), human-computer interface guidelines, and system requirements specifications. Human-computer interface guidelines will help ensure a standard "look and feel" for Safeguards Information Management Systems (SIMS) products. System requirements specifications will ensure that SIMS products will be compatible with each other and with existing IAEA systems.

Some of the more important factors to consider in SIMS development include the following:

Organizational Issues; Division of Responsibilities. The Agency has not yet determined how responsibilities for systematic analysis will be assigned within the Department of Safeguards. This determination will impact system design objectives for SIMS products.

Security. Security of the information must be maintained and access should be restricted to designated staff on a need-to-know basis. SIMS design must make provision for IAEA security concerns.

User Limitations. Information management systems provided through SIMS should be designed with consistent, user-friendly interfaces. On-line help should be provided as an option for less-experienced users.

Support. It is essential that any hardware or software systems provided by SIMS be backed up by ongoing post-delivery support and maintenance until such time as handoff to IAEA support organizations is feasible. This support must include training for both system users and system support staff, where required. In addition, systems must be delivered with adequate documentation. This support commitment should be included in SIMS cost estimates.

Compatibility with Existing Systems. Compatibility with the current IAEA computer environment is highly desirable. Development of a System Requirements specification by the Technology and Systems Group would assist in the design of future SIMS products.

In the view of the SIMS User Requirements Group, priorities for SIMS support to the IAEA are as follows:

- enhance INSIST, with the priority being upgrade of the INSIST user interface, and assistance to the IAEA in expediting data entry;

- develop interim capabilities to support environmental monitoring field trials under Program 93+2, Task 3, including delivery in FY 1994 of a 93+2 workstation with adequate capabilities for environmental monitoring data storage and retrieval;

- assist the 93+2, Task 5 team in expediting data entry and in furthering defining systematic analysis information management needs and move to address these needs through rapid prototyping;

- develop prototype in-field support information management tools, coordinating this effort with Agency efforts on the In-Field Support System (IFSS) and the Brief-Case Inspection System (BIS); and

- support SEE information management needs, especially those dealing with developing a basis for expanded SIR conclusions.

Additional details are provided below. Requirements by major task area are summarized in Table ES-1.

Table ES-1. Requirements Summary

Task Area	Capability Required	Impact	Urgency
Action Team Activities	Enter high volume of data of various types (streamline translation of data into electronic form)	High	Immediate
	Store/retrieve data according to its geographic location	High	Immediate
	- inventories		
	- design information/drawings		
	- seals information		
	- inspection results		
	- images/graphics		
	- video/stills		
	- sites and facilities		
	- layouts of piping		
	- equipment photos		
	Store/retrieve text, including open-source information		
	- provide flexible retrieval tools	High	immediate
	- associate text with locations/facilities	Medium	1/2-1 yr.
	- provide context-sensitive search	Medium	>1 yr.
	Store/retrieve data on nuclear activities	High	Immediate
	- suppliers, i.e., countries, firms, intermediaries		
	- Iraqi nuclear programmatic activities		
	- accounting data		
	- export/import reports		
	- Iraqi reports and declarations		
	- information from UNSCOM and 3rd parties		
	Store/retrieve data related to environmental monitoring/ sample taking (see Environmental Monitoring task area)	High	Immediate
	Import data from INSIST to PC/MS-DOS	High	Immediate
	Computer-assisted analysis of data		
	- export/import reports	Medium	>1 yr.
	- view data from different frames of ref.	High	Immediate
	- modelling of process flows, pathways	Medium	>1 yr.
	- analyze environmental monitoring data (see Environmental Monitoring task area)	Medium	>1 yr.
	- correlation analysis between different data cat.	Medium	1/2-1 yr.
	- perform change detection on images	Medium	>1 yr.
	- provide technical ref. tools/databases	Medium	>1 yr.
	Lightweight, small volume, portable PC (see field support for conventional safeguards)	Medium	1/2-1 yr.
Environmental Monitoring	Store/retrieve data related to sample taking	High	Immediate
	- sample type		
	- location		
	- coordinates		
	- measurement points		
	- date/time of sample taking		
	- sample data		
	- where sample is being analyzed		
	- status of analysis		
	- results of analysis		
	Access/store/retrieve supplemental data for sample analysis	High	Immediate
	- meteorological data		
	- land contours		

Table ES.1. (contd)

Task Area	Capability Required	Impact	Urgency
Environmental Monitoring (contd)	- maps		
	Geo-reference data	High	Immediate
	Compute distance between two given points (i.e., a sample point and a reference point)	Medium	1/2-1 yr.
	Provide flexible tools for standard mathematical and statistical analyses	Medium	1/2-1 yr.
	Track strategically located samples over time	High	1/2-1 yr.
	Provide physical transport modeling tools	High	1/2-1 yr.
	Model operations of different facility types	Medium	> 1 yr.
	Decision support to guide sample analysis	Medium	> 1 yr.
	Suggest locations for environmental monitoring	Medium	> 1 yr.
	Help develop sampling plans	Medium	> 1 yr.
	Provide data presentation/visualization tools (standard types of graphs and charts, plus map overlays)	Medium	1/2-1 yr.
	Provide in-field support for sample taking and logging	Medium	> 1 yr.
	- previous sample locations		
	- sample type		
	- location (e.g., near what site, city, ...)		
	- coordinates		
	- measurement points		
	- date/time of sample taking		
	Provide in-field visualization tools	Low	> 1 yr.
	Provide the ability to exchange data between Agency computers (workstation or desktop computer) and laptops to take to the field	Medium	1/2-1 yr.
	Provide the ability to input data from field instruments to a laptop computer, e.g.:	Medium	> 1 yr.
	- portable analysis instruments		
	- bar code readers (lower urgency)		
	- weather instruments		
	- GPS receivers		
Systematic Analysis	Store/retrieve text, including open-source information		
	- provide flexible retrieval tools	High	Immediate
	- provide context-sensitive search	Medium	> 1 yr.
	- associate text with locations/facilities	Medium	1/2-1 yr.
	Store/retrieve other data	High	Immediate
	- suppliers, i.e., countries, firms, intermediaries		
	- States' nuclear programmatic activities		
	- accounting data		
	- export/import reports		
	- States' reports and declarations		
	Store/retrieve data related to environmental monitoring/ sample taking (see Environmental Monitoring task area)	Medium	1/2-1 yr.
	Store/retrieve data according to its location (geographic or relative location within site, facility, or building)	Medium	1/2-1 yr.
	- inventories		
	- design information/drawings		
	- seals information		
	- inspection results		
	- images/graphics such as maps		
	- video/stills		

Table ES.1. (contd)

Task Area	Capability Required	Impact	Urgency
Systematic Analysis (contd)	- sites and facilities		
	- layouts of piping		
	- equipment photos		
	Computer-assisted analysis of data		
	- export/import reports	Medium	> 1 yr.
	- view data from different frames of ref.	High	Immediate
	- analyze environmental monitoring data (see Environmental Monitoring task area)	Medium	> 1 yr.
	- modelling of process flows, pathways	Medium	> 1 yr.
	- correlation analysis between different data cat.	Medium	1/2-1 yr.
	- perform change detection on images	Medium	>1 yr.
	- provide technical ref. tools/databases	Medium	>1 yr.
Training	Move training materials to multimedia environment	Low	>1 yr.
	- hypertext		
	- run-time video		
	- interactive audio		
	- CD-ROM		
	- Video disk		
	Training for new systems must address users and those providing support/maintenance	Medium	1/2-1 yr.
	User-friendly interface	High	1/2-1 yr.
Conventional Safeguards	Store/retrieve new safeguards information (or improve methods for certain types of current safeguards information)	Medium	> 1 yr.
	- expanded declarations		
	- facility design information (includes maps and plans)		
	- location and type of surveillance equipment		
	- facility specific provisions of the safeguards agreement		
	- location and identities of tags and seals		
	Improve examination and verification of design information (electronic storage and retrieval)	Medium	1/2-1 yr
	Upgrade ISIS	Low	> 1 yr.
	Accept systematic analysis results as input to SIR	High	1/2-1 yr.
	Specialized modeling and analysis tools for SEE	Medium	> 1 yr.
	Summarize and check consistency of data at multiple levels (MBA, facility, country, region)	Medium	1/2-1 yr.
	Security (read-only db access, password control)	High	ongoing
Conventional Safeguards Field Support (CSFS)	Lightweight, small volume, portable PC	Medium	> 1 yr.
	Store/retrieve (coordinated with BIS and IFSS)	Medium	1/2-1 yr. (partial)
	- inventory information		
	- design information/drawings		> 1 yr. (rest of items)
	- seals information		
	- record inspection results		
	- images/graphics such as maps, pictures of POCs		
	- video/stills of hot areas		
	- facility information		
	- safeguards criteria		

Table ES.1. (contd)

Task Area	Capability Required	Impact	Urgency
CSFS (contd)	- diagrams of material flow process w/components and technical parameters		
	- layouts of piping		
	- equipment photos		
	- containment/surveillance equipment lists with service dates		
	Tailor information to site visited	Medium	> 1 yr.
	Tools to optimize utilization of manpower and time	Low	> 1 yr.
	Decision support for inspection procedure	Medium	> 1 yr.
	- sampling plans		
	- which parts of facility to visit		
	Model/review containment and surveillance measures	Low	> 1 yr.
	Model material flow	Medium	> 1 yr.
	Model diversion scenarios	Medium	> 1 yr.
	Show history of equipment layouts	Medium	> 1 yr.

Enhance INSIST Capabilities

The Action Team's requirements are immediate, not a year or more down the road as with some aspects of the Safeguards Department's Systematic Analysis. The high volume of data already exceeds the ability of Action Team analysts to efficiently manage. Furthermore, the recent turnover of personnel carries the potential for loss of "corporate memory." Newer team members are concerned that vital information could be sitting in some obscure file drawer without their knowing it; they see great benefit in having reliable, automated access to information. But data cannot be retrieved electronically until it exists in electronic form, and data entry also represents a near-term priority problem for the Action Team.

In the near-term, most of the Action Team's requirements for data manipulation, modeling, and analysis are not as urgent as the requirement simply for entering, storing, searching, and retrieving information. Furthermore, the more ambitious of the modeling and analysis goals still require more R&D to identify what methods and algorithms are effective and appropriate. To the extent that near-term efforts are possible under SIMS, priority probably should be given to assisting the IAEA in:

- scanning hardcopy data into electronic form
- the ability to filter and categorize documents
- adding a text retrieval capability to INSIST
- adding a gazetteer capability to INSIST
- developing and integrating new databases
- modifying the INSIST user interface to better meet user needs and abilities
- developing a capability to take information to the field on notebook computers
- networking Action Team desktop PCs with each other and with the INSIST workstation

Provide for Near-Term Environmental Monitoring Information Management Needs

The Task 3 team is already engaged in field trials, so there is a time-urgent need for information management support for analysis of field trial data. Two timescales must be supported: (1) the short-term needs generated from field trials, and (2) the long-term information management support needed for any environmental monitoring actually implemented as part of enhanced safeguards. The user group for the short-term is the 93+2, Task 3 Team. The primary user groups for the long-term needs will be inspectors collecting information in the field and inspectors or analysts analyzing the results of the samples.

Priority in FY 94 should be given to supporting the 93+2, Task 3 information management requirements by providing a suitable workstation with adequate data storage and retrieval capabilities for environmental monitoring data.

In addition, the IAEA has requested, and the U.S. should support, arrangements for IAEA personnel to visit the U.S. and meet with users of geo-referenced computer systems in order to gain a better appreciation for capabilities and needs.

Further Explore Opportunities for Supporting Systematic Analysis Information Management Needs

For the near-term, the primary concern of the 93+2, Task 5 team seems to be dealing with the daunting volume of data available to it. SIMS efforts in support of Task 5 should include:

- guidance on how to analyze open source information;
- assistance in determining how to streamline the categorization of documents;
- computer-assisted means of evaluating the contents of documents; and
- a means of automating the annotation of documents to preserve human efforts at document analysis.

Certain analytically complex modeling and analysis tools desired for systematic analysis do not yet exist, and the necessary methodologies and algorithms are yet to be developed and tested. An ongoing program of research on analytical methodologies for systematic analysis appears necessary (an illustration of the systematic analysis process is provided in Figure ES-1). This effort should be coordinated with efforts supporting the Action Team, as needs are, in many respects, similar. In the meantime, DOE/AN should seek to discourage the Agency from installing additional INSIST-like platforms in operations divisions, since the requirement for such capability is unclear. Rather, PC-based tools designed to support well-defined analysis tasks appear a more cost-effective early technology enhancement path.

Develop Prototype In-Field Information Management Tools

The Safeguards Department is currently pursuing efforts to enhance in-field information management capabilities with its In-Field Support System (IFSS) and the Briefcase Inspection System (BIS) (see Section 4.5.2.3). Both of these initiatives support accountancy-related inspection activities and deal with largely quantitative data. SIMS should seek to support and/or complement these initiatives. The Action Team desires computing resources for their inspections in Iraq, where they would be used

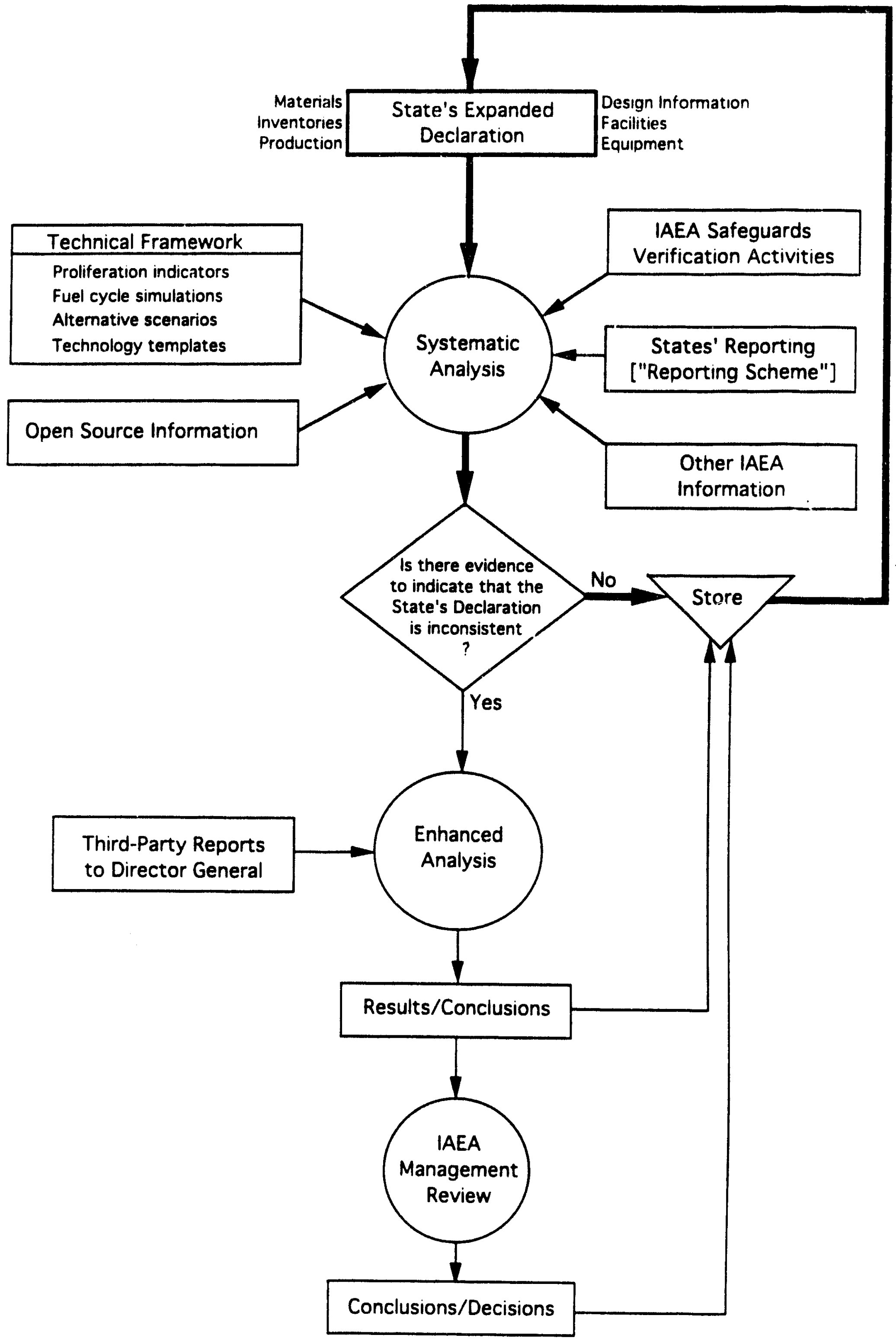

Figure ES.1. An Illustration of the Systematic Analysis Process after daily inspection activities for entering data, assessing preliminary results, and planning the next day's activities. In-field IM support for 93+2, Task 3 is desirable, but not time-urgent.

Support SEE IM Needs

The Safeguards Implementation Report (SIR) will be expected to comment on the possibility of undeclared activities. The results of Systematic Analysis will be needed by SEE for such an expanded SIR. SEE also may require specialized modeling and evaluation tools unique to the expanded SIR that are not specifically required for systematic analysis alone. In the future, the SIR will need to contain conclusions regarding the possibility of undeclared activities. The evaluation necessary to draw such conclusions is not seen as quantifiable and developing a procedure to reach such a conclusion for the SIR is of great concern. This is a time-urgent need, but it is not clear how SIMS should proceed to support it. Furthermore, this is an area that POTAS has been considering for initiation of an SP-I and Member State support. Therefore, DOE/AN should coordinate any proposed SIMS initiatives with ISPO.

Acknowledgments

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Contents

Annex 1 - Requirements Summary

Annex 2 - Basic Concepts of IAEA Nuclear Material Accounting

Annex 3 - Board Papers

- a - IAEA Board of Governors Paper, GOV/2698
- b - Briefing Notes for Missions
- c - IAEA Board of Governors Paper, GOV/INF/737

Annex 4 - Country Officer Responsibilities, 1993-02-05

Annex 5 - SGCP Country Information System Users Guide, 1993-11-19

Annex 6 - Consultants Group Meeting on Environmental Monitoring and Special Analysis Methods for Safeguards

Figures

Tables

1.0 Introduction

1.1 Purpose

The purpose of this document is to describe the needs of the International Atomic Energy Agency (IAEA) for enhanced safeguards information management capabilities from the standpoint of the projected end user, i.e., the person or persons expected to actually employ these capabilities in the conduct of their job or task.

1.2 Background

The Safeguards Information Management Systems (SIMS) initiative is a program of the Department of Energy's (DOE) Office of Arms Control and Nonproliferation being undertaken by Los Alamos, Lawrence Livermore, Pacific Northwest, and Sandia National Laboratories with the aim of supporting the International Atomic Energy Agency's (IAEA) efforts to strengthen safeguards, in part through the enhancement of safeguards information management capabilities.[a] The DOE hopes to provide the IAEA with improved capabilities to store, retrieve, integrate, correlate and analyze data from existing and new sources of information, including publicly available information (i.e., open source information), information available through new safeguards reporting schemes, such as that on imports and exports, design information, and environmental monitoring data. The first step in the DOE's effort is to identify and define IAEA user requirements. This effort involves a systematic process to identify the information managements needs of the IAEA projected end user, as well as characteristics of the end user and attributes of the current environment.

1.3 Approach

User requirements for the SIMS initiative are being developed in an iterative manner through close interaction with the IAEA. The material presented in this document was prepared by the SIMS User Requirements Group on the basis of structured interviews conducted at the IAEA during 10-14 January 1994 and 9-13 May 1994, review of materials obtained before and after the interviews, and the subject-matter expertise of group members. Follow-up contacts (visits/communications) will be made over the life of the SIMS initiative to further clarify and define emerging IAEA safeguards information management needs.

(a) Information management is used here to connotate the use of computer systems (hardware and software) and related systems and procedures to assist in the storage, retrieval, processing, analysis, presentation/visualization, and communication of data/information.

2.0 International Atomic Energy Agency

The International Atomic Energy Agency was established in 1957 under the aegis of the United Nations to promote the *peaceful* use of atomic energy. Although the SIMS initiative and, in turn, this document, focus on the safeguards aspect of the IAEA's Statute, it is important to recognize the wider purpose of the IAEA and the relationship of various IAEA systems and activities in areas such as nuclear power and safety, to the Agency's safeguards system and to its safeguards information management needs. It is beyond the scope of this document to provide an in-depth description and evaluation of the IAEA safeguards system; rather, the purpose of this section is to provide a context for assessing the safeguards information management needs described in Sections 4-8. Where appropriate, references are provided in footnotes for readers that may desire additional details.

2.1 Safeguards Mission and Charter

Article III.A.5 of the IAEA Statute authorizes the Agency to "establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose...".[a]

2.1.1 Treaty on the Non-Proliferation of Nuclear Weapons

The cornerstone of the Agency's safeguards system is the Treaty on the Non-Proliferation of Nuclear Weapons (known as the NPT), which came into being in 1968. The Treaty requires that non-nuclear weapon States party to it must accept safeguards on all source or special fissionable material in all their peaceful nuclear activities. INFCIRC/153 is the model for safeguards agreements between the IAEA and Member States party to the NPT.[b] There continue to be agreements in place with the Agency under an earlier system referred to as INFCIRC/66/Rev.2.[c]

(a) Statute of the IAEA.
(b) INFCIRC/153 (Corrected): The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons, June 1972.
(c) INFCIRC/66/Rev.2: The Agency's Safeguards System (1965, as provisionally extended in 1966 and 1968).

2.1.2 Political Objectives of Safeguards

The IAEA has stated that "Safeguards are essentially a technical means of verifying the fulfillment of political obligations undertaken by States in concluding international agreements relating to the peaceful uses of atomic energy". It goes on to say that, "The main political objectives of safeguards are:

To assure the international community that States are complying with their non-proliferation and other 'peaceful use' undertakings;

To deter (a) the diversion of safeguarded nuclear materials to the production of nuclear explosives or for other military purposes and (b) the misuse of safeguarded facilities with the aim of producing unsafeguarded nuclear material."[a]

Note that States undertake NPT obligations and safeguards agreements voluntarily and that doing so entails a considerable relaxing on their part of their sovereign rights. The issue of sovereignty is always a consideration in the actual implementation of safeguards by the Agency. Furthermore, when States become party to the NPT, they incur certain obligations pursuant to the safeguarding of nuclear materials that result in the safeguards system being a cooperative system between States (and within States, facility operators) and the Agency (see the discussion on State Systems of Accounting and Control in Section 2.2.1).

2.1.3 Technical Objective of Safeguards

The Department of Safeguards is the technical arm of the IAEA primarily responsible for achieving the political objectives of safeguards. Over the years, the Department developed the technical means for addressing its safeguards responsibilities. The technical objective of safeguards under INFCIRC/153 is "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purposes unknown and deterrence of such diversion by risk of early detection." This objective was further clarified through the establishment of precise definitions for "significant quantities," and "timeliness."[b]

2.2 Safeguards Implementation

Under the NPT, non-nuclear weapon States renounce the acquisition of nuclear weapons and thus, the declarations of such States with regard to their peaceful nuclear activities are meant to be comprehensive, i.e., they are not to have undeclared or clandestine nuclear activities. Thus, safeguards

(a) IAEA Safeguards: An Introduction, IAEA/SG/INF/3, 1981.
(b) See IAEA Glossary, IAEA/SG/INF/1 (Rev.1), 1987.

agreements between such States and the IAEA are termed "Comprehensive Safeguards Agreements." It is the Agency's purpose under such agreements to verify States' declarations. Until very recently, the Agency's practice in making its verification was to establish the truth of statements regarding the amounts, presence and use of nuclear material or other items subject to safeguards as recorded by the facility operators and as reported by the States to the Agency for *declared material and facilities*. Nuclear material accountancy (complemented by containment and surveillance) has been the bedrock of the IAEA's verification practice. The purpose of nuclear materials accounting is to establish the quantities of nuclear material present within defined areas—termed "material balance areas"—and the changes in these quantities that take place within defined periods of time.

2.2.1 The State's System of Accounting for and Control of Nuclear Materials (SSAC)

Safeguards agreements concluded pursuant to the NPT require the State to establish a national system of accounting for and control of nuclear materials, termed an SSAC. The Agency has published guidelines for the establishment and operation of an SSAC.[a] Nuclear materials accountancy and verification are based on reports submitted by the SSAC as well as records maintained at the facility by the facility operator. The Agency has a well-established system for managing States' accountancy data (see Section 3). In addition to accounting reports listing, among other things, nuclear material inventories, receipts and shipments, the Agency examines other information provided by the State, including facility design information, documents amplifying and clarifying reports, and advanced notification of international transfers.

2.2.2 Safeguards Inspections

In order to verify a State's declarations and the correctness of information submitted by the State, the IAEA performs on-site inspections, termed "routine inspections," of a State's declared nuclear facilities. Inspectors check to see that operating and accounting records maintained at the facility are consistent with the reports submitted to the Agency. Inspectors also make independent measurements of and inventory nuclear material, verify design information, check, affix and remove seals, collect surveillance records (video tapes), service/calibrate equipment, obtain samples, and perform other inspection duties. An important concept in the IAEA's verification efforts is "material unaccounted for," or "MUF." This is the difference between the book stock maintained by the facility operator and the actual physical stock verified by the inspector. A significant unresolved MUF (and MUF may be attributed to measurement uncertainties) leads to the possibility of a diversion.

Inspection requirements are specified in the 1991-1995 Safeguards Criteria developed by the Department of Safeguards. Routine inspections have become quite proceduralized allowing the use of software tools to aid in the recording of inspection results (see Section 3).

(a) IAEA Safeguards: Guidelines for States' Systems of Accounting for and Control of Nuclear Materials, IAEA/SG/INF/2.

The Agency also performs two other types of inspections: "ad hoc inspections," generally made immediately after the conclusion of the safeguards agreement but before inspection details have been fully negotiated (although there are other reasons for performing ad hoc inspections); and "special inspections," made in addition to routine inspections when unusual circumstances occur and/or verification activities produce the appearance of an inconsistency that cannot be resolved through other means. Although the IAEA Board of Governors recently reaffirmed the Agency's right to make special inspections, they are in practice, very rare (presumably, because of their pejorative connotation).

2.3 Measures to Strengthen Safeguards

The discovery of Iraq's clandestine nuclear weapon development program was a watershed in the history of IAEA safeguards and has resulted in the Agency undertaking an ambitious program for strengthening its safeguards system. The basis for this strengthening program is the recognition that safeguards must give assurance not only of the non-diversion of declared material or that declared facilities are not being misused, but also of the absence of any undeclared nuclear activities in States which have signed comprehensive safeguards agreements with the Agency. At the same time, budgetary constraints (the Agency is under a "zero-real-growth" budget policy) require that the Agency undertake measures to streamline safeguards and improve the system's overall cost-effectiveness.

2.3.1 Information on States' Nuclear Activities

The IAEA has determined that the detection of undeclared nuclear activities and the creation of confidence in the continuing peaceful use of declared material and facilities is largely dependent on more information being made available to the Agency and on the capability of the Agency to make more effective use of this additional information, as well as existing information. Measures to obtain additional information include:

- early provision and use of design information
- voluntary reporting by Member States (over and above that required in their safeguards agreements) of exports, imports and production of nuclear material
- voluntary reporting by Member States of exports and imports of certain equipment and non-nuclear material
- collection by the Agency of information from "open sources" (e.g., the public press) about States' nuclear activities
- the provision by Member States of "intelligence" information obtained from satellites and other means

2.3.2 IAEA Program 93+2

In April 1993, the Standing Advisory Group on Safeguards Implementation (SAGSI) recommended to the IAEA Director General (DG) certain measures for strengthening and improving the cost-effectiveness of safeguards.[a] The DG, in turn, reported to the IAEA Board of Governors and they requested that the IAEA Secretariat develop concrete proposals for the assessment, development and testing of measures proposed by SAGSI. This is being done by the Secretariat under a program referred to internally as "Program 93+2." Details on this program are contained in Annex 3. Program 93+2 consists of the following tasks:

Task 1: Cost analysis of present safeguards implementation

Task 2: Assessment of potential cost-saving measures

Task 3: Environmental monitoring techniques for safeguards applications

Task 4: Increase cooperation with SSACs and other measures for improving the cost-effectiveness of safeguards

Task 5: Improved analysis of information on States' nuclear activities

Task 6: Enhanced safeguards training

Task 7: Proposal for strengthening and improving the efficiency of the safeguards system

2.4 Objectives of Enhanced Information Management

The IAEA expects to obtain through expanded reporting and its own collection measures a much greater volume of information than it is currently required to manage. Furthermore, the information being obtained is fundamentally different in several respects from that it has experience dealing with under conventional safeguards. First, the new information is much more qualitative in nature than conventional safeguards data, which, as has been stated, consists primarily of accountancy data—something represented quantitatively. Second, the new information is, in many respects, inherently less reliable than conventional safeguards data. It comes from a variety of sources, its accuracy is often questionable (especially when the source is the press), it is not necessarily provided in a prescribed format, and it is open to manipulation by those who generate the data in the first place. Third, the data is open-ended, rather than tied to some basic and well-defined safeguards concept (e.g., "material balance area").

(a) Report to the Director General on the 36th Series of SAGSI Meetings (SAR-15), April 1993.

The vastly increased amount of data that the Agency must deal with and its essentially qualitative nature and other characteristics demand new and innovative information management systems and techniques by the Agency in order for it to make effective use of the information in meeting its expanded safeguards mission. The objective of Task 5 of Program 93+2 is "to ensure a coherent and comprehensive approach to the acquisition, management and analysis of information available to the Secretariat regarding a State's nuclear activities."[a]

2.5 Organization of IAEA Safeguards

The Department of Safeguards is one of six principal departments of the IAEA. It forms the technical arm of the IAEA's safeguards program. Assistance in the drafting and negotiating of safeguards agreements and in safeguards policy matters is provided by the Department of Administration. In addition, an Iraq "Action Team" was formed in the Director General's Office (DGO) to implement United Nations Security Council resolutions regarding Iraq's violation of the NPT and its safeguards agreement with the IAEA. The IAEA Director General receives advice on safeguards matters from the Standing Advisory Group on Safeguards Implementation (SAGSI), an ad hoc group made up of representatives from some 14 to 16 Member States.

2.5.1 Safeguards Department

The Department of Safeguards consists of approximately 280 professional and 200 general staff, of which 200 are trained inspectors. It has an annual budget of about $65 million, plus extra-budgetary resources of approximately a third again as much. In this respect, it constitutes by far the Agency's largest budgetary program. The Department is organized into six divisions, three of which are Operations Divisions (see Figure 2.1). These divisions are responsible for performing safeguards inspections, as well as other safeguards verification activities. There are two Regional Offices—Tokyo and Toronto—attached to Operations. Analytical assistance is provided to the Department by the Safeguards Analytical Laboratory (SAL) at Seibersdorf, and by a Network of Analytical Laboratories (NWAL) that perform analysis of samples collected by inspectors.

The three support divisions include the Division of Information Treatment (SGIT), which is responsible for the development and support of departmental information management capabilities and the computer processing of a variety of safeguards information including the accounting data furnished by Member Sates, inspection data, and to a lesser extent, design information. In addition, there are two sections that report directly to the Deputy Director General for Safeguards (DDG-SG). They are the Section for Programme and Resources (SPR) and the Section for Effectiveness Evaluation (SEE). The former is responsible for financial and administrative matters, including personnel and budget. The

(a) Briefing Notes for Missions: Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System: Additional Details on the Report by the Director General on the Secretariat's Programme for Assessment, Development and Testing of SAGSI's Recommendations on the Implementation of Safeguards, 15 November 1993. [see Annex 3.]

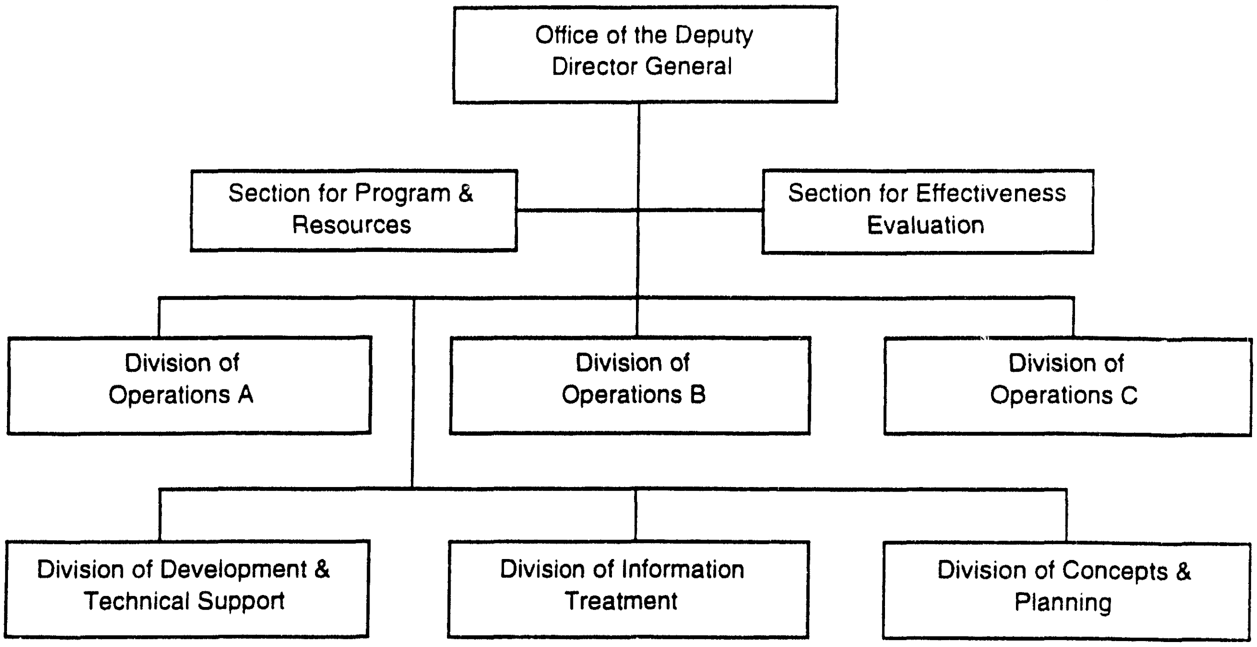

Figure 2.1. Organization of the Department of Safeguards

latter is responsible for preparation of the annual Safeguards Implementation Report (SIR), which is the Agency's primary report to its Member States on the results of its safeguards verification activities.

2.5.2 Information Analysis Responsibilities

The responsibility for analyzing information available to the Agency on States' nuclear activities and drawing conclusions about the possible existence of undeclared activities is a matter not yet completely decided by the Agency. At one time, the former DDG-SG determined that "Country Officers" assigned in each Operations Division would have the primary responsibility to "have at all times an up-to-date knowledge about safeguards- and other proliferation-relevant situations, and nuclear and nuclear-related activities, that are directly relevant to the implementation of safeguards, for each designated State."[a]

The Country Officer was to: (a) prepare and maintain the "country file;" (b) inform line management about activities which might be inconsistent with the State's safeguards and non-proliferation undertakings, and other problems related to safeguards implementation; and (c) prepare contributions to the divisional Country Status Reports and to prepare specific reports, as requested (see Annex 4 for additional details). Although it was envisioned that support divisions (Information Treatment, and the Division of Concepts and Planning) would assist Country Officers in this undertaking, it was

(a) DDG-SG Interoffice Memo, 1993-02-05.

subsequently decided that the concept required further consideration before being fully implemented. The primary objection to the concept was that Country Officer responsibilities were to be assigned to safeguards inspectors and these inspectors were expected to retain their inspection responsibilities as well. This was considered to be an unrealistic workload.

At this stage of their deliberations, the Secretariat appears to be exploring several alternatives for dealing with the analysis of information on States' nuclear activities. These alternatives include the Country Officer concept, the idea of an "analyst group" in each operations division whose sole responsibility would be akin to that envisioned for Country Officers, and the idea of an analyst group in SGIT and/or the Systems Studies Section of Concepts and Planning. It seems likely that whatever decision is ultimately made, the process of acquiring, evaluating and analyzing information on States' nuclear activities, drawing conclusions, submitting reports, incorporating findings in the SIR, and so on, will be a distributed process and will require a high degree of collaboration among various groups in the organization.

2.5.3 Systematic Analysis versus Enhanced Analysis

The Department of Safeguards is not the only organizational entity within the IAEA analyzing information about States' nuclear activities. In fact, the *raison d'etre* of the IAEA is to deal with States' nuclear activities. Therefore, it has been important for the Agency to consider how it might make more effective use—for safeguards/non-proliferation purposes—of information available through various channels and departments of the Agency. One area in which the Agency has felt the need to make a distinction and establish a policy for dealing with such information is the provision by a State to the Agency of "intelligence" information (also referred to as "third-party" information) about other States nuclear activities. Analysis of this information is referred to as "*enhanced analysis*." Such information is provided directly to the DG and is analyzed by a selected and limited group of individuals in the DGO. This information is not distributed in its original form outside the DGO. Analysis of all other information by the Department of Safeguards is referred to as "*systematic analysis*."

2.6 User Population

The permanent professional staff of the Department of Safeguards consists primarily of scientists and engineers. Because the policy of the Agency is to recruit as widely as possible among its some 112 Member States, the staff come from a very diverse cultural and technical background, ranging from developed nations like the United States, to third-world countries. The Agency does its business in English and requires its staff to have a working knowledge of English. Nevertheless, the staff vary widely in their English language skills.

In addition to its policy on recruiting, the Agency has a policy on retention. It offers new staff three-year contracts, then, given satisfactory performance, offers an extension of up to two years. Beyond this, the Agency is very selective in offering extensions; its policy is to limit staff to five years. Thus turnover at the Agency is comparatively high.

The Agency also employs temporary staff provided through Member State Support Programs (MSSPs). These individuals come primarily from the developed nations (USA, UK, Japan, Canada, France, etc.) and their computer skills are generally relatively good. Their assignments to the Agency generally last two to three years.

Although computer literacy in the department has improved steadily over the last three to five years, it is, on average, still quite modest. The Head of Safeguards Training considers this fact to be a major consideration in the introduction of new computer systems in the department. He stated that the recent introduction of IBM-compatible computers and a local area network (LAN) has run into serious problems because users are not adequately equipped in terms of qualifications or training to use the systems.

2.7 Operational Environment

The IAEA is headquartered in the Vienna International Center (VIC) in Vienna, Austria. VIC offices are typical of any modern office complex. There would appear to be no special environmental considerations necessary to the installation of computer systems at the VIC (details on the IAEA computing infrastructure are provided in Section 3). On the other hand, IAEA inspections are performed all over the world in a wide variety of environments and under very different circumstances. Computing resources are required in the field and must be designed to meet field conditions (e.g., portability, ruggedness). Furthermore, data communications are necessary between IAEA Headquarters, Regional Offices, and the field. Depending upon the nature of the data being transmitted, there may be special considerations for the design of both hardware and software.

2.8 Issues and Constraints

IAEA budget. As stated previously, the IAEA operates under a zero-real-growth budget policy. Thus, the costs associated with the acquisition and/or introduction of new systems and equipment are a key consideration for the Agency. Although initial procurements for SIMS are likely to be funded by the USA, follow-on procurement, and maintenance and support costs will likely be borne by the Agency. Thus SIMS must have as a key design objective the development and deployment of systems that minimize Agency support costs.

Staff computer skills. A large portion of the cost associated with the introduction of new computing systems is often attributed to user training. As stated previously, the typical user for SIMS products is likely to have only modest computer skills. Thus, unless SIMS products are designed specifically to minimize learning time and maximize ease of use, the introduction of SIMS products in the Agency may well pose an unacceptable training burden to the Safeguards Department.

Security. The information that the Agency deals with can range from unclassified to "safeguards confidential." Information provided to the Director General's Office concerning possible proliferation activities of States may bear a higher classification. Even open source information, when taken together, may be considered sensitive by the Agency. Therefore, it is essential that SIMS developers consider the security concerns of the Agency for any given application and for processing information in general.

3.0 IAEA Information Management Systems

3.1 Safeguards Information Management Systems

It is important to recognize that the International Atomic Energy Agency has an extensive computing infrastructure, consisting of mainframe computers, workstations, and desktop computers connected through local area networks (LANs). The Department of Safeguards has, for the last several years, been upgrading its computing environment and information management capabilities. Systems being developed under the SIMS initiative must be compatible with the Agency's computing environment.

3.1.1 The Safeguards Local Area Network

The entire Safeguards Department is connected via the Safeguards Local Area Network (Figure 3.1). This LAN connects the available IBM, DEC and data and word processing systems as a distributed and unified information processing environment for Safeguards users and as the common platform for the integration of Safeguards technical applications and office automation throughout the department. As of October, 1993 there were more than 330 LAN workstations providing computing resources and services to more than 400 safeguards users. The LAN was originally envisioned as a means of upgrading office automation and providing electronic mail capabilities. The LAN provides access to the safeguards IBM mainframe, SQL servers and a MicroVaxII. There is one way access to the IAEA shared mainframe via a 3270/SNA gateway. This allows users of the Safeguards LAN to access data on the IAEA LAN, but prevents access into the Safeguards LAN. Each division in the Safeguards Department has its own servers. The servers are Compaq SystemPro 486's running the Banyan Vines Network Operating System (NOS), with the exception of four SQL database servers, which run OS/2. The intention is to move to WindowsNT in the near future. Most members of the Safeguards Department are now connected to the Safeguards LAN through Gateway 2000 PC's, with applications running under Windows.

3.1.2 Safeguards Information Systems/Databases

IAEA Safeguards Information System (ISIS). ISIS is the repository for safeguards nuclear materials accounting data. The database resides on an IBM 9000 mainframe and is managed using the ADABAS database management system (DBMS). Structured query is performed using the NATURAL query language. ISIS has been on-line since 1972. It currently contains about 12 million records. The database grows about 10% annually. All its data is encoded numerical data which comes in on magnetic tapes. The chief activity is transit matching. Approximately 17,000 international shipments a years are processed. About 25% of these are matched by machine. In addition, there are approximately 120,000 domestic shipments each year. About 75% of these are matched by machine. Transactions not matched by machine are matched manually. The data come from State Systems of Accounting & Control (SSACs). Inquiries by users (typically, inspectors) are made through SGIT data clerks. According to the Section Head for Data Operations in SGIT, Joseph Nardi, there are about 5000 different stand-alone "applications" used by inspectors to process this data. In addition there are about

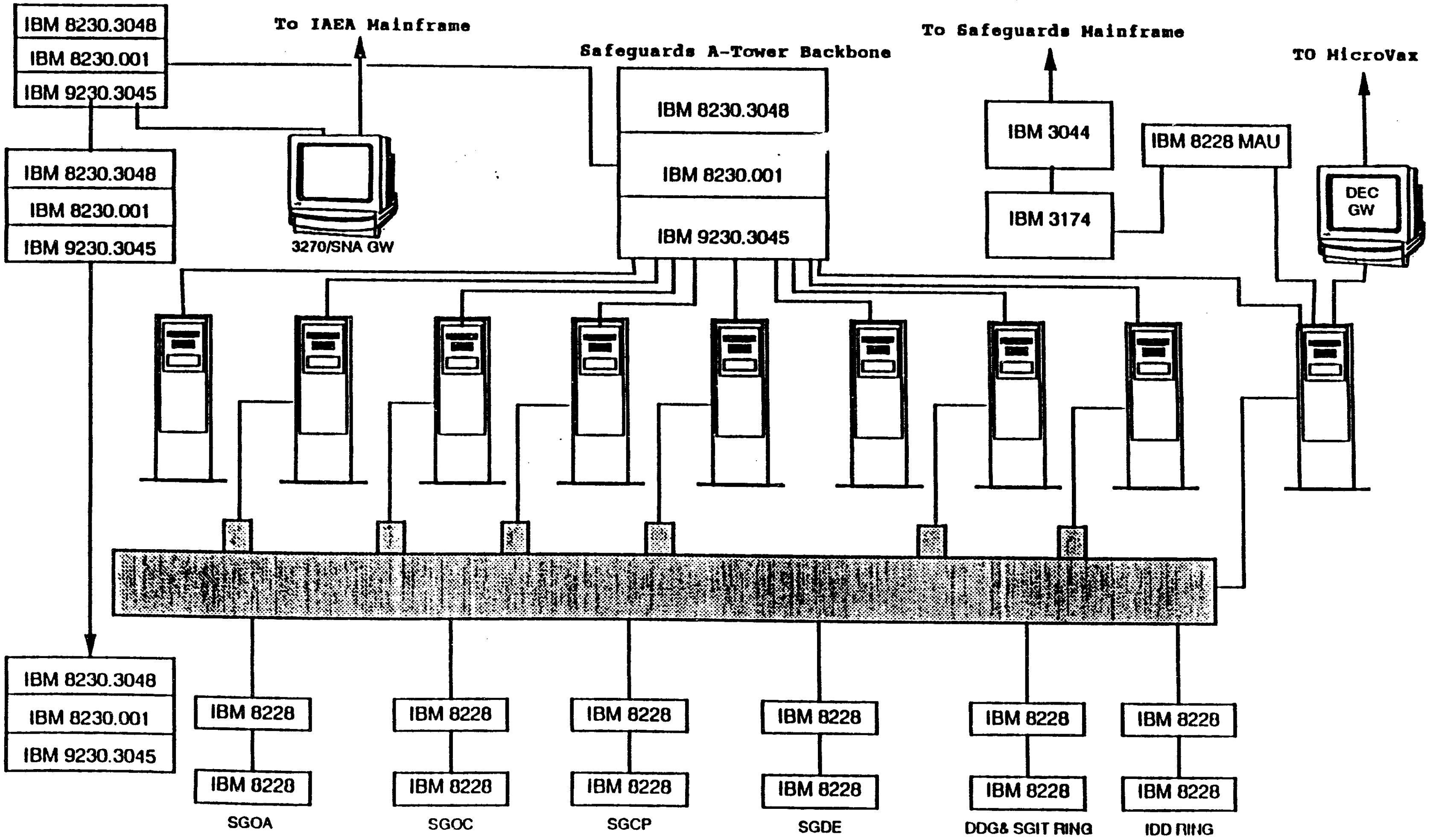

Figure 3.1. Safeguards Local Area Network

750 formal applications, developed by Nardi's section, that inspector use. When tapes are received, standard quality control routines are applied. Safeguards clerks examine the data and assign codes.

Nardi stated that ISIS works well; it has low maintenance requirements and very low error rates. When there are errors, the IAEA communicates with the State to resolve them. The data conforms to IAEA format specifications. Another view was expressed by the SGIT Data Development Section Head, Duncan Gardiner, who felt that the accounting system needs to migrate to something more modern. He stated that it contains 700 programs written in PL/1, and requires high maintenance, which he said required 3 full-time equivalent (FTE) staff. He went on to say that currently there are about 600 quality control checks done on the mainframe, and these should be rewritten into a rule base. He felt that there was a need to develop a long-term software development strategic plan.

Support Program Reporting and Information Communications System (SPRICS). SPRICS maintains data on Member State Support Programs and tasks. It was originally developed for the Wang, but there is an effort underway to transfer the system to the Gateway PC environment. Unlike most department-wide systems, SPRICS is managed by SGDE, not SGIT. Member States can query SPRICS remotely.

Safeguards Management Information System (SMIS). The SMIS is a management information and decision support system for administrative and management purposes being developed by the Section for Program and Resources (SPR) assisted by SGIT. It was developed using "Lightship," accesses various safeguards databases, and displays information with a graphical user interface. SMIS can be accessed via the Safeguards LAN from the Gateway desktop PCs.

Computerized Inspection Report (CIR). The CIR is a computer-based inspection reporting system that allows inspectors to input their inspection results directly to the computer database for later evaluation by SEE.

Safeguards Implementation Report (SIR) Evaluation Program. The SIR is an annual IAEA report describing the degree of inspection goal attainment accomplished by IAEA verification activities and the conclusions of the IAEA with regard to potential diversion of nuclear material. This report is produced annually, in the spring and covers the previous calendar year. SEE has an SIR Evaluation Program, written in PL1, that evaluates the CIR and accounting reports from Member States to determine the degree of inspection goal attainment. Safeguards goal attainment is evaluated at both facility and state level. In addition, SEE reviews working notes produced by inspectors. Up to now, the majority of data evaluated by SEE, i.e., material accountancy data, could be dealt with relatively objectively.

In-Field Support System (IFSS). IFSS consists of a laptop, PC-compatible computer loaded with Agency-developed software designed to assist IAEA safeguards inspectors in the field. The software was developed with Clipper and dBase. Facility operators are asked to provide data on diskettes for use in IFSS. IFSS was designed to be adaptable to a variety of inspection environments through the development of modular software. The software modules support: facility configuration, new inspection initialization, records examination, comparison of records with reports, verification of material, and utilities. Apparently, IFSS shortcomings prevent its generally effective use. Additional details are provided in Section 4.5.2.3.

Safeguards Effectiveness Evaluation System (SEES). The Safeguards Effectiveness Evaluation Section (SEE) has developed, with the assistance of SGIT, a computer system called the "Safeguards Effectiveness Evaluation System (SEES)" to assist with the section's management of the data generated under the expanded reporting and systematic analysis approach being implemented by the Agency. SEES acquires data from ISIS through a structured query language (SQL) and displays the information in a graphical user interface (GUI) produced through the use of "Object View" software. SEES also allows the acquisition of other databases, such as the Nuclear Energy and Facility Information System (NEFIS), which itself acquires data from a variety of Agency databases, including the Power Reactor information System (PRIS), the Research Reactor Database (RRDB), the Energy and Economic Database (EEDB), and others (six in all). NEFIS was developed and is maintained by the Agency Computer Services Department. SEES is essentially a way to view a variety of data in various tabular formats. It provides no analysis capability and has limited visualization provisions. The SEE Section Head seeks to add analysis capabilities to SEES and has suggested the use of an expert system.

SGCP Country Information System (SCIS). The SCIS database, developed in the Systems Studies Section of the Division of Concepts and Planning (SGCP), incorporates a country file structure approved by Safeguards management. SCIS is implemented in "Micro-ISIS", a UNESCO-developed database development package, on a MS-DOS stand-alone desktop computer (Gateway 2000). SCIS was implemented in April 1993 and updated in June 1993. It is designed to manage open source information, i.e., text drawn from various open sources such as newspapers and journals. The system provides a text based, flexible menu driven search routine that enables the user to locate material of interest. It is key word driven and does not provide context sensitive text processing. Full text of original source reports is not retained but the sources of information are indicated. This system has been installed in the three Operations Divisions (SGOA, SGOB, and SGOC), on the DDG's terminal, and in the Director General's Office. Data are acquired for this system from the Emerging Nuclear Suppliers Database (ENSDOB), Carnegie Nuclear Nonproliferation Database (daily updates); IAEA daily news service; Monterey Database (quarterly updates); FBIS; and PressReview (daily updates). It does not contain any IAEA safeguards information. This system does not provide analysis capabilities, and improved capabilities for text processing are needed. In addition, the Department requires a means for evaluating the reliability and significance of open source material . This is discussed further in Section 4.3 and illustrated in Figure 4.1. The SCIS Users Guide is contained in Annex 5.

Briefcase Inspection System (BIS). This system is being developed by R. Muller (SGIT) and R. Arlt (SGDE) on a PC to run under Microsoft Windows using dBASE. It is intended to be a collection of DOS and Windows tools, some commercial and some developed in house that will run on a laptop. Maps, photos of safeguards officers, images of hot spots, design information, drawings of facilitates, facility relevant information, what kind of verification to do, visa forms etc. are intended to be loaded into the system. Text and image storage and retrieval capabilities are to be included.

Furthermore, the plan is to have data downloaded to BIS before an inspection. Finally, BIS is to include tools that can read data directly from material measurement devices.

3.1.3 International Nuclear Safeguards Inspection Support Tool

Although not strictly a Department of Safeguards system, the International Nuclear Safeguards Inspection Support Tool (INSIST) supports safeguards functions specific to IAEA monitoring and inspection of Iraqi nuclear activities. INSIST provides access to world-wide maps, satellite and aerial imagery, photographs, video and text all in a geo-referenced framework. The INSIST workstation consists of a Sun Sparcstation integrated with a variety of peripheral devices for information input and output, including a videodisc player and recorder, a VCR, a large-screen monitor for displaying maps and imagery, both a flatbed and slide scanner, laser and cclor printers, and a single frame video camera that allows direct input to the system (see Figure 3.2).

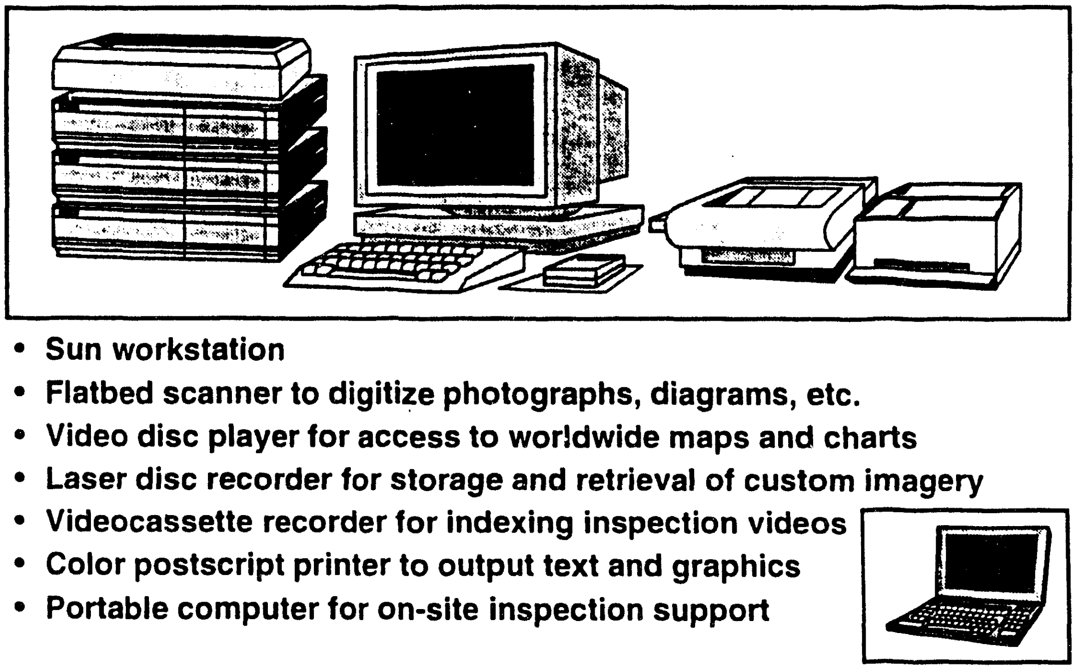

Figure 3.2. International Nuclear Safeguards Inspection Support Tool

3.2 IAEA Information Systems

3.2.1 IAEA LAN

The IAEA LAN serves the needs of other departments within the Agency. Users of the Safeguards LAN may access data on the IAEA LAN via a 3270/SNA gateway; users of the IAEA LAN do not have access to the Safeguards LAN.

3.2.2 IAEA Information Management Systems/Databases

Nuclear Data Information System (NDIS). This database contains numerical nuclear physics data describing the interactions of radiations with matter. It has been operational since 1992 and is continuously updated.

Energy and Economic Data Bank (EEDB). This database contains energy and economic statistics on countries. The data dates back to 1950 and is used to generate status and trend reports.It has been operational since 1980 and is updated annually. It resides on the IAEA mainframe using the ADABAS database management system.

International Nuclear Event Scale (INES). This database stores textual Event Rating Forms Within 24 hours the INES event rating from is sent from the INES national officer via the INES coordinator to all other INES national officers. The database has been operation since 1991 and resides on a PC. It employs dBASE III and Clipper for database management.

Nuclear Fuel Cycle Information System (NFCIS). This contains an international directory of civilian nuclear fuel cycle facilities. It includes data on uranium mining, ore processing, recovery of uranium from phosphoric acid, uranium refining conversion and enrichment, fuel fabrication, and reactor spent fuel storage and reprocessing, heavy water production and production of nuclear grade zirconium and zircalloy tubing fabrication facilities. This system has been on-line since 1987 and contains over 500 records on worldwide nuclear fuel cycles. The information was obtained from the literature and through input from IAEA member states.

Power Reactor Information System (PRIS). This system contains operating information from nuclear power plants. The data is supplied voluntarily by member states. There are records from about 5400 reactor years of operating experience representing a coverage of over 90% of world operating experience. Outage data are recorded with codes from the main caused of outages and the main plant systems affected in equipment failure. This system has been operational since 1980 on the IAEA mainframe using the ADABAS database management system.

Research Reactors Database (RRDB). This database contains data related to research reactors. It holds design and operating data on 583 reactors in 69 countries. For each of these reactors (operational, shutdown, under construction, and planned) the IAEA maintains on the RRDB a record with general and specific information. It has been operational since 1983 and is updated annually. It resides on the IAEA mainframe and employs the ADABAS database management system.

Waste Management Data Base (WMDB). This database holds data on national radioactive management programs, activities, plans, inventories, policies and regulation. Data is provided by each Member State.

Nuclear Energy and Facilities Information System (NEFIS). This system provides centralized, query-only access to data on six different databases. This Windows-based system provides an easy-to-use interface to databases developed independently for query purposes. Accessible databases are EEDB, INES, NFCIS, PRIS, RRDB, and WMDB. NEFIS is hosted on mainframes and PC's.

4.0 User Requirements

The description of user requirements in this section reflects the focus of the SIMS initiative, which is the support, through enhanced information management capabilities, of IAEA efforts to strengthen safeguards. The section covers the Iraq Action Team; the Program 93+2 teams dealing with environmental monitoring, systematic analysis, and training; and finally, certain aspects of conventional safeguards. Each of these areas include: (1) a brief description of the target population, (2) information to be managed, (4) functional requirements, and (5) issues and constraints. Functional requirements covers: data acquisition, storage and retrieval; and data manipulation, modeling and analysis.

4.1 Iraq Action Team

Mission. The Iraq Action Team was established in 1991 to carry out the IAEA's responsibilities under UN Security Council Resolution 687, enacted at the end of the Persian Gulf War. Among its other provisions, UNSC Resolution 687 called for the IAEA to inspect, render harmless, and monitor indefinitely all Iraqi capabilities of potential nuclear weapons significance. The Resolution forbids Iraq to possess nuclear weapons or "weapons-usable nuclear material" (e.g., highly enriched uranium or separated plutonium). It also forbids any supporting facilities, equipment, or research for producing nuclear weapons or weapons-usable nuclear material. The Resolution has similar provisions addressing chemical weapons, biological weapons, and ballistic missiles, but the IAEA has no direct involvement in their implementation.

Two subsequent Security Council Resolutions, 707 and 715, also affected the Action Team's mission. Resolution 707, passed because of ongoing Iraqi efforts to withhold key details of its past nuclear program, called on Iraq to make a full, final, and complete disclosure of that program. It forbids nearly all nuclear activities in Iraq, even many peaceful nuclear applications, until such time as the Security Council is satisfied with Iraq's compliance. Resolution 715 gave Security Council approval to the IAEA's plan for ongoing monitoring and verification of Iraq's nuclear activities.

Organization and Personnel. The Action Team is organizationally separate from the Department of Safeguards. It reports to the Director General, who (on matters concerning Resolutions 687, 707, and 715) reports directly to the UN Security Council . This is in contrast to most other Agency activities, including safeguards, in which the Director General reports to the IAEA Board of Governors.

The Action Team coordinates its activities with the UN Special Commission (UNSCOM) in New York. UNSCOM was established by Resolution 687 to oversee the implementation of the Resolution's weapons-of-mass-destruction provisions. It has sole responsibility for chemical, biological, and missile inspections, but for nuclear inspections the IAEA has the lead, with UNSCOM providing logistical and other support.

The Action Team now has about nine full-time staff: the Action Team Leader, Deputy Leaders for operations, assessment, and information treatment, two clerical staff, and three data entry personnel. In addition, several experienced inspectors and other senior professionals are borrowed on a part-time basis from the Safeguards Department, from other IAEA elements, and from member states. Compared with the IAEA overall safeguards inspectorate, the Action Team's full-time and part-time personnel are exceptionally well qualified and experienced. However, their expertise with computers is varied (see paragraph 4.1.3).

Tasks and Activities. The Action Team's job in Iraq has many parallels to the activities envisioned in other States under proposed safeguards strengthening measures. As a consequence, many of the information management needs of the Action Team are similar to those that will be required for enhanced safeguards. At the same time, some aspects of the Action Team's job are unique and require special information management support. Similarities and differences are listed in Tables 4.1a and 4.1b, below.

4.1.1 Information to be Managed

In carrying out its tasks, the Action Team needs to track information about Iraq's nuclear and potentially nuclear-related activities, facilities, exports and imports, declarations, inspection results, environmental monitoring results, and other information bearing on the Agency's monitoring and verification activities in Iraq. The following paragraphs describe the data content in more detail and then discuss the functional requirements for managing and manipulating that data.

In a recent working draft, dated 25 November 1993, the Action Team enumerated the data types that should be handled by their information systems. The Action Team's picture of its needs may evolve somewhat, but the list shown in Table 4.2—based directly on the November 1993 draft—is a fairly comprehensive summary.

During our May visit to the IAEA, the Action Team expressed a time-urgent need for a computer tool to help them manage Iraqi declaration data. Iraq is required to declare all nuclear and nuclear-related activities, including nuclear material, non-nuclear material, isotopes, equipment, sites, facilities, and buildings.

Table 4.1a. Action Team Similarities

Action Team information management needs that are similar to those required for a strengthened safeguards system:

- The Action Team receives and evaluates expanded declarations that go far beyond what is required under normal safeguards.
- The Action Team receives and evaluates information from many sources, and tracks Iraqi activities on a country-wide basis. In doing so the Team must:
  - evaluate the reliability of information from open sources and third parties;
  - build, maintain, and access relevant databases; and
  - look for indications of undeclared sites, undeclared facilities and equipment, undeclared materials, and undeclared activities.
- When indications warrant, the Action Team must plan how to further investigate suspicions and inconsistencies. It makes inquiries of member states, it asks questions of Iraq, and, in consultation with UNSCOM, it plans and conducts suspect site visits.
- The Action Team's rights of access and inquiry greatly exceed those of ordinary safeguards.
- The Action Team has made extensive use of environmental sampling for detection and monitoring.

Table 4.1b. Action Team Differences

Unique aspects of the Action Team's job requiring special consideration in system design: • The Action Team is organizationally compact, suggest that its information management and analysis activities will be somewhat more centralized than may be the case for the Safeguards Department's. • The Action Team interacts with UNSCOM. Where possible, compatibility between UNSCOM and Action Team information management systems would be advantageous. • The sheer volume and detail of information generated by the Iraq inspections is a staggering challenge to manage. • The scope of the Action Team's charger is uniquely broad. In addition to monitoring nuclear sites, the Team inspects and monitors a wide range of military-industrial manufacturing establishments and other non-nuclear facilities that potentially could be misused to support future nuclear weapons work. • As a part of ongoing monitoring and verification, the Action Team will be required to establish import/export controls and accountancy for a wide range of nuclear and dual-use commodities. • In the course of planning and conducting so many inspections of previously unknown sites, the Action Team has acquired a large body of non-text information, such as photographs and site diagrams, which must be sorted, stored, and retrieved as needed. • While the Safeguards Department still is studying how best to implement systematic analysis of states' nuclear activities, the Action Team already is performing such analysis with respect to Iraq. The Action Team's information management requirements are immediate. • In addition to desktop PC's, the Action Team has available the U.S. DOE-supplied International Safeguards Inspection Support Tool (INSIST). INSIST is a Sun SparcStation-based multimedia workstation with geo-referencing capabilities. Near-term strategies for meeting the Action Team's information management requirements will be strongly influenced by the presence of INSIST.

4.1.2 Functional Requirements

Functional requirements are reviewed for two major classes of activities: data acquisition, storage, and retrieval; and data manipulation, modeling, and analysis.

4.1.2.1 Data Acquisition, Storage, and Retrieval

The Action Team needs to enter, store, search, and retrieve a very high volume of data of several types. During our May 1994 visit, members of the Action Team stressed the need for some way of reducing the burden on the team of sifting through the vast amounts of open source information to determine what is relevant and should be entered in a database. They asked about methods for automating data acquisition directly from the original source (e.g., a journal article).

Table 4.2. Action Team Data to Be Managed

- *Sites and facilities.* Includes the names, location, characteristics, specifications, and current status of every site, facility, or location reported and identified in the course of implementing Security Council resolutions 687, 707, and 715.
    - *Inventories.* List of inventories of all nuclear material, non-nuclear material, and nuclear and other equipment reported or identified. Includes information about the characteristics, specifications, location, and current status of items on the inventory.
    - *Inspection reports.* Past and current reports on inspection activities. This includes daily field reports, technical reports, and summary report.
    - *Supplier information.* Countries, firms, and intermediaries which supplied materials and equipment to Iraq. Includes descriptions of the items supplied.
    - *Iraqi programmatic activities.* List of current nuclear and nuclear-related activities and their specifications.
    - *Monitoring and verification results.* Results of IAEA monitoring and verification activities, including sampling, environmental monitoring, measurements, etc.
    - *Accounting information* on nuclear and specified non-nuclear material data in Iraq.
    - *Export/import reports* from Iraq and member states, as required by the long-term monitoring plan.
    - *Iraqi reports and declarations concerning their nuclear and nuclear-related activities* and relevant programs.
    - *Maps, diagrams, photographs, and other non-text data.* Mapsets, site diagrams, charts, process diagrams, satellite and aerial imagery, ground photography of sites and their internals, video photography, and other graphical data relevant to Iraq.
    - *Open-source information* on Iraq's nuclear and nuclear-related activities, facilities, materials, and equipment.
    - *Information from member-states*, including intelligence information, information from customs and export-licensing authorities, etc.
    - *Information from UNSCOM teams.* Information on Iraqi military and industrial activities, sites, equipment, and material obtained in the course of monitoring and verification activities conducted by other UN teams that might be relevant to nuclear and nuclear-related activities in Iraq.
    - *Other relevant information* collected by inspectors in the course of their monitoring and inspection activities.

Some information with which the Action Team must deal should be stored according to its geographic location, so that the data can be associated with a specific, location, site, building, or room. For these location-referenced data, items should be displayed on site or building diagrams and on maps of various scale. This would include the Iraq declarations data referred to in paragraph 4.1.1, above. It also is necessary to search and retrieve data based on parameters other than location. Text retrieval tools, incorporating keywords, indexed free-text searches, Boolean expressions, etc., could accomplish much of this function. The data sets resulting from such searches should be displayed on the analyst's monitor screen with forward and backward scanning capabilities. If possible, search terms should be highlighted in the retrieved text, and there should be a capability to annotate and store some or all of the retrieved text in separate working files. The ability to build, maintain, and manipulate relational databases also is desired.

Action Team information management systems should provide the capability to print out selected sets of stored or retrieved data in pre-defined and customized formats, including color printouts of maps, photographs, and cther color graphics.

For both geo-referenced and textual data, users want the capability to navigate or browse through the system in a hierarchical, "drill down" fashion, with general information leading to more detailed information. With geo-referenced data, for example, users should be able to zoom in on selected regions of a map and to move from maps to site diagrams to building layouts where available. Analysts should be able to retrieve and display documents, photographs, and other data linked to specific locations. The Action Team has a strong preference for an easy-to-use, user-friendly, graphical interface; an oft-repeated theme heard during our interviews with IAEA personnel. To the extent possible, they would like to have relatively "seamless" access to all data types from their individual offices and through a common interface.

The Action Team desires the ability to import data from the INSIST Sun workstation into common MS-DOS PC applications (e.g., WordPerfect, Excel, etc.) used in the Team's offices. During our May visit, the Action Team expressed the desire to use the INSIST Sun Sparc workstation in a client-server environment involving an Action Team LAN (not connected to the Safeguards LAN) and PC desktop systems running Microsoft Windows.

Because, the Action Team does so much of its work in the field, users want the capability to download selected data to notebook computers to use and manipulate in Iraq, including that acquired from Iraqi declarations. During our May visit to the Agency, the Action Team clarified this requirement by stating that they did not anticipate using computers during their actual in-field inspection activities, but rather in a "mobile office," or at their hotel room.

The Action Team's requirements are immediate, not a year or more down the road as with some aspects of the Safeguards Department's Systematic Analysis. The high volume of data already exceeds the ability of Action Team analysts to efficiently manage. Furthermore, the recent turnover of personnel carries the potential for loss of "corporate" memory. Newer team members are concerned that vital information could be sitting in some obscure file drawer without their knowing it; they see great benefit in having reliable, automated access to information.

But data cannot be retrieved electronically until it exists in electronic form, and data entry also represents a near-term priority problem for the Action Team. A huge backlog of information exists only in hardcopy form. (One side-effect of this backlog is that INSIST is not yet used very much by Action Team analysts, because the data they require for most problems is probably not yet in the system.) Even with careful selection and prioritization, a substantial amount of text and graphical information will need to be scanned in. And even when this backlog is worked off satisfactorily, there will be an ongoing requirement to scan new hardcopy information. Examples include written communications from Iraq (and these sometimes will require translation from Arabic), written communications from member states, inspection photographs, and many other types. Table 4.3 summarizes near-term Action Team needs.

4.1.2.2 Data Manipulation, Modeling, and Analysis

The Action Team has expressed an interest in data manipulation, modeling, and analysis tools to assist in the interpretation and assessment of information. At the present time, however, ideas about such tools are still fairly general. The Action Team has requested guidance from the U.S.on how to analyze open source information. Table 4.4 describes some of the capabilities that have been suggested.

In the near-term, most of the Action Team's requirements for data manipulation, modeling, and analysis are not as urgent as the requirements simply for entering, storing, searching, and retrieving information. Furthermore, the more ambitious of the modeling and analysis goals still require more R&D to identify what methods and algorithms are effective and appropriate. Several Action Team

Table 4.3. Near-Term Action Team Needs

- Scanning hardcopy data into electronic form
- The ability to filter and categorize documents
- Adding a text retrieval capability to INSIST
- Adding a gazetteer capability to INSIST
- Developing and integrating new databases
- Modifying the INSIST user interface to better meet user needs and abilities
- Developing a capability to take information to the field on notebook computers
- Networking Action Team desktop PCs with each other and with the INSIST workstation

Table 4.4. Suggested Data Manipulation, Modeling and Analysis Capabilities

- Analysis of export/import information, including the identification of inconsistencies and trends

  This is one of the few "definitely required" Action Team capabilities in the manipulation/modeling/analysis area. Under the Security-Council-approved long-term monitoring plan, Iraq and other states are required to report Iraqi import and export transactions involving a wide variety of nuclear and non-nuclear equipment and materials. The IAEA has to establish a reporting and tracking system to manage that information and identify inconsistencies.

- Computer-assisted analysis of open source information, including the capability to preserve and retrieve the results of human efforts at analysis for future review/evaluation

- Comparison of two different images of the same area (satellite images, aerial photographs, or ground photographs) for purposes of change detection

  This could range from simple side-by-side display to more powerful methods such as image warping followed by digital subtraction.

- Automated change detection with other sorts of data, such as inventories, declarations, etc.

- Viewing data from many different frames of reference (e.g., by site, by date, by personnel, by organizational grouping, by facility type, by sample type, and so forth)

- Technical reference tools, ranging from on-line technical tutorials to tools that would identify the potential nuclear-related applications associated with particular commodities or keywords

- Modeling tools, such as process flow models or pathway models

- Analyzing correlations between different data categories

  Just what those correlations might be remains to be clarified. Ultimately, such tools might be able to identify trends and inconsistencies or even suggest inferences drawn from multiple data sources that an analyst might not otherwise recognize.

- Analyzing environmental data

  It is likely that whatever tools are developed for Programme 93+2/Task 3 also will be applicable to Action Team needs.

members expressed the view that for now and perhaps for the indefinite future, they can best perform such analytically complex tasks "in their heads" or by hand.

To the extent that near-term efforts are possible under SIMS, priority probably should be given to:

- a system for analysis of export/import information

- the capability to view data from multiple frames of reference

- environmental data analysis tools (also driven by Programme 93+2 needs)
- data manipulation or technical reference tools that can be clearly described, proof-tested, and implemented now, without the need for significant additional R&D.

4.1.3 Issues and Constraints

The following issues and constraints should be considered in SIMS development efforts.

Security. Most Action Team information is confidential in nature. Some of the data is confidential between Iraq and the IAEA/UN; some of the data is provided in confidence by member states (including information from intelligence sources); and some of the data reveals proprietary or proliferation-sensitive technology. In all these cases, the security of the information must be maintained. Access should be restricted to designated staff on a need-to-know basis.

User Limitations. Not all Action Team users will have had much experience with computers, especially with complex systems. Information management systems provided by SIMS should be mutually compatible and should include a user-friendly interface. A "point-and-click" approach, preferably with the look and feel of Microsoft Windows (already in wide use at the IAEA) is desirable. On-line help should be available.

Support. Unlike the Safeguards Department, the Action Team has no specific in-house support structure to help maintain and troubleshoot its computer systems. It is essential that any hardware or software systems provided by SIMS be backed up by ongoing post-delivery support and maintenance, and this commitment should be included in cost estimates. Based on discussions during our May 1994 visit to the Agency, support should include training for Action Team staff charged with database administration and other computer systems support activities.

Compatibility with Existing Systems. Compatibility with the current IAEA computer environment (discussed in Section 3) is highly desirable. For example, it would be very advantageous if data on the Action Team's INSIST workstation could be accessed remotely by users working on MS-DOS PCs in nearby offices, probably via a dedicated Action Team LAN. Access to other in-house and outside databases also would be useful.

Need for Development of Analytical Methodologies. Certain analytically complex modeling and analysis tools in the Action Team's "wish list" do not yet exist, and SIMS cannot provide them until such time as the necessary methodologies and algorithms are developed and proven. (The same can be said for methods to be used in systematic analysis by the Safeguards Department; see Section 4.3.2). This suggests the need for an ongoing program of research in analytical methodologies, though not necessarily under the umbrella of SIMS, together with efforts to monitor relevant R&D performed for non-IAEA users that might also be applicable to IAEA needs.

Enhanced Analysis by the Director General's Office. Enhanced analysis deals with the use of intelligence information, which normally will not come in electronic form and may require additional security measures. Organizational elements involved include the Director General, Special Assistant to the DG, External Affairs, and Legal, in coordination with senior members of the Safeguards Department. Aside from the use of third-party information and the consideration of additional factors, the nature of the enhanced analysis task is fairly similar to systematic analysis. In performing enhanced analysis, the DG's office likely would benefit greatly from access to information management systems used for systematic analysis.

4.2 Program 93+2 Team/Task 3: Environmental Monitoring

Task 3 under 93+2 assesses the use of environmental monitoring techniques for the detection of undeclared nuclear activities at both declared and undeclared sites. The purpose of the environmental monitoring would be to detect: enrichment, by any process, of uranium in the isotope 235U; reactor operations for the production of plutonium and uranium-233; and reprocessing of spent reactor fuel to recover plutonium and uranium 233.

Sample analysis would presumably be aimed at detecting or measuring isotopic levels of uranium, plutonium, and their decay products. Sampling would be done at "short range" during inspections (special, ad hoc, and routine) to check for the presence of (or enhance the assurance of the absence of) undeclared nuclear activity at a site, and may be done at "long range" to enhance the assurance of the absence of nuclear activity on a country-wide basis. Environmental monitoring techniques and analysis methods were addressed by a special consultants group that met at the IAEA in the Spring of 1993. The consultant's group report provides additional details that may be useful in determining information management needs for environmental monitoring. This report is contained at Annex 6.

The Task 3 team is already engaged in field trials, so there is a time-urgent need for information management support to analysis from the trials (but any subsequent widespread implementation also needs to be supported). Needs or desires for analytical tools or visualizations tools were stated in fairly generic terms, in part because the Agency is still formulating its approach to environmental monitoring data analysis. It should be noted that the Iraq Action Team is also doing environmental monitoring; perhaps there is something to learn from their experience. Like the Action Team, members of the 93+2/Task 3 team requested U.S. guidance how computers might be used to assist in the analysis of environmental monitoring data, particularly with regard to geographic information system (GIS) capabilities.

Two timescales must be supported: (1) the short-term R&D needs generated from field trials, and (2) the long-term information management support needed to support any environmental monitoring actually implemented as part of enhanced safeguards. The User Group for the short-term is the 93+2 Task 3 Team. The primary user groups for the long-term needs will be inspectors collecting information in the field and inspectors or analysts evaluating the results of the sample analysis.

4.2.1 Information to be Managed

The primary information to be tracked is structured information on samples. Samples will be of water, sediment, and biota. Samples may be taken "near to" or "far from" a site and therefore the users of an information management system need flexibility in how they reference and view the data. For each sample, data to be tracked includes:

- sample type, location (e.g., near what facility), coordinates (latitude and longitude), measurement points, and date and time of sample taking

- sample data
- where sample is being analyzed
- status of laboratory analysis
- results of analysis (there is a preference for results in the form of isotopic ratios rather than concentrations)

Compared to some of the other user groups, IAEA staff concerned with environmental monitoring were much more specific about their information needs. However, the SIMS steering committee needs to consider carefully which needs to address under SIMS and when to address them. In particular, the longer term needs for support of widespread implementation of environmental monitoring are apt to remain ill-defined until the Task 3 team has evaluated the results of field trials and various options, and Member States have agreed to accept specific environmental monitoring measures. In addition, some needs may be better met through other support programs; implementations or tools that require specialized knowledge, such as some of the physical transport codes, may fall in this category.

A question that may be worth exploring is what the requirement is for knowing the latitude and longitude for an item versus distances. What are the accuracy requirements for both location (lat, long) and distance (possibly expressed as error distance over distance between points)? Under what circumstances are each used?

In addition to the sample information, some supplemental information is needed in order to perform analyses or modeling. The additional information includes: meteorological data (need to be able to take it into account during analysis); land contours; and maps.

4.2.2 Functional Requirements

Functional requirements are reviewed for data acquisition, storage, and retrieval; and for data manipulation, modeling, and analysis. This includes a discussion of data presentation and visualization. Because there was a strong interest in field support, functional requirements for this class of activities are also discussed.

4.2.2.1 Data Acquisition, Storage and Retrieval

There is a need to store environmental monitoring data for future retrieval (particularly analysis results, past sampling points, and basic information about past samples). Although the basis for retrieval was not explicitly defined during conversations with IAEA representatives, some intelligent guesses can be made based on the fields defined above for sample tracking. Storing data for future retrieval is clearly a key requirement and there are both short-term and long-term needs in this area. For the short-term, the Task 3 Team will need to be able to retrieve information about its field trials; since trials are already under way, this is a time-urgent need. In the long-term, inspectors or analysts will want to be able to pull up historical records of samples taken and their results. However, since the nature of the records will presumably be defined as the Task 3 Team performs its assessment, the long-term needs are less well-defined.

Data should be geo-referenced. The desire here is to be able to retrieve information based on its geographic location. Geo-referencing is very important for the environmental data in part because of the types of modeling and analysis that the IAEA will want to perform on this data. This is a time-urgent need for the 93+2 Task Team. The SIMS initiative is currently addressing this need by providing the IAEA an INSIST-like workstation.

4.2.2.2 Data Manipulation, Modeling and Analysis

Data manipulation, modeling and analysis addressed: computing the distance from a given reference point; mathematical and statistical data analysis; tracking samples taken over time at a strategic point; physical transport modeling tools; modeling operations of different facility types; use of decision trees to streamline/guide environmental data analysis; suggesting locations for environmental monitoring; and helping in the development of sampling plans. These areas are addressed in the following paragraphs.

Compute distance from a reference point. Compute the distance from a given reference point, such as a facility or a hypothetical source, to a given sample point and report to the user. This information could be used evaluate the significance of the sampling results based on analyses involving transport modeling. It is probably possible to compute this information by hand, but, if feasible, it is important to provide this capability to the 93+2 Task 3 Team in order for them to analyze the results of their field trials.

Standard mathematical and statistical analyses. Mathematical and statistical data analysis (with respect to geography, time, isotope, etc.). The need here is for flexible tools that allow the user to perform standard mathematical and statistical analyses. The 93+2 Task 3 Team is still defining its approach to environmental monitoring and therefore cannot define explicitly what analyses it would like to perform. Again the need is probably time urgent for the Task 3 Team so that they can analyze their field trial results.

Track strategically-located samples over time. Track samples taken over time at a strategic point. The need here supports trend analysis by allowing the user to look at what happens at a single location over time. The Task 3 Team may evaluate this kind of analysis and may therefore have a time urgent need for such a capability. Once an environmental monitoring regime is adopted, this capability will be important because trend analysis is a good way to discern emerging patterns.

Physical transport modeling tools. The desires here fall into two categories: 1) codes for things like neutron transport modeling, and 2) tools to model how effluents would be dispersed in the physical environment surrounding a facility. Again, these tools are useful for interpreting the results of environmental sampling and analysis. The need may be time urgent for flexible modeling tools that can help the Task 3 Team interpret their data. One possible option for SIMS is to provide the platform for such tools rather than the tools themselves.

Model operations of different facility types. Develop models of the operations at different types of facilities to determine what effluents might be expected. This need again helps with the interpretation of sampling data. The time urgency and importance to the safeguards mission need to be clarified.

Decision tree to streamline/guide environmental data analysis. The desire here is for a decision support tool that can help an inspector make the best use of his resources and data. The tool could suggest when to stop analyzing a sample or could suggest what analyses to try based on results of other analyses, past history, etc. This is of value because it can help optimize the use of resources, but this capability does not seem to be critical to performing environmental monitoring. This seems to be a longer term need.

Suggest locations for environmental monitoring. The desire here is for a decision support tool that can help inspectors choose locations for environmental monitoring. This is important in that it can help optimize use of resources and ensure that meaningful samples are taken. This is a longer-term need.

Help develop sampling plans. The desire here is for a tool to help inspectors develop a detailed sampling plan for the site including where, when, how, and in what order. This tool is more implementation-oriented than the tool for selecting environmental monitoring locations. This is also a longer-term need.

Effective data presentation and visualization are necessary to enable users to employ analytical tools effectively. The desire here is for flexible tools that allow the user to display or visualize information in a variety of ways, through the use of charts, graphs, and overlays (e.g., trend lines on map displays). For maximum efficiency, software tools should be integrated, combining spreadsheet, statistics, graphing and presentation.

This capability is important to allow users to interpret their information and is probably a time urgent need for the Task 3 Team. We were told that David Hayes at Savannah River has a suite of tools to support environmental monitoring information management support that Erwin Kuhn is interested in. Those members of the development team addressing environmental monitoring information management needs should follow up to assess how best to make use of these tools. Furthermore, it was suggested that the U.S. arrange to bring IAEA personnel to the U.S. to meet with users of software tools similar to those envisioned by the Agency for use in environmental monitoring. This will help the Agency further define/clarify their requirements.

4.2.2.3 Information Management in the Field

Discussions on information management needs also touched on field support. There was a moderate desire for field support, particularly to support sample taking and logging. For example, it may be important to take samples at the same location as on a previous occasion. A fieldable information management system that has information about previous samples could help the user locate the right location on a map or using GPS. Once a sample is taken, it is important to log key information; this could be done directly into a portable PC. Decision support tools, particularly for developing sampling plans may also be very useful.

There was some concern expressed about how to address quality control for data entry. One solution suggested by an IAEA staff member was a field system that could take inputs from bar code readers, weather instruments, GPS, etc.

The need for visualization tools in the field is rather limited. Such tools would be most useful for sample analysis results, which will probably not be available until after the inspection team returns to Vienna.

Although a fieldable information management system for environmental monitoring would undoubtedly be welcomed at the IAEA, the need for it did not appear to be as time urgent as other needs discussed above.

4.2.2.4 Data Communications

Data communication needs include being able to download information from an Agency workstation or desktop computer to a laptop computer for use in the field, being able to upload information from a laptop to Agency computers, and being able to directly enter data from field instruments in a laptop computer.

4.2.3 Issues and Constraints

Many of the issues and constraints covered for the Action Team apply to the 93+2/Task 3 team as well, including provisions for security in system design, the need for SIMS developers to provide technical and systems support to the IAEA during system installation and start-up activities, and compatibility with existing systems. The following additional issues and constraints should be considered in SIMS development efforts.

Information Security. What is the need for data security on communications? Is there a need to protect information in field-portable systems? Are field test data sharable or safeguards confidential?

Environmental Monitoring Approach. One major issue is that the approach to environmental monitoring (EM) is still undefined. The approach is likely to remain undefined until the technical evaluation by the Task 3 Team is complete and a regime that is acceptable to the Member States has been defined.

Customization of Tools. Some tools, particularly in the visualization or GIS arenas, may require a fair amount of knowledge to modify or customize for particular data sets. What is the best way to support these needs? The utility of some software tools may be easier to evaluate if there are some data against which to test them.

User Limitations. Like the Action Team, users of the environmental monitoring workstation will likely start with very limited experience and/or skills in using computer-assisted analysis. This dictates a carefully thought-out approach to interface design. SIMS systems should have an intuitive interface, and software tools should be designed to aid analysis paths, but not force analysts into a particular way of interpreting their data.

INSIST as a platform for EM Information Management. The people interviewed were interested in building on INSIST; the geo-referencing made it an appropriate platform. Questions for the future:

- How much data will the system be required to store?
- What are timeliness requirements?
- How many users will there be?
- Where will users be located?

4.3 Program 93+2/Tasks 5: Improved Analysis of Information on States' Nuclear Activities

As discussed earlier in Sections 2.3.1 and 2.5.3, systematic analysis by the Department of Safeguards will expand the sources of information used and the scope of the activities evaluated in the Agency's collection and analysis of information about states' nuclear activities. The objective is to maintain comprehensive knowledge of nuclear and nuclear-related activities, and safeguards and non-proliferation situations in each state. Through such comprehensive knowledge, systematic analysis is intended to contribute to early detection of activities that appear inconsistent with a state's non-proliferation and safeguards obligations, and to contribute to safeguards planning.

4.3.1 Information to be Managed

Under Task 4 of Program 93+2, which deals with increased cooperation with SSACs and other measures for improving the cost-effectiveness of safeguards, the Safeguards Department is studying a variety of additional measures for strengthening safeguards. To the extent that such measures prove feasible and acceptable, and eventually are adopted, they will add information management demands that are closely linked to those of systematic analysis. They will add new sources of information and will create new requirements for comprehensive information and analysis. Examples of measures under study include:

- expanded declarations;
- more timely declarations, including early provision of design information;
- expanded access to locations, especially within and adjacent to declared sites;
- expanded inspection activities at sites;
- managed access to undeclared locations; and
- unpredictability of verification.

The division of organizational responsibilities for systematic analysis is a subject that is still under discussion at the IAEA. See Section 2.5.2 and 2.5.3 for details. It appears likely that the overall process will be a distributed one, involving collaboration among various groups.

4.3.1.1 Systematic Analysis Tasks

Many of the information management needs for systematic analysis and Program 93+2 Task 4 measures are similar to those required by the Iraq Action Team, so readers of this section of the document may also wish to consult Section 4.1, which discusses the Action Team. Systematic analysis tasks include:

- Gathering, screening, evaluating, and reviewing on a continuous basis all available information on nuclear and nuclear-related activities in each state. Information sources include a variety of open and safeguards sources. The credibility and independence of sources must be evaluated.

- Filing evaluated information, together with appropriate annotations regarding credibility or known errors, for later retrieval.

- Continuously developing and maintaining a comprehensive picture of each state's nuclear and nuclear-related activities. Users should be able to find and select pertinent stored data, and ask how the new information squares with other facts and suppositions.

- Identifying possible inconsistencies with a state's safeguards and nonproliferation undertakings.

- Identifying new facilities and other information bearing on safeguards planning and development.

- Evaluating and assessing identified possible inconsistencies, including developing plans for clarifying or further investigating them.

- As warranted, documenting and reporting inconsistencies to the Director General's Office for further resolution.

4.3.1.2 The Systematic Analysis Process

An illustration of the systematic analysis process as we currently understand it from our two visits to the IAEA, is shown in Figure 4.1. This figure will be referred to periodically as we cover information to be managed and functional requirements for 93+2/Task 5. The State's expanded declaration is shown as the starting point for systematic analysis. The analyst may be testing the hypothesis that the State's declaration is false, or looking for evidence of inconsistencies in the State's declaration and the information acquired from other sources. This is a "longitudinal" task, i.e., it is a task that takes place over an extended period of time to which the analyst comes back periodically with new or expanded data. This is illustrated by the "feedback loop" shown in bold on the right side of the diagram.

The longitudinal nature of the task is important because it points to the need for some method to capture the analyst's interim results so that they may be retrieved and brought to bear upon future analyses. This should be done in a way that fits the analyst's results to his/her thought process, e.g., to the hypothesis being tested and/or the case being developed. This is an area in which computer assistance could be very helpful.

The State's expanded declaration (now being termed a "broader declaration" by the Agency) is intended to make a State's nuclear fuel cycle and associated activities as "transparent" as possible.

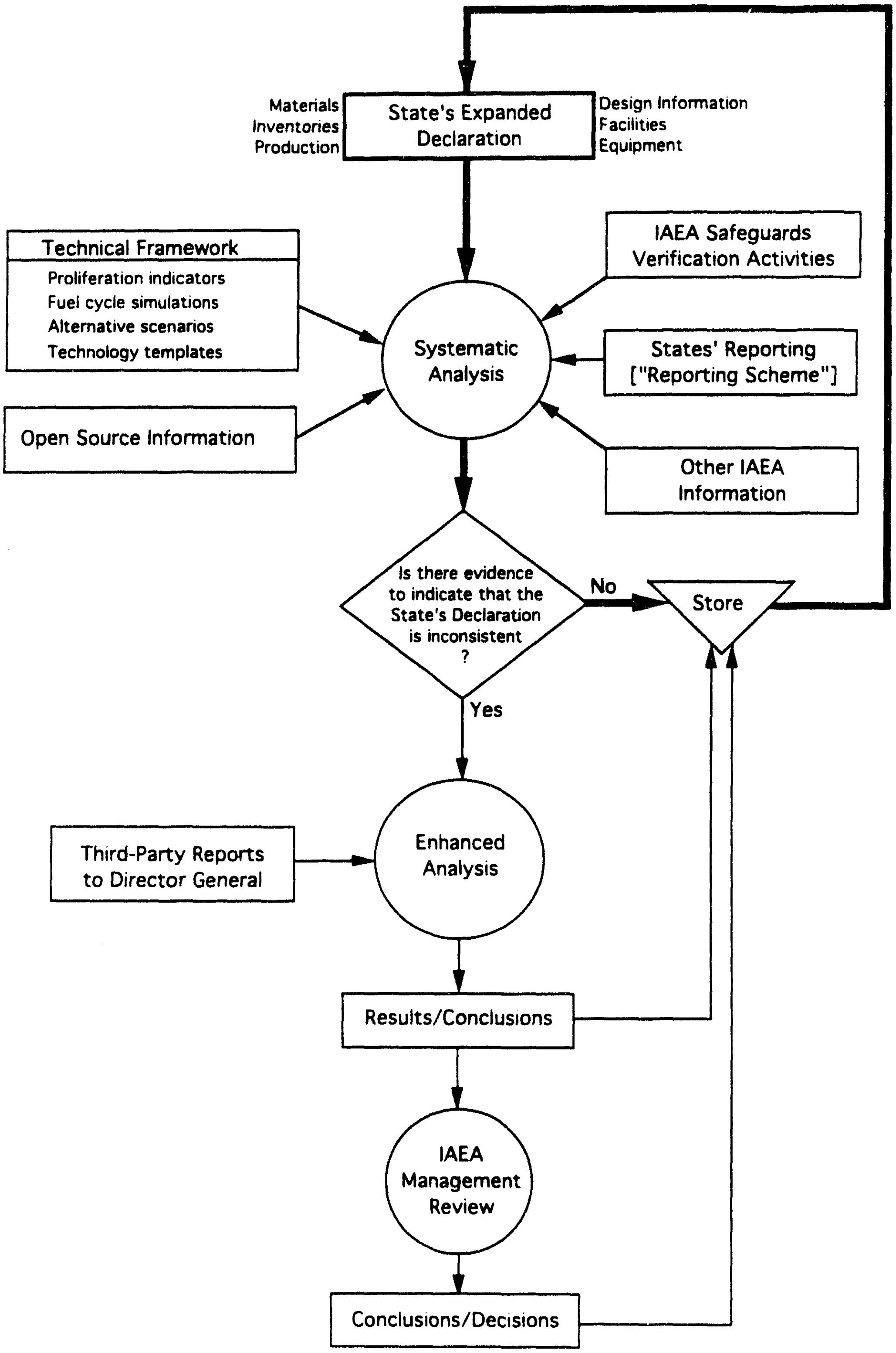

Figure 4.1. An Illustration of the Systematic Analysis Process

This declaration may include, in addition to all nuclear material, a description and the location of all nuclear-related processes, production, R&D, and training. It becomes obvious that the Agency's intent then is to cross check the State's declaration with the information it gathers through it's independent verification activities (e.g., routine inspections on site), through the "reporting scheme" recently endorsed by the IAEA Board of Governors, through the review of other IAEA information, and through the analysis of open source information. Such cross checking is another area well-suited to automation.

4.3.1.3 Safeguards and Open Information to be Managed

The SGCP Country Information System (SCIS) is currently used to support systematic analysis (see Section 3.1.2 and Annex 5). Copies of SCIS have been made available to the three operations division directors and to the DG's office. SCIS represents a preliminary step toward the sort of information management tools that will be required in using open-source information in building and evaluating country profiles as part of systematic analysis.

In its present form, SCIS generally does not include the full text of underlying source reports. Rather, open-source reports are manually pre-processed and correlated, after which summarized, key-worded listings are entered into appropriate parts of the database. Hardcopy reports of database contents by country are being made available in the form of "country files" in 3-ring binders. But the power of SCIS is the fairly easy-to-use search capability. One can do Boolean searches via country, data category, data subcategory, "attribute", keywords, or free text. For each search parameter a menu of choices appears, and entering the first letter of a desired menu choice lets the user jump ahead to the relevant section of a long menu.

From the perspective of the IAEA, the information to be tracked might be divided into two categories, "safeguards information" and "open information." Table 4.5 lists the information to be managed in these categories.

From the perspective of subject matter and data types, information might be characterized in a manner analogous to that used in the discussion of the Iraq Action Team (Section 4.1):

- *Declarations* concerning states' nuclear and nuclear-related activities and relevant programs. Under proposed measures, such declaration might, for example, be expanded to cover all nuclear-related activities, even if they are only at an R&D scale and even if they do not use reportable quantities of nuclear material.

- *Sites and facilities*, including the names, location, characteristics, specifications, and current status of every site, facility, or location reported and identified in the course of implementing safeguards in a state.

- *Design information* for declared facilities.

Table 4.5. Safeguards and Open Information to Be Managed

Safeguards information to be managed includes:
• declarations and other information provided by a state under safeguards agreements
• information developed in the course of implementing proposed safeguards-strengthening measures (examples; expanded schemes for reporting of export/import information, environmental monitoring data, etc.)
• information collected during inspections
• inspectors' observations
Open information to be managed includes:
• safeguards-relevant information from outside the safeguards system
• IAEA documents
• IAEA databases (such as nuclear power, nuclear safety or technical assistance databases)
• non-IAEA databases (such as MIIS or Carnegie databases)
• open publications, including technical publications and nontechnical journals and news media

- *Inventories* of all nuclear material, non-nuclear material, and nuclear and other equipment reported or identified. Includes information about the characteristics, specifications, location, and current status of items on the inventory.

- *Inspection reports*, past and current, on inspection activities.

- *Monitoring and verification results* of IAEA monitoring and verification activities, including sampling, environmental monitoring, measurements, etc.

- *Accounting information* on nuclear and specified non-nuclear material

- *Export/import reports* from the host state and other member states, to the extent that proposed reporting schemes are endorsed and adhered to by member states.

- *Maps, diagrams, photographs, and other non-text data,* including mapsets, site diagrams, charts, process diagrams, satellite and aerial imagery, ground photography of sites and their internals, video photography, and other graphical data relevant to nuclear and nuclear-related activities in a state.

- *Open-source information* on states' nuclear and nuclear-related activities, facilities, materials, and equipment.

- *Information from Member-States* [for enhanced analysis, but not for systematic analysis], including intelligence information, information from customs and export-licensing authorities, and other third-party sources.

- *Other relevant information* collected by inspectors in the course of their activities.

Another perspective on the data to be managed is the "Country Profile" format described in the IAEA's draft description of Country Officer responsibilities (see Annex 4).

4.3.2 Functional Requirements

Functional requirements are reviewed for two major classes of activities: data acquisition, storage, and retrieval; and data manipulation, modeling, and analysis.

4.3.2.1 Data Gathering, Screening, Evaluation, and Storage

All available information on nuclear and nuclear-related activities in each state must be gathered, screened, evaluated, and reviewed on a continuous basis. For open source information in particular, the credibility and independence of sources must be evaluated, and the information annotated accordingly. Both text and non-text data need to be stored for later retrieval and use.

The acquisition of open source information and its transformation into electronic form and evaluation for relevance and reliability is of particular concern to the IAEA. An illustration of this screening and evaluation process is shown in Figure 4.2.

4.3.2.2 Data Retrieval

Data of several types must be sought and retrieved. Some text and graphical information will need to be scanned in, including a present hardcopy backlog and an ongoing flow of new hardcopy information. Some data should be stored according to its *geographic location*, so that the data can be associated with a specific, location, site, building, or room. For these location-referenced data, items should be displayed on site or building diagrams and on maps of various scale.

It also is necessary to search and retrieve data based on parameters *other* than location. Text retrieval tools, incorporating keywords, indexed free-text searches, Boolean expressions, etc., could accomplish much of this function. The data sets resulting from such searches should be displayed on the analyst's monitor with forward and backward scanning capabilities. If possible, search terms should be highlighted in the retrieved text, and there should be a capability to annotate and store some or all of the retrieved text in separate working files. The ability to build, maintain, and manipulate relational databases is also desired. One should be able to print out selected sets of stored or retrieved data in pre-defined and customized formats, including color printouts of maps, photographs, and other color graphics.

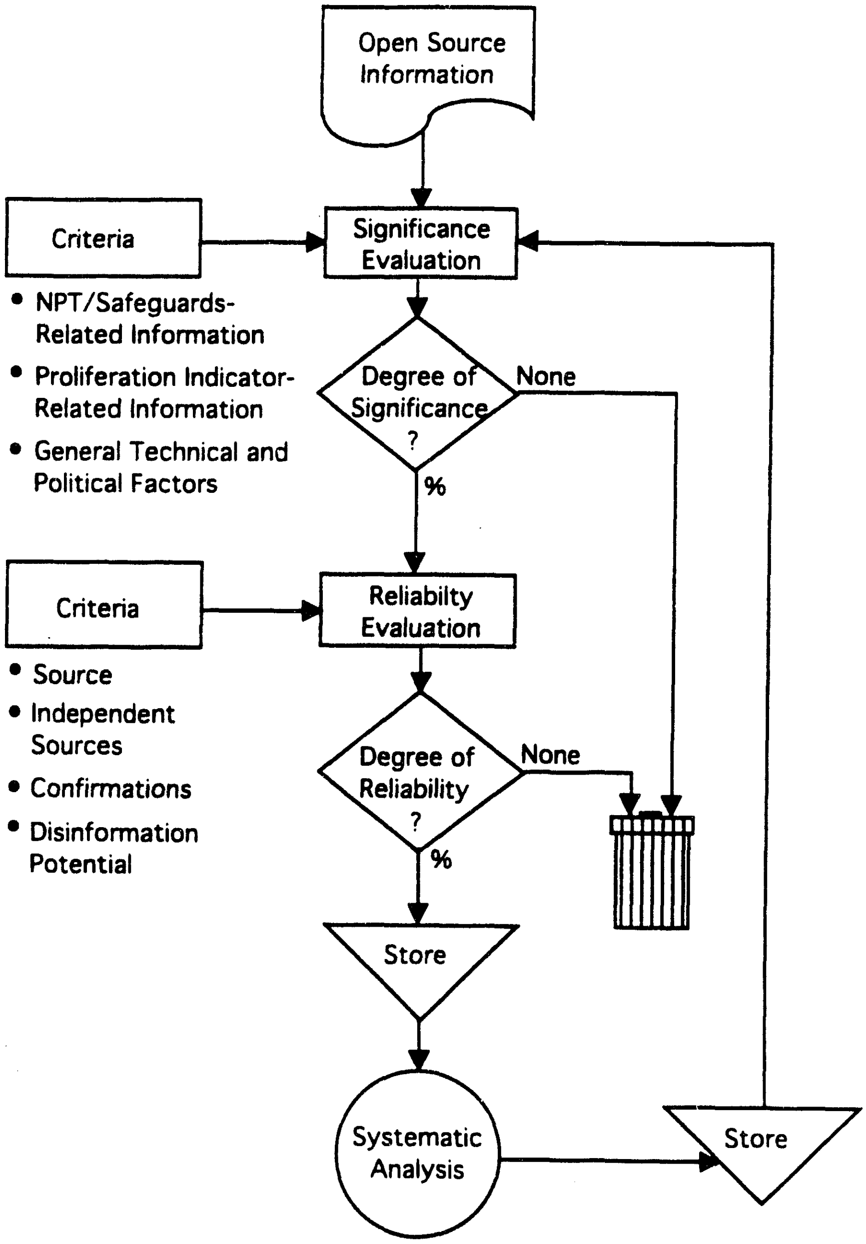

Figure 4.2. Screening and Evaluation of Open Source Information

For both geo-referenced and textual data, users want the capability to navigate or browse through the system in a hierarchical, "drill down" fashion, with general information leading to more detailed information; a user-friendly interface is a must. With geo-referenced data, for example, users should be able to zoom in on selected regions of a map and to move from maps to site diagrams to building layouts where available. Analysts should be able to retrieve and display documents, photographs, and other data linked to specific locations. To the extent possible, users would like relatively "seamless" access to all data types from their individual offices and through a common interface.

Inspectors have expressed interest in a capability to download selected data to notebook computers to use and manipulate in the field. Some steps in this direction are already under consideration.

4.3.2.3 Data Manipulation, Modeling, and Analysis

As new data is gathered and evaluated, analysts seek to continuously develop and maintain a comprehensive picture of each state's nuclear and nuclear-related activities, asking themselves how the new information squares with other facts and suppositions. In some cases, they will be looking for possible inconsistencies with a state's safeguards and nonproliferation undertakings—inconsistencies that could signal the existence of undeclared activities or other violations. In other cases, they will be looking to clarify or refine suspicions that already have been developed as a result of previously detected inconsistencies. Some users in the Safeguards Department have expressed an interest in data manipulation, modeling, and analysis tools to assist in the interpretation and assessment of information. Capabilities suggested are described in Table 4.6.

Some of the more ambitious ideas for modeling and analysis tools would still require more research and development work in order to identify appropriate methods and algorithms. For the near term, some of the more complex analytical tasks probably are best handled by trained, human analysts. Still, there are opportunities to provide computer assistance in the analysis of a state's nuclear activities.

For example, as shown in Figure 4.1, a "technical framework" database might be developed that analysts could refer to when assessing an hypothesis about the relevance of information obtained from any of the myriad of sources available to the Agency. This technical framework, or set of "technical reference tools," might include proliferation indicators, models of various fuel cycles, or even fuel cycle simulations, alternative scenarios for peaceful and non-peaceful uses of nuclear materials, and templates of core technologies for weaponization programs. Data might, for example, be drawn from the Nuclear Suppliers Trigger List and Dual-Use List (see INFCIRC/254). The framework could also be used to help guide analysts build a case about an hypothesized diversion path or proliferation method. The idea of "case building" could be used to help data fusion over the extended period of time during which an analyst will typically be monitoring a state's nuclear activities.[a] Not all users will have had much experience with computers, especially with complex systems. Information management systems provided by SIMS should be mutually compatible and should include a user-friendly

(a) See for example, the report "Collaborative Human-Machine Nuclear Non-Proliferation Analysis," prepared for the DOE by the Pacific Northwest Laboratory (PNL-8922, October 1993).

Table 4.6. Information Management Capabilities for Systematic Analysis

• *View data from many different frames of reference* (e.g., by site, by date, by personnel, by organizational grouping, by facility type, by sample type, and so forth).
• *Technical reference tools*, ranging from on-line technical tutorials to tools that would identify the potential nuclear-related applications associated with particular commodities or keywords.
• *Modeling tools*, such as process flow models or pathway models.
• *Analyze correlations between different data categories*. Just what those correlations might be remains to be clarified. Ultimately, such tools might be able to identify trends and inconsistencies or even suggest inferences drawn from multiple data sources that an analyst might not otherwise recognize.
• *Design information verification tools*.
• *Inspection planning tools*.
• *Compare two different images of the same area* (satellite images, aerial photographs, ground photographs, or video frames) for purposes of change detection. This could range from simple side-by-side display to more powerful methods such as image warping followed by digital subtraction.
• *Automated change detection with other sorts of data*, such as inventories, declarations, etc.
• *Analysis of export/import information*, including transit matching and identification of inconsistencies and trends.

interface. SIMS user interfaces should have a similar "look and feel." A "point-and-click" approach, preferably with the look and feel of Microsoft Windows (already in wide use at the IAEA) is desirable. On-line help should be available.

4.3.2.4 Support

The Safeguards Department has some in-house capability to help maintain and troubleshoot computer systems. However, it is likely that some SIMS products will be sufficiently complex and specialized that the IAWA will not at first be in a position to support users on their own. It is essential that any hardware or software systems provided by SIMS be backed up by ongoing post-delivery support and maintenance until such time as handoff to IAEA support organizations is feasible. This support commitment should be included in SIMS cost estimates.

4.3.2.5 Compatibility with Existing Systems

Compatibility with the current IAEA computer environment (discussed in Section 3) is highly desirable. For example, it would be very advantageous if data on SIMS Sun-based workstations could be accessed remotely by users working on MS-DOS PCs in separate offices, probably via the Safeguards LAN, which also would provide access to other in-house and outside databases.

4.3.2.6 Need for Development of Systematic Analysis Methodologies

As discussed in Section 4.1 in the Action Team context, certain analytically complex modeling and analysis tools desired for systematic analysis do not yet exist, and the necessary methodologies and algorithms are yet to be developed and tested. An ongoing research program of research on analytical methodologies for systematic analysis appears necessary, though not necessarily under the umbrella of SIMS. Relevant R&D also may be underway in the U.S. and for non-IAEA applications.

4.4 Program 93+2/Task 6: Training

Task 6 of Program 93+2 deals with the development of training programs to ensure that staff of the Department of Safeguards are prepared to implement the various measures being developed to strengthen the safeguards system. Safeguards training is the responsibility of the Safeguards Training Section (DTR) assigned to the Director of Development and Technical Support (SGDE). The team leader of Task 6 of Program 93+2 is the Section Head of DTR.

The Training Section has only 5 full-time professional staff (plus 3 cost-free experts). Instructors are drawn from Operations and Support Divisions on as needed basis. DTR will be responsible for developing the training necessary to support implementation of the various measures for strengthening safeguards. Some of the more important training areas being examined by DTR include:

- training operations staff and others to perform "systematic analysis"
- training inspectors to examine and verify design information
- training inspectors to enhance their "knowledge acquisition skills"

4.4.1 Information to be Managed

The training section manages information dealing with administrative training matters, such as student and curricular data. In addition, they prepare and present training materials using various training delivery systems, including computers.

4.4.2 Functional Requirements

4.4.2.1 Data Acquisition, Storage and Retrieval

DTR was interested in hypertext, run-time video and interactive audio. The impression at the Agency was that CD-ROM and video disk are too expensive. There is currently a multi-lab effort underway to look at training for the Agency and there is an SP-1 out to support these needs. Improving training clearly can have a positive impact on the safeguards mission.

4.4.2.2 Data Manipulation, Modeling and Analysis

The Safeguards Training Section Head (SH-DTR) is very interested in the use of multi-media for training purposes and wants to use computer-based training to deliver more training courses. He feels the benefits are more uniform training, less demand for instructors (which must be drawn from other divisions, especially Operations), less boring for instructors (who may have to give the same course multiple times), and less demanding on staff resources (because they don't have to pull in large numbers of inspectors all at once).

4.4.3 Issues and Constraints

Naturally, DTR is concerned about the training implications of the introduction of new information management systems in the Department of Safeguards. Among DTR concerns, the following appear most important:

Computer Literacy. The recent introduction of Gateway computers in the department caused "serious problems." The staff aren't using network functions provided through the recently installed LAN and are not using the Help Line available to them. An expert has been brought in to provide one-on-one training support for users and this is proving to be the most successful approach to the problem of getting staff comfortable with their computers.

Computer Support. SH-DTR considered computer support in the department to be inadequate. He stressed the importance of training in the introduction of new computer systems and stated that training must address both the end user and the people that will support/maintain the systems. Further, SH-DTR stressed the importance of developing "user friendly" systems to reduce the training burden on the Agency.

Country Officer Training. SH-DTR was asked to arrange training for "Country Officers," but hasn't done so because organizational issues haven't yet been resolved [there is disagreement within the department about the role and responsibility of COs and even whether there will be COs]. SH-DTR stated that a training course was given on the use of open source information and the SGCP Country Information System (SCIS) that Tolchenkov had developed in SGCP/PSS (see below), but SH-DTR considered the course inadequate.

4.5 Conventional Safeguards

The keystone to conventional safeguards is nuclear material accounting and control. Over the years, a rather elaborate system for material accountancy has evolved; detailed descriptions of this system are available in several other documents, and basic concepts in IAEA nuclear material accounting are presented in Annex 2. Rather than try to duplicate such descriptions here, the authors will focus on the information management needs under conventional safeguards, particularly those needs that are relevant to SIMS.

In the realm of Conventional Safeguards, three major information user groups were addressed: the Data Processing Services Section, the Inspectorate, and the Safeguards Effectiveness Evaluation Section (SEE). A general job/task description for each user group is provided below.

Data Processing Services. The Data Processing Services Section in SGIT is responsible for storage and processing of all accounting information. Accounting information from Member States comes in three forms: (1) ICR - Inventory Change Report (reports changes in material or movement of material); (2) MBR - Material Balance Report (consolidated summary of accounting information for a material balance area); and (3) PIL - Physical Inventory Listing (results of a physical inventory taking).

The tasks performed by the Data Processing Services Section include receiving accounting information from Member States, performing quality checks on the incoming information (i.e., to determine if the fields are filled in correctly), performing consistency checks on the information, and supplying reports or summaries to the Safeguards Operations Divisions and to SEE. Information from inspections is also stored by the Data Processing Services Section.

Inspectorate. The Inspectorate is organized within the three Divisions of Operations. Each Division has a Procedures Section that is responsible for planning the inspections, and three operations sections that carry out the inspections. Inspectors compare the processed accounting information to information gathered on inspections. Inconsistencies in the accounting data can be used to trigger inspections or the inspections themselves may turn up inconsistencies that need to be further checked out. In addition to independently verifying the quantities and locations of nuclear materials, inspectors may engage in other activities including checking the operation and calibration of their instruments, gathering information on possible causes of inconsistencies, etc. (see Section 2.2.2). Inspectors record their information in the Computerized Inspection Report as well as Inspection Working Papers (IWPs).

Safeguards Effectiveness Evaluation Section (SEE). SEE is responsible for producing the Safeguards Implementation Report (SIR), the annual IAEA report describing the degree to which inspection goals have been attained by the Agency and the conclusion of the Agency regarding any possible diversion of nuclear material. Input for the SIR includes accounting data from ISIS and information on the results of inspections, which is documented in the Computerized Inspection Report (CIR). As noted in Section 3.2.1, SEE has developed the SIR Evaluation Program to evaluate the CIR with respect to the 1991-95 Safeguards Criteria and determine the degree of inspection goal attainment. Inspection goal attainment is evaluated at both the facility and state levels.

4.5.1 Information to be Managed

A complete list of information to be tracked can be found in the model Code 10 and facility attachments. A representative list is shown below:

- Nuclear Material Inventories
- Inventory Changes (including transactions with other facilities or MBAs)
- Material Balances
- Facility design information (including maps and plans)
- Location of MBAs and KMPs
- Location and type of surveillance equipment
- Facility specific provisions of the safeguards agreement
- Inspection results (Checklists, analysis results, sampling plan)
- Locations and identity of tags and seals used
- Safeguards criteria

4.5.2 Functional Requirements

Functional requirements are reviewed for data acquisition, storage, and retrieval and for data manipulation, modeling, and analysis. This includes a discussion of data presentation and visualization. Because there was a strong interest in field support for inspections, functional requirements for this class of activities are also discussed.

4.5.2.1 Data Storage and Retrieval

Generally, ISIS supports storage and retrieval of data pertaining to conventional safeguards. However, there are a few needs of potential interest to the SIMS project:

- *Improve the examination and verification of design information.* There were several comments to the effect that not much was done with design information. Some sort of mechanism that allowed for electronic storage and retrieval of the design information could be quite useful. This could be important for the safeguards mission because parts of a facility might become inaccessible once the facility comes on line. Checking the accuracy of information provided to the Agency is hard without a good mechanism for dealing with the information. The time urgency did not seem to be particularly great.

- *ISIS.* The safeguards database is aging and may need to be upgraded. There were mixed comments on the need to upgrade the safeguards database. The current system is adequate and therefore any effort in this area would not have much impact on the safeguards mission. This does not seem to be a time urgent need.

- *Field use.* One suggestion was that inspectors might want to selectively download information (to a laptop). This will presumably require good information selection tools and format compatibility between the two systems.

4.5.2.2 Data Manipulation, Modeling and Analysis

For declared facilities and materials, there is already an elaborate, complex, but well-defined procedure to evaluate whether safeguards goals have been achieved. For this, SEE relies on the IAEA's Computerized Inspection Reports as well as accounting reports from Member States (ICRs, MBRs, etc.). Safeguards goal achievement is evaluated both at facility level and the State level. To the extent that proposed ideas about expanded declarations are accepted and implemented, SEE may need to take into consideration a large body of newly available information about declared facilities.

As regards undeclared activities, there are changes underway in how safeguards effectiveness evaluation will be performed. The Safeguards Implementation Report (SIR) will now be expected to comment on the possibility of undeclared activities. The results of systematic analysis will be needed by SEE for such an expanded SIR. SEE also may require specialized modeling and evaluation tools unique to the expanded SIR that are not specifically required for systematic analysis alone. Other areas that SIMS may be able to impact include:

- *Design information:* Checking of the design information may be easier if design drawings can be easily manipulated or updated. This could have a significant impact on the safeguards mission and is probably of an intermediate time urgency.

- *Transit matching:* There are currently some computer programs to assist with transit matching. It is possible that these could be improved on and so reduce the human resources required to complete this activity. However, the information processing departments are understandably reluctant to turn ambiguous judgments over to a computer program; the potential repercussions in the international community are simply too great.

- *Viewing data at a country level:* There may be some need to permit summarizing data or consistency checking at a conceptual level higher than an MBA or facility.

Data presentation and visualization are important factors in the utility of analysis activities and tools. Currently, some inspectors want data listed in a particular format to better match the inspected facilities records. This need is currently being met. Few other specific needs were identified in this area. One potential area is with presentation or visualization of facility design information. Comments relating to this area can be found below in the section on information management in the field.

4.5.2.3 Information Management in the Field

One of the surprises of the user requirements trip was the strong interest in field support for inspections. The Safeguards Department is currently pursuing initiatives in this area with its In-Field Support System (IFSS) and the Briefcase Inspection System (BIS) (see Section 3). Both of these initiatives support accountancy-related inspection activities and deal with largely quantitative data.

In addition to accountancy-related verification, there was some discussion of using in-field support for other activities such as site familiarization, design information verification, and providing more detailed information about the processes and equipment at the facility. There was even the suggestion that a sufficiently powerful field system could assist inspectors in resolving anomalies in the field. As ever, field systems will need to be lightweight and compact. Some of the current resistance to field systems from inspectors is due to weight and volume.

Information to be managed is somewhat similar to that listed above for conventional safeguards, and includes:

- inventory information
- design information/drawings
- seals information
- record inspection results
- images/graphics such as maps from the airport to the facility, pictures of POCs
- video/stills of hot areas
- facility information
- safeguards criteria
- diagrams of the material flow process w/ components and technical parameters
- Layouts of piping and how it had changed

- photos of equipment (particularly tied to diagram of facility or process)

- Containment and surveillance equipment lists with servicing dates

Storage and retrieval requirements for field support systems were not discussed in detail. One interesting point however, was the need to tailor the information in the field to the site being visited. One of the problems cited with the IFSS is that it is too generic.

A variety of modeling, analysis, and data presentation/visualization ideas were discussed; they are described in Table 4.7.

Data communications needs were not discussed explicitly. Desires for communication between the field and IAEA headquarters should be explored in more detail.

The impact on Safeguards Missions/Objectives, time urgency, and the interrelationship of these to other needs/initiatives need to be clarified for the needs identified above for in-field information management support. Note that some of the ideas listed above may work equally well or better in Vienna.

Table 4.7. Data Modeling, Analysis, and Presentation Capabilities for Information Management in the Field

- *Inspection planning* - the desires here were for tools to help optimize the utilization of manpower and time. Performing inspections uses a lot of manpower and therefore optimization tools could have a positive impact on the safeguards mission. It would be useful to find out what is already being done in this area.

- *Inspection procedure* - the desire here was for tools to aid the inspector in selecting how to inspect a facility. For conventional safeguards, this appeared to refer mostly to developing sampling plans for checking inventory and materials. in the future, it could also cover things like helping identify which parts of a facility to visit and how to cover those areas in a reasonable length of time.

- *Model/review containment and surveillance* - the concept here is that if there is a failure on the part of a containment or surveillance system, the inspector could have a three-dimensional model available that allowed him to assess the impact of the failure and to evaluate possible diversion scenarios.

- *Model material flow*

- *Model diversion scenarios*

- *Show the history of the layout of equipment.* With such information, inspectors could look for changes and possibly detect undeclared activity.

- *Diagrams of the material flow process* with components and technical parameters could be useful for helping the inspector understand what he is seeing at a facility.

4.5.3 Issues and Constraints

Several issues were raised during the user needs assessment of conventional safeguards at the IAEA. These issues are described below.

SIR Conclusions. In the future, the SIR will need to contain conclusions regarding the possibility of undeclared activities. The evaluation necessary to draw such conclusions is not seen as quantifiable and developing a procedure to reach such a conclusion for the SIR is of great concern.

Security. Security issues will need to be considered carefully for the SIMS project. Generally users are provided read-only database access and password control is used to regulate access to sensitive information.

Text and Image Storage/Retrieval. Text and image storage and retrieval is being explored this year for the LAN. SGIT is considering Quick Index, ZyIndex and ZyImage, and Keyfile.

Documentation. Past deliveries of software from the national laboratories have apparently caused some problems because not enough documentation was provided. SGIT winds up supporting any delivered software by default (they are who the users call when there are problems). As a result, the Information Treatment Section Heads were interested in as much documentation as possible including a copy of SIMS systems designs in "System Architect" or a copy of the CASE tool utilized by the SIMS team.

Sensitivity of Photos. Detailed information on a site could be extremely sensitive. In particular, photos might not be able to leave site.

System development resources. The Department's resources for systems/software development are limited and interest was expressed in U.S. support of Agency development efforts, especially in the area of field support systems, where a collaborative development effort was suggested. SIMS development work in the area of field-use systems needs to be coordinated with BIS and IFSS development.

5.0 Summary and Conclusions

The International Atomic Energy Agency is undertaking a program for strengthening its safeguards system based on the recognition that safeguards must give assurance not only of the non-diversion of declared material or that declared facilities are not being misused, but also of the absence of any undeclared nuclear activities in States which have signed comprehensive safeguards agreements with the Agency. At the same time, budgetary constraints require that the Agency undertake measures to streamline safeguards and improve the system's overall cost-effectiveness.

The IAEA has determined that the detection of undeclared nuclear activities and the creation of confidence in the continuing peaceful use of declared material and facilities is largely dependent on more information being made available to the Agency and on the capability of the Agency to make more effective use of this additional information, as well as existing information.

The IAEA expects to obtain through expanded reporting and its own collection measures a much greater volume of information than it is currently required to manage. Furthermore, the information being obtained is fundamentally different in several respects from that it has experience dealing with under conventional safeguards. The vastly increased amount of data that the Agency must deal with and its essentially qualitative nature and other characteristics demand new and innovative information management systems and techniques in order for the Agency to make effective use of the information in meeting its expanded safeguards mission.

5.1 User Needs

IAEA information management user needs are summarized in the paragraphs below and listed by task area in Annex 1.

5.1.1 Iraq Action Team

The Action Team needs to track information about Iraq's nuclear and potentially nuclear-related activities, facilities, exports and imports, declarations, inspection results, environmental monitoring results, and other information bearing on the Agency's monitoring and verification activities in Iraq. The Action Team needs to enter, store, search, and retrieve a very high volume of data of several types. Some of this information should be stored according to its geographic location, so that the data can be associated with a specific location, site, building, or room. For these location-referenced data, items should be displayed on site or building diagrams and on maps of various scale.

It also is necessary to search and retrieve data based on parameters other than location. Text retrieval tools, incorporating keywords, indexed free-text searches, Boolean expressions, etc., could accomplish much of this function. The data sets resulting from such searches should be displayed on the analyst's monitor with forward and backward scanning capabilities. If possible, search terms should be highlighted in the retrieved text, and there should be a capability to annotate and store some or all of the retrieved text in separate working files. The ability to build, maintain, and manipulate relational databases also is desired.

Action Team information management systems should provide the capability to print out selected sets of stored or retrieved data in pre-defined and customized formats, including color printouts of maps, photographs, and other color graphics.

For both geo-referenced and textual data, users want the capability to navigate or browse through the system in a hierarchical, "drill down" fashion, with general information leading to more detailed information. With geo-referenced data, for example, users should be able to zoom in on selected regions of a map and to move from maps to site diagrams to building layouts where available. Analysts should be able to retrieve and display documents, photographs, and other data linked to specific locations.

The Action Team has a strong preference for an easy-to-use, user-friendly, graphical interface. To the extent possible, they would like to have relatively "seamless" access to all data types from their individual offices and through a common interface.

The Action Team desires the ability to import data from the INSIST Sun workstation into common MS-DOS PC applications (e.g., WordPerfect, Excel, etc.) used in the Team's offices. Furthermore, because, the Action Team does so much of its work in the field, users want the capability to download selected data to notebook computers to use and manipulate in Iraq.

5.1.2 Program 93+2/Task 3: Environmental Monitoring

The longer term needs for support of widespread implementation of environmental monitoring are apt to remain ill-defined until both the Task 3 team has evaluated the results of field trials and various options, and Member States have agreed to accept specific environmental monitoring measures. In addition, some needs may be better met through other support programs; implementations or tools that require specialized knowledge, such as some of the physical transport codes, may fall in this category. The primary information to be tracked is structured information on samples. Samples will be of water, sediment, and biota.

For the short-term, the Task 3 Team will need to be able to retrieve information about its field trials; since trials are already under way, this is a time-urgent need. In the long-term, inspectors or analysts will want to be able to pull up historical records of samples taken and their results. However, since the nature of the records will presumably be defined as the Task 3 Team performs its assessment, these needs are less time-urgent.

Data should be geo-referenced. The desire here is to be able to retrieve information based on its geographic location. Geo-referencing is very important for the environmental data in part because of the types of modeling and analysis that the IAEA will want to perform on this data. This is a time-urgent need for the 93+2 Task Team. The IAEA has requested that the U.S. arrange for IAEA personnel to visit the U.S. to meet with users of geo-referenced systems dealing with environmental data in order to gain a better appreciation for capabilities and needs.

No requirements were explicitly stated for retrieval tools. It was clear, however, that any such tools should be easy to use because the end-users may not have much experience with computers. Effective data presentation and visualization are necessary to enable users to employ analytical tools effectively. The desire here is for flexible tools that allow the user to display or visualize information in a variety of ways.

5.1.3 Program 93+2/Task 5: Systematic Analysis

The objective of systematic analysis is to maintain comprehensive knowledge of nuclear and nuclear-related activities, and safeguards and non-proliferation situations in each state. Through such comprehensive knowledge, systematic analysis is intended to contribute to early detection of activities that appear inconsistent with a state's non-proliferation and safeguards obligations, and to contribute to safeguards planning. It appears likely that the overall systematic analysis process will be a distributed one, involving collaboration among various groups.

As new data is gathered and evaluated, analysts seek to continuously develop and maintain a comprehensive picture of each state's nuclear and nuclear-related activities, asking themselves how the new information squares with other facts and suppositions. In some cases, they will be looking for possible inconsistencies with a state's safeguards and nonproliferation undertakings, inconsistencies that could signal the existence of undeclared activities or other violations. In other cases, they will be looking to clarify or refine suspicions that already have been developed as a result of previously detected inconsistencies. Users in the Safeguards Department have expressed an interest in data manipulation, modeling, and analysis tools to assist in the interpretation and assessment of information.

5.1.4 Conventional Safeguards

To the extent that proposed ideas about expanded declarations are accepted and implemented, the Safeguards Effectiveness Evaluation Section (SEE) may need to take into consideration a large body of newly available information about declared facilities. As regards undeclared activities, there are changes underway in how safeguards effectiveness evaluation will be performed. The SIR will be expected to comment on the possibility of undeclared activities. The results of systematic analysis will be needed by SEE for such an expanded SIR. SEE also may require specialized modeling and evaluation tools unique to the expanded SIR that are not specifically required for systematic analysis alone. Other areas that SIMS may be able to impact include: design information examination/verification, transit matching, and viewing information at the State level, rather than facility level.

5.2 Priorities for SIMS Development Efforts

The priorities described below are based upon the authors' perception of impact on the Agency's safeguards mission and time urgency. The highest priorities are listed first.

5.2.1 Enhance INSIST Capabilities

The Action Team's requirements are immediate, not a year or more down the road as with some aspects of the Safeguards Department's Systematic Analysis. The high volume of data already exceeds the ability of Action Team analysts to efficiently manage. Furthermore, the recent turnover of personnel carries the potential for loss of "corporate" memory. Newer Team members are concerned that vital information could be sitting in some obscure file drawer without their knowing it; they see great benefit in having reliable, automated access to information. But data cannot be retrieved electronically until it exists in electronic form, and data entry also represents a near-term priority problem for the Action Team. In the near-term, SIMS Action Team support efforts should include:

- assistance in scanning hardcopy data into electronic form;
- providing the ability to filter and categorize documents;
- adding a text retrieval capability to INSIST;
- adding a gazetteer capability to INSIST;
- developing and integrating new databases;
- modifying the INSIST user interface to better meet user needs and abilities;
- developing a capability to take information to the field on notebook computers; and
- networking Action Team desktop PCs with each other and with the INSIST workstation.

In the near-term, most of Action Team's requirements for data manipulation, modeling, and analysis are not as urgent as the requirements simply for entering, storing, searching, and retrieving information. Furthermore, the more ambitious of the modeling and analysis goals still require more R&D to identify what methods and algorithms are effective and appropriate. To the extent that further near-term efforts are possible under SIMS, priority probably should be given to (1) a system for analysis of export/import information, (2) the capability to view data from multiple frames of reference, (3) environmental data analysis tools (also driven by Program 93+2 needs) and (4) such data manipulation or technical reference tools that can be clearly described, proof-tested, and implemented now, without the need for significant additional R&D.

5.2.2 Provide for Near-Term Environmental Monitoring Information Management Needs

The 93+2, Task 3 team is already engaged in field trials, so there is a time-urgent need for information management support for analysis of data from the trials. Two timescales must be supported: (1) the short-term needs generated from field trials, and (2) the long-term information management support needed for any environmental monitoring actually implemented as part of enhanced safeguards. The user group for the short-term is the 93+2 Task 3 Team. The primary user groups for the long-term needs will be inspectors collecting information in the field and inspectors or analysts analyzing the results of the samples. Priority in FY 94 should be given to supporting the 93+2/Task 3 team information management requirements by providing a suitable workstation with adequate data storage and retrieval capabilities for environmental monitoring data.

5.2.3 Further Explore Opportunities for Supporting Systematic Analysis Information Management Needs

For the near-term, the primary concern of the 93+2, Task 5 team seems to be dealing with the daunting volume of data available to it. SIMS efforts in support of Task 5 should include:

- guidance on how to analyze open source information;
- assistance in determining how to streamline the categorization of documents;
- computer-assisted means of evaluating the contents of documents; and
- a means of automating the annotation of documents to preserve human efforts at document analysis.

Certain analytically complex modeling and analysis tools desired for systematic analysis do not yet exist, and the necessary methodologies and algorithms are yet to be developed and tested. An ongoing program of research on analytical methodologies for systematic analysis appears necessary. This effort should be coordinated with efforts supporting the Action Team, as needs are, in many respects, similar. In the meantime, DOE/AN should seek to discourage the Agency from installing additional INSIST-like platforms in operations divisions, since the requirement for such capability is unclear. Rather, PC-based tools designed to support well-defined analysis tasks appear a more cost-effective early technology enhancement path.

5.2.4 Develop Prototype In-Field Information Management Tools

The Safeguards Department is currently enhancing its in-field information management capabilities with its In-Field Support System and the Briefcase Inspection System. Both of these initiatives support accountancy-related inspection activities and deal with largely quantitative data. SIMS should seek to support and/or complement these initiatives. In-field IM support for the Action Team and 93+2, Task 3 is desirable, but not time-urgent.

5.2.5 Support SEE IM Needs

The Safeguards Implementation Report (SIR) will be expected to comment on the possibility of undeclared activities. The results of Systematic Analysis will be needed by SEE for such an expanded SIR. SEE also may require specialized modeling and evaluation tools unique to the expanded SIR that are not specifically required for systematic analysis alone. In the future, the SIR will need to contain conclusions regarding the possibility of undeclared activities. The evaluation necessary to draw such conclusions is not seen as quantifiable and developing a procedure to reach such a conclusion for the SIR is of great concern. This is a time-urgent need, but it is not clear how SIMS should proceed to support it. Furthermore, this is an area that POTAS has been considering for initiation of an SP-I and Member State support. Therefore, DOE/AN should coordinate any proposed SIMS initiatives with ISPO.

5.3 Important Considerations

Organizational Issues; Division of Responsibilities. The Agency has not yet determined how responsibilities for systematic analysis will be assigned with the Department of Safeguards. This determination will impact system design objectives for SIMS products.

Security. Security of the information must be maintained, and access should be restricted to designated staff on a need-to-know basis. SIMS design must make provision for IAEA security concerns.

User Limitations. Information management systems provided through SIMS should be designed with consistent, user-friendly interfaces. On-line help should be provided as an option for less-experienced users. The SIMS Technology and Systems Group should develop a Human-Computer Interface (HCI) specification towards this end.

Support. It is essential that any hardware or software systems provided by SIMS be backed up by adequate documentation, ongoing post-delivery support and maintenance until such time as handoff to IAEA support organizations is feasible. This support should include training IAEA staff for system support/database administration.

Compatibility with Existing Systems. Compatibility with the current IAEA computer environment is highly desirable. Development of a System Requirements specification by the Technology and Systems Group would assist in the design of future SIMS products.

Annexes

1. Requirements Summary

2. Basic Concepts of IAEA Nuclear Material Accounting

3. Board Papers

   (a) IAEA Board of Governors Paper, GOV/2698, Strengthening the Effectiveness and Improving the Efficiency of the Safeguards Systems: Report by the Director General on the Secretariat's programme for assessment, development and testing of SAGSI's recommendations on the implementation of safeguards, November 3, 1993; and

   (b) Briefing Notes for Missions - Strengthening the Effectiveness and Improving the Efficiency of the Safeguards Systems: Additional Details on the Report by the Director General on the Secretariat's programme for assessment, development and testing of SAGSI's recommendations on the implementation of safeguards, November 15, 1993.

   (c) IAEA Board of Governors Paper, GOV/INF/737, The Secretariat's Development Programme for a Strengthened and More Cost-Effective Safeguards System: A progress report by the Director General, May 12, 1994.

4. Country Officer Responsibilities, 1993-02-05.

5. SGCP Country Information System (SCIS) Users Guide, 1993-11-19.

6. Consultants Group Meeting on Environmental Monitoring and Special Analysis Methods for Safeguards, Final Report, IAEA, Vienna, 30 March - 2 April 1993.

Annex 1

Requirements Summary

REQUIREMENTS SUMMARY

Task Area	Capability Required	Impact	Urgency
Action Team Activities	Enter high volume of data of various types (streamline translation of data into electronic form)	High	Immediate
Action Team Activities	Store/retreive data according to its geographic location - inventories - design information/drawings - seals information - inspection results - images/graphics - video/stills - sites and facilities - layouts of piping - equipment photos	High	Immediate
Action Team Activities	Store/retrieve text, including open-source information		
	- provide flexible retrival tools	High	Immediate
	- associate text with locations/facilities	Medium	1/2-1 yr.
	- provide context-sensitive search	Medium	>1 yr.
Action Team Activities	Store/retrieve data on nuclear activities - suppliers,i.e., countries, firms, intermediaries - Iraqi nuclear progammatic activities - accounting data - export/import reports - Iraqi reports and declarations - information from UNSCOM and 3rd parties	High	Immediate
Action Team Activities	Store/retrieve data related to environmental monitoring/sample taking (see Environmental Monitoring task area)	High	Immediate
Action Team Activities	Import data from INSIST to PC/MS-DOS	High	Immediate
Action Team Activities	Computer-assisted analysis of data		
	- export/import reports	Medium	>1 yr.
	- view data from different frames of ref.	High	Immediate
	- modelling of process flows, pathways	Medium	>1 yr.
	- analyze environmental monitoring data (see Environmental Monitoring task area)	Medium	>1 yr.
	- correlation analysis between different data cat.	Medium	1/2-1 yr.
	- perform change detection on images	Medium	>1 yr.
	- provide technical ref. tools/databases	Medium	>1 yr.
Action Team Field Support	Lightweight, small volume, portable PC (see field support for conventional safeguards)	Medium	1/2-1 yr.

Task Area	Capability Required	Impact	Urgency
Environmental Monitoring	Store/retrieve data related to sample taking - sample type - location - coordinates - measurement points - date/time of sample taking - sample data - where sample is being analyzed - status of analysis - results of analysis	High	Immediate
Environmental Monitoring	Access/store/retrieve supplemental data for sample analysis - meteorological data - land contours - maps	High	Immediate
Environmental Monitoring	Geo-reference data	High	Immediate
Environmental Monitoring	Compute distance between two given points (i.e., a sample point and a reference point)	Medium	1/2-1 yr.
Environmental Monitoring	Provide flexible tools for standard mathematical and statistical analyses	Medium	1/2-1 yr.
Environmental Monitoring	Track strategically located samples over time	High	1/2-1 yr.
Environmental Monitoring	Provide physical transport modeling tools	High	1/2-1 yr.
Environmental Monitoring	Model operations of different facility types	Medium	> 1 yr.
Environmental Monitoring	Decision support to guide sample analysis	Medium	> 1 yr.
Environmental Monitoring	Suggest locations for environmental monitoring	Medium	> 1 yr.
Environmental Monitoring	Help develop sampling plans	Medium	> 1yr.
Environmental Monitoring	Provide data presentation/visualization tools (standard types of graphs and charts, plus map overlays)	Medium	1/2-1 yr.
Environmental Monitoring	Provide in-field support for sample taking and logging - previous sample locations - sample type - location (e.g., near what site, city, ...) - coordinates - measurement points - date/time of sample taking	Medium	> 1yr.
Environmental Monitoring	Provide in-field visualization tools	Low	> 1 yr.
Environmental Monitoring	Provide the ability to exchange data between Agency computers (workstation or desktop computer) and laptops to take to the field	Medium	1/2-1 yr.
Environmental Monitoring	Provide the ability to input data from field instruments to a laptop computer, e.g.: - portable analysis instruments - bar code readers (lower urgency) - weather instruments - GPS receivers	Medium	> 1yr.

Task Area	Capability Required	Impact	Urgency
Systematic Analysis	Store/retrieve text, including open-source information		
	- provide flexible retrival tools	High	Immediate
	- provide context-sensitive search	Medium	> 1yr.
	- associate text with locations/facilities	Medium	1/2-1 yr.
Systematic Analysis	Store/retrieve other data	High	Immediate
	- suppliers,i.e., countries, firms, intermediaries		
	- States' nuclear progammatic activities		
	- accounting data		
	- export/import reports		
	- States' reports and declarations		
Systematic Analysis	Store/retrieve data related to environmental monitoring/sample taking (see Environmental Monitoring task area)	Medium	1/2-1 yr.
Systematic Analysis	Store/retreive data according to its location (geographic or relative location within site, facility, or building)	Medium	1/2-1 yr.
	- inventories		
	- design information/drawings		
	- seals information		
	- inspection results		
	- images/graphics such as maps		
	- video/stills		
	- sites and facilities		
	- layouts of piping		
	- equipment photos		
Systematic Analysis	Computer-assisted analysis of data		
	- export/import reports	Medium	> 1yr.
	- view data from different frames of ref.	High	Immediate
	- analyze environmental monitoring data (see Environmental Monitoring task area)	Medium	> 1yr.
	- modelling of process flows, pathways	Medium	> 1yr.
	- correlation analysis between different data cat.	Medium	1/2-1 yr.
	- perform change detection on images	Medium	>1 yr.
	- provide technical ref. tools/databases	Medium	>1 yr.
Training	Move training materials to multimedia environment	Low	>1 yr.
	- hypertext		
	- run-time video		
	- interactive audio		
	- CD-ROM		
	- Video disk		
Training	Training for new systems must address users and those providing support/maintenance	Medium	1/2-1 yr.
Training	User-friendly interface	High	1/2-1 yr.

Task Area	Capability Required	Impact	Urgency
Conventional Safeguards	Store/retrieve new safeguards information (or improve methods for certain types of current safeguards information) - expanded declarations - facility design information (includes maps and plans) - location and type of surveillance equipment - facility specific provisions of the safeguards agreement - location and identities of tags and seals	Medium	> 1yr.
Conventional Safeguards	Improve examination and verification of design information (electronic storage and retrieval)	Medium	1/2-1 yr or >1
Conventional Safeguards	Upgrade ISIS	Low	> 1 yr.
Conventional Safeguards	Accept systematic analysis results as input to SIR	High	1/2-1 yr.
Conventional Safeguards	Specialized modeling and analysis tools for SEE	Medium	> 1 yr.
Conventional Safeguards	Summarize and check consistency of data at multiple levels (MBA, facility, country, region)	Medium	1/2-1 yr.
Conventional Safeguards	Security (read-only db access, password control)	High	ongoing
Conventional Safeguards Field Support (CSFS)	Lightweight, small volume, portable PC	Medium	> 1 yr.
CSFS	Store/retrieve (coordinated with BIS and IFSS) - inventory information - design information/drawings - seals information - record inspection results - images/graphics such as maps, pictures of POCs - video/stills of hot areas - facility information - safeguards criteria - diagrams of material flow process w/ components and technical parameters - layouts of piping - equipment photos - containment/surveillancc equipment lists with service dates	Medium	1/2-1yr. (partial) > 1 yr. (rest of items)
CSFS	Tailor information to site visited	Medium	> 1 yr.
CSFS	Tools to optimize utilization of manpower and time	Low	> 1yr.
CSFS	Decision support for inspection procedure - sampling plans - which parts of facility to visit	Medium	> 1 yr.
CSFS	Model/review containment and surveillance measures	Low	> 1 yr.
CSFS	Model material flow	Medium	> 1 yr.
CSFS	Model diversion scenarios	Medium	> 1 yr.
CSFS	Show history of equipment layouts	Medium	> 1 yr.

Annex 2

Basic Concepts of IAEA Nuclear Material Accounting

BASIC CONCEPTS OF

IAEA

NUCLEAR MATERIAL ACCOUNTING

BASIC CONCEPTS OF IAEA NUCLEAR MATERIAL ACCOUNTING

Overview

Nuclear material accounting within the framework of IAEA safeguards begins with the associated activities which are undertaken by or on behalf of facility operators in response to requirements set by the State System for the Accounting for and control of nuclear material. Safeguards agreements based on INFCIRC/153 provide for reporting to the IAEA nuclear material accounting information concerning inventory changes, physical inventories and material balances. Based on this information, the keeping and evaluating of the nuclear material accounts at the IAEA is one of the methods providing the basis for the identification of situations which may indicate a loss or diversion of nuclear material.

Session Objectives

After the session, the participants will be able to:

- Define IAEA nuclear material accounting,
- Explain the legal basis for nuclear material accounting reports,
- Identify the activities associated with nuclear material accounting,
- Explain the basic components of IAEA nuclear material accounting,
- Recognize the basic facility MBA and KMP structures,
- Determine the reporting requirements based on the facility MBA and KMP structure,
- Identify the types of nuclear material accounting reports,
- Apply the concept of the material balance period evaluation.

BASIC CONCEPTS OF IAEA NUCLEAR MATERIAL ACCOUNTING

O U T L I N E

1. INTRODUCTION
    - 1.1 Definition
    - 1.2 Legal Basis
2. ACCOUNTING CONCEPTS
3. ACCOUNTING DATA
    - 3.1 Types of Data
    - 3.2 Application of Reports
4. PROCESSING OF NPT DATA
    - 4.1 The IAEA Safeguards Information System
    - 4.2 Flow of Accounting Data

1. INTRODUCTION

This paper describes nuclear material accounting from the standpoint of IAEA Safeguards and how this accounting is applied by the IAEA. The basic concepts of nuclear material accounting are defined, and how these apply to NPT accounting is presented.

The supporting documents to be used as references include "The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons", INFCIRC/153, June 1972; the model Subsidiary Arrangements; the model Facility Attachments; the IAEA Safeguards Glossary, and the Guidelines for States Systems for Accountability and Control of nuclear material (SSAC).

1.1 Definition

Nuclear material accounting is defined as "the activities carried out to establish the quantities of nuclear material present within defined environments and the changes in those quantities taking place within defined periods of times."

Nuclear material accountancy within the framework of IAEA safeguards begins with the associated activities which are undertaken by or on behalf of facility operators in response to requirements set by the State system for the accounting for and control of nuclear material (SSAC), arising from obligations defined in agreements between the IAEA and the State. The activities and the corresponding accounting information generated are verified through independent IAEA inspections which can be described as follows:

- Independently verifying nuclear material quantities and locations, using inspection methods such as examination of accounting records and comparison with accounting reports,

- Item counting and identification,

- Independent measurements,

- Verifying the operation and calibration of instruments and other measurement and control equipment,

- Verifying information on possible causes of material unaccounted for (MUF), shipper/receiver differences and uncertainties in the book inventory,

- Carrying out other activities as provided for in the safeguards agreement.

Activities involved in nuclear material accounting occur at various stages:

- Dividing nuclear material operations into material balance areas (MBAs),
- Maintaining records describing the quantities of nuclear material held within each MBA,
- Measuring and recording all transactions involving the transfer of nuclear material (international or domestic) from one MBA to another or other changes in the amount of nuclear material present such as nuclear production, nuclear loss, measured discards, transfers to waste,
- Periodically determining the quantities of nuclear material present within each MBA through the taking of physical inventories,
- Closing the material balance for the time period between two successive physical inventory takings and computing the MUF for the period,
- Providing for a measurement control programme to determine the accuracy of measurements and calibrations and the correctness of recorded source and batch data,
- Testing the computed MUF against its limits of error for indication of undetected loss,
- Analysing the accounting data to determine the cause and magnitude of mistakes in recording, unmeasured losses, accidental losses and unmeasured inventory (e.g. holdup),
- Preparing and submitting accounting reports to the IAEA,
- Ensuring that the accounting procedures and arrangements are correctly followed,

Once the accounting information arrives at the Agency, the Data Processing Services Section in the Division of Safeguards Information Treatment is responsible for storing and processing the data. The Inspectorate Divisions and the Section for Effectiveness Evaluation are responsible for the verification and analysis of the data.

NPT accounting records received by the IAEA are used in the evaluation of nuclear material accounts in a given area for a certain duration of time. For this given area, a beginning measurement is made. After a length of time, an ending measurement is made. Based on these measurements and a record of the material entering, leaving, transformed or consumed in the area, the amount of material remaining in the area can be calculated.

1.2 Legal Basis

The legal basis for the collection of this data is through the ratification of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), which was opened for signature in 1968 and entered into force in 1970.

Under the terms of the Treaty, States are required to negotiate a safeguards agreement with the IAEA. The guidelines for such agreements are established in Agency document INFCIRC/153. After a safeguards agreement based on INFCIRC/153 agreed, Subsidiary Arrangements are prepared which define procedures for implementing the requirements specified in the Safeguards Agreement. The Subsidiary Arrangements are divided into 10 parts, of which the last document is referred to as Code 10. Code 10 defines the format and data elements to be reported to the Agency, along with the codes to facilitate the processing of the data in an information system.

Whereas the Safeguards Agreement and Subsidiary Arrangements apply to an entire State, the Facility Attachment is used to define certain site-specific details. There is a set of model Facility Attachments, one for each type facility such as light water reactors, conversion plants, etc.

Figure 1 shows the structure of the legal basis for NPT nuclear material accounting.

2. ACCOUNTING CONCEPTS

In order to account for amounts of material in a given area, certain definitions need to be made. These definitions form the environment under which NPT accounting is implemented. An understanding of the following concepts is necessary with respect to NPT nuclear material accounting.

Facility

A reactor, critical facility, conversion plant, fabrication plant, reprocessing plant, isotope separation plant, separate storage installation or any location where more than one effective kilogram of material is used.

Material Balance Area (MBA)

An area in or outside a facility such that the quantity of material transferred into and out of the area can be determined and that the physical inventory of material within the area can be determined.

Key Measurement Point (KMP)

A location within an MBA where nuclear material appears in such a form that it can be measured to determine material flow or inventory. Generally, flow KMP codes are represented with numbers and inventory KMP codes are represented with letters.

Material Balance Period

The material balance period (MBP) is the period of time between two consecutive inventory takings. An MBP is the unit of time during which the nuclear material balance is established for an MBA.

Book Inventory

Within an MBA, the book inventory is the algebraic sum of the most recent physical inventory and all inventory changes since the most previous inventory taking. Material flows into and out of the MBA via a KMP. As this flow takes place and as inventories of material in the MBA are made, records are kept of these events. Based on these records, book inventories can be calculated and inspections carried out to verify the records reported.

The book inventory as of a given date can be represented by the expression:

book inventory = previous physical inventory
+ increases
- decreases.

Physical Inventory

The physical inventory is the sum of all the measured or derived estimates of batch quantities of nuclear material present at a given time within a material balance area, obtained in accordance with specified procedures.

The concept of nuclear materials accountancy is contained in the material balance equation, or simply the MUF equation. This equation compares the quantities of nuclear material which should be present as reflected in accounting records (book inventory) with those quantities which are present, as determined by actual physical inventory taking. The difference, the material unaccounted for (MUF), is not in itself an indication that diversion has occurred, but does constitute an estimate of the quantity which might have been available for diversion. The statement "might have been" is emphasized, because other factors can also lead to the observation of a non-zero material unaccounted for.

The notation for the difference between book inventory and physical inventory (MUF) is:

$$MUF = PB + X - Y - PE$$

where,

PB = beginning physical inventory for the material balance period.

X = sum of increases to inventory (receipts, nuclear production, de-exemption, etc.).

Y = sum of decreases from inventory (shipments, nuclear loss due to radioactive decay or burn-up, exemptions, measured discard, accidental loss, etc.).

PE = ending physical inventory for the period.

Batch

A portion of nuclear material handled as a unit for accounting purposes at a KMP and for which the composition and quantity are defined by a single set of specifications or measurements. Examples of a batch include one fuel assembly, one UF_6 cylinder etc.

Facility MBA Structures

Two basic principles that may be used to define the MBA structure of a facility are the use of a single MBA or the use of multiple MBAs. The MBA structure for a facility is specified in the associated facility Attachment. Figures 2 and 3 show the basic diagram and flow of material for a typical facility containing a single MBA and a for a facility containing more than one MBA, respectively. It should be emphasized that these structures are basic and that the actual MBA structure for a facility is specified in the facility attachment.

The single MBA structure, shown for a light water reactor (LWR), has the advantage of reducing the number of Inventory Change Reports (ICRs) required to report the flow of material within the facility. Additional ICRs are required in a multiple MBA structure since movement of material is reported upon the transfer of nuclear material into or out of an MBA.

Depending on the type of facility, a single or multiple MBA structure will be used. It should be remembered that this is a very basic presentation, and that in some cases the MBA and KMP structure is more complex.

3. ACCOUNTING DATA

3.1 Types of Data

Nuclear material accounting information is provided to the Agency by means of the following reports:

- PIL - Physical Inventory Listing
- ICR - Inventory Change Report
- MBR - Material Balance Report

The PIL is a listing of all batches of material separately and specifies material description or identification and batch data for each batch. This detailed listing of material in an MBA is prepared based on a Physical Inventory Taking (PIT). The PIL is attached to an MBR.

An ICR is a report of changes in the inventory of nuclear material. If a batch has been transferred from one MBA to another, an ICR is required to report this event. In addition to material transfer, any change in inventory must be reported as required in the facility attachment and includes, for example, plutonium production upon discharge of fuel from a power reactor.

The MBR is a summary of the associated PIL and all ICR data reported since the previous PIL. It is a report of the total amounts of material within an MBA rather than of individual items or batches. The MBR shows the total inventory of the different types of nuclear material, the total ICR activity since the previous PIL, any inventory adjustments, such as roundings, and MUF.

In addition to the accounting reports mentioned above, Concise Notes are provided which are explanatory texts, records or information that are supplied to the Agency detailing facts about a facility or giving additional information to explain details about accounting data that has been reported.

There is also a promptness aspect involved with reporting to the IAEA. A PIL should be submitted with each MBR, and they should be dispatched to the Agency within 30 days after an inventory is taken. Inventory changes must be dispatched to the Agency within 30 days after the end of the month in which the change takes place. Information on the timing of these reports is specified in the appropriate Agreement or Subsidiary Arrangements.

Additional reporting requirements may be established in the associated Facility Attachment.

3.2 Application of Reports

The consistency of reporting with respect to nuclear material accountancy is established by evaluating the material balance period (MBP). The material balance period is a fixed time interval where the Member State completes a physical inventory taking (PIT) at the beginning of a period and completes another PIT at the end of the period. In the time period between these two PITs, ICRs are submitted which report changes to the inventory during this time. The Member States are obliged to report a PIL and an MBR for each PIT. An MBR is not required with the initial reporting of an inventory.

By applying the information reported in the PILs, ICRs and MBRs, a determination can be made as to whether the material balance period is "open" or "closed". This is an indication of the accountancy status of an MBA.

A "closed" material balance period is one where the information in the MBR agrees with what the State has reported in the corresponding PIL and ICR data.

The following conditions for each type of material constitute a "closed" MBP:

- The physical ending (PE) of the previous period equals the physical beginning (PB) of the current period.
- The sum of each material for each element code in the PIL equals the corresponding MBR physical ending for the PIT.
- The sum of the ICR activity for each element and inventory change equals that summarized in the MBR.
- When shipper-receiver differences (DI) are reported, the book adjusted (BA) = book ending (BE) minus shipper-receiver difference (DI).

- Book adjusted (BA) minus physical ending (PE) = material unaccounted for (MF).

When any one of the above conditions are not met, the MBP is considered to be "open".

When a material balance period is open, action must be taken to determine the reasons for the open condition and to resolve the problem. In most cases, the lack of reporting rounding adjustments or errors in reporting are the cause for an open MBP.

Figure 4 shows the application of PIL, ICR and MBR data in the evaluation of a material balance period (MBP). This example is for a light water reactor. The reports correspond to the events occuring from the PIT at time (t) to the PIT at time (t + 1). The LWR single MBA structure for a facility is used in this example.

Table 1 contains a very simplified summary of activities for the material balance period shown in figure 4. The amounts indicate the principle of how PIL, ICR and MBR data are related.

The beginning inventory shows 1000 grams of fuel (enriched uranium) in the core (KMP B), 900 grams of fuel in the cooling pond (KMP C) and 10 grams of plutonium contained in the 900 grams of discharged fuel (both in batch 2). The MBR shows the beginning inventory summary for the facility. Inventory figures from the previous MBR are not shown in this example.

The changes that occur during the time period include the receipt of 1000 grams of fresh fuel, shown in the flow KMP 1. In addition, the reactor is refuelled with the newly received fuel, and the Facility Attachment in this case calls for a report of nuclear production and loss at the time of discharge. Thus, 100 grams of nuclear loss (burn-up) and 10 grams of plutonium production are reported in KMP 2. The 100 grams of burn-up and 10 grams of plutonium production are shown under the same batch (1).

The ending inventory indicates the current status of the material in the facility. Note that batch 3, the fresh fuel, is now shown in the core (KMP B) having already passed through a storage KMP. The ending MBR reflects the corresponding beginning inventory plus those changes occurring during the period. In the event material had been shipped from the facility, this would have been reflected in an ICR, in the ending MBR and would not be included in the ending PIL for the period.

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2 of 4

4. PROCESSING OF NPT DATA

4.1 The IAEA Safeguards Information System

ISIS is the acronym for the IAEA Safeguards Information System. This computerized data information system is the collection point for NPT accounting data. The files and the software in the system are used to maintain this data for the benefit of the users. The main users are the Inspectorate Division and the Division of Safeguards Information Treatment. In addition, all other Divisions in the Department are users of ISIS. The Member States also receive information from ISIS.

4.2 Flow of Accounting Data

Figure 5 shows an overview of the path that the data follows. This data is received either in hard copy (on paper forms) or in machine readable form (e.g. magnetic media). Most of the data is received at the Agency on magnetic media. The difference in the processing of these forms of input is that the hard copy must first pass through a data entry step to place the information in a machine readable form.

Once the information is available in a machine readable form, the input step places the data into the data base and makes the data available for processing. A quality control computer program is then executed in order to check the data for completeness and accuracy. Examples of these checks are to verify if the MBA code supplied is a valid code or to be sure that a weight field is reported as numeric.

The analysis-edit phase is a manual effort by Agency staff to examine the output from ISIS and to resolve any problems. This may involve the correction of a data entry mistake or may involve contacting the Inspectorate Divisions or a Member State. In any case, all changes made to the data are effected through the edit cycle where new records showing the correct data are provided. In some cases, the Member State is notified of a problem, and the Member State provides the necessary correction to the Agency. In the event that a change in reported data is noted by a State, the State is obligated to provide updated information to the Agency. The Agency information system maintains an audit trail of all corrections made in the data base files.

Output applications are computer programs that access the information stored in ISIS and provide either a printed report or information on magnetic media. An example of the information provided to the Member States is a computer printout of the semi-annual statement of book inventories. This is produced as of the end of June and as of the end of December every year on a recurring basis, and the Agency is required to produce these within 90 days after the end of each period. This printout contains a book inventory of the material in each MBA for each country.

The output information that is provided to the Agency is varied and is distributed at several levels to users, including the Safeguards Information Treatment Division, the Inspectorate Divisions and the Section for Effectiveness Evaluation. Some of this information is also used in the Agency Annual Report and in the Safeguards Implementation Report.

TABLE 1
SUMMARY OF MBP ACTIVITY

	Material	Batch	KMP	Weight	
BEGINNING INVENTORY					
PIL(t)	UE	1	B	1000 g	
	UE	2	C	900 g	
	PU	2	C	10 g	
MBR(t)	UE			1900 g	Ending physical inventory (PE)
	PU			10 g	Ending physical inventory (PE)
CHANGES TO INVENTORY					
ICR	UE	3	1	1000 g	Receipt domestic (RD)
	UE	1	2	100 g	Nuclear loss (NL) (burn-up)
	PU	1	2	10 g	Nuclear production (NP)
ENDING INVENTORY					
PIL(t+1)	UE	1	C	900 g	
	UE	2	C	900 g	
	UE	3	B	1000 g	
	PU	1	C	10 g	
	PU	2	C	10 g	
MBR(t+1)	UE			1900 g	Beginning inventory (PB)
	PU			10 g	Beginning inventory (PB)
	UE			1000 g	Receipt (RD)
	UE			100 g	Nuclear Loss (LN)
	PU			10 g	Nuclear Production (NP)
	UE			2800 g	Adjusted ending book inventory (BA)
	PU			20 g	Adjusted ending book inventory (BA)
	UE			2800 g	Ending physical inventory (PE)
	PU			20 g	Ending physical inventory (PE)

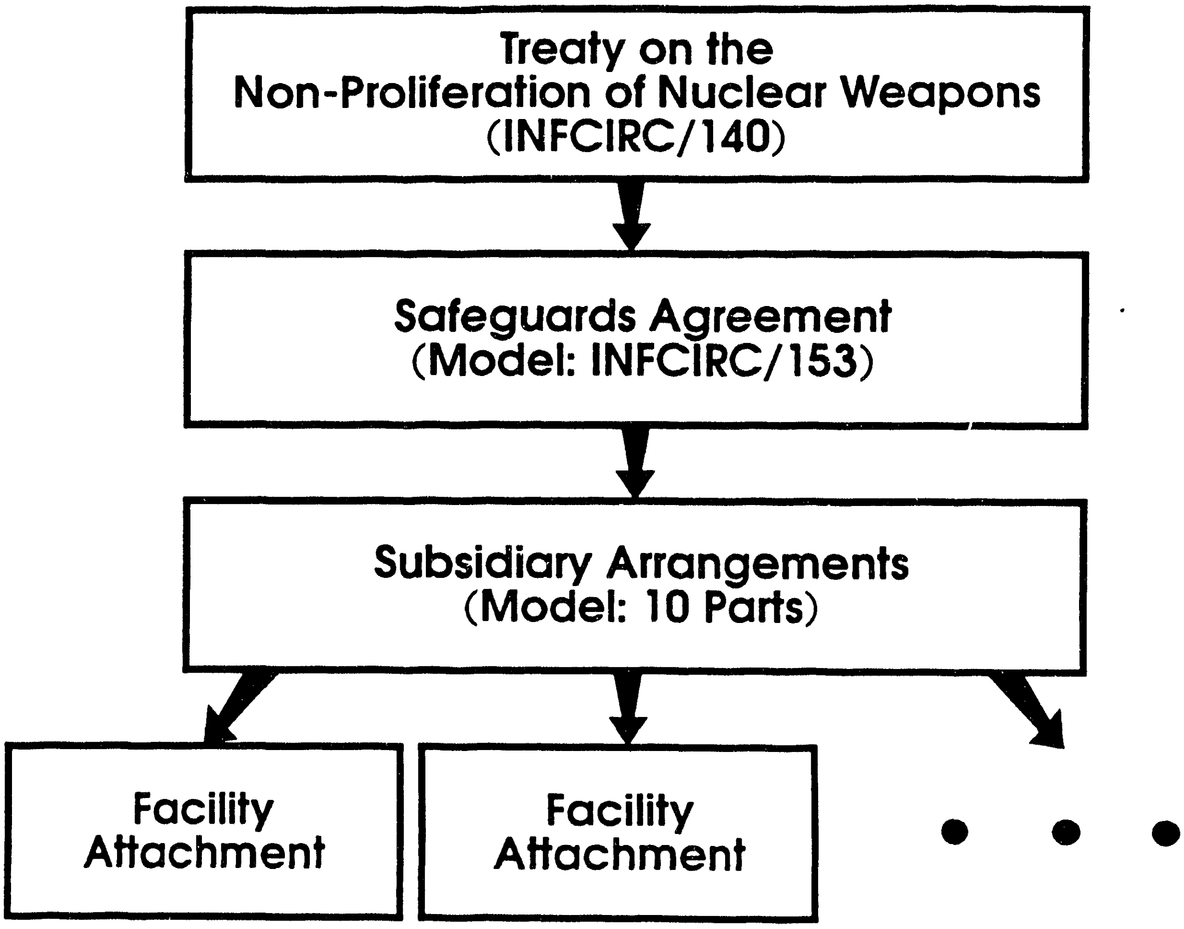

FIGURE 1

LEGAL BASIS FOR NPT
NUCLEAR MATERIAL
ACCOUNTING

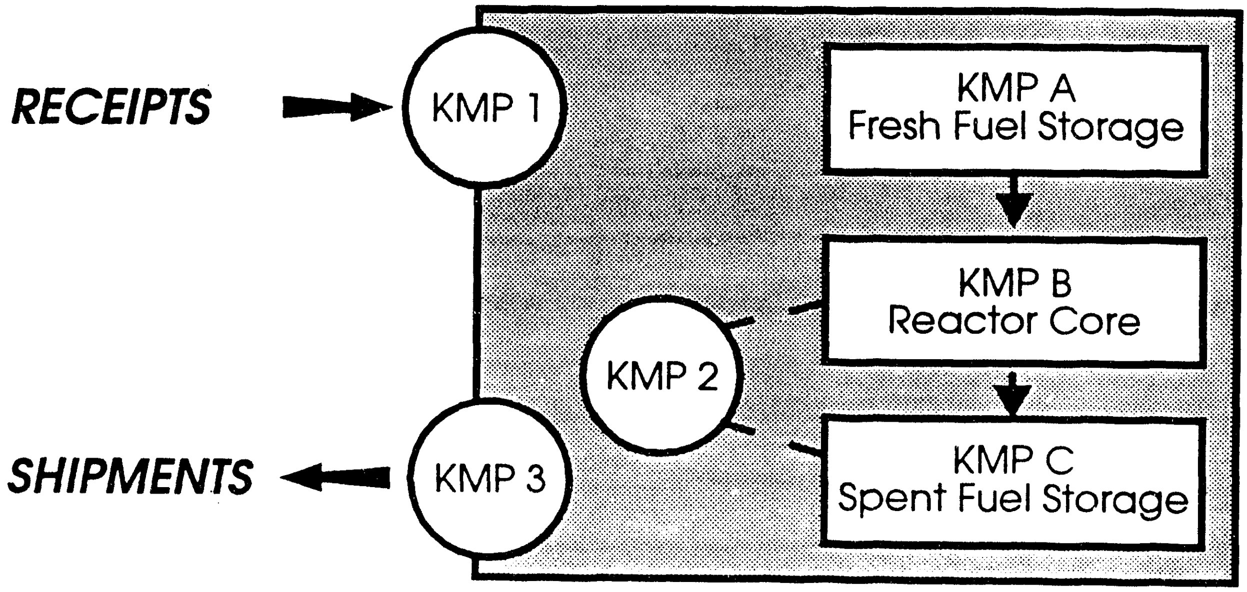

FIGURE 2

SINGLE MBA STRUCTURE

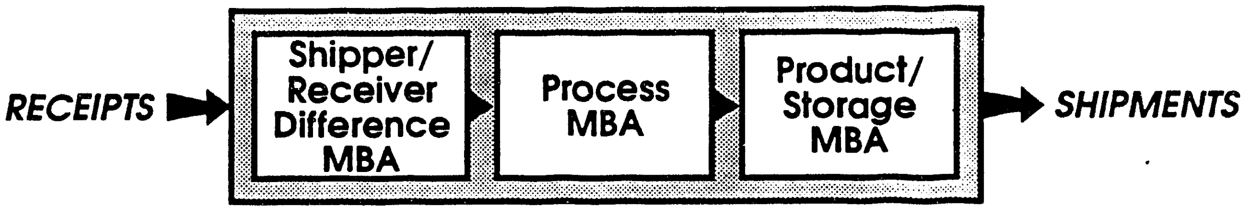

FIGURE 3

MULTIPLE MBA STRUCTURE

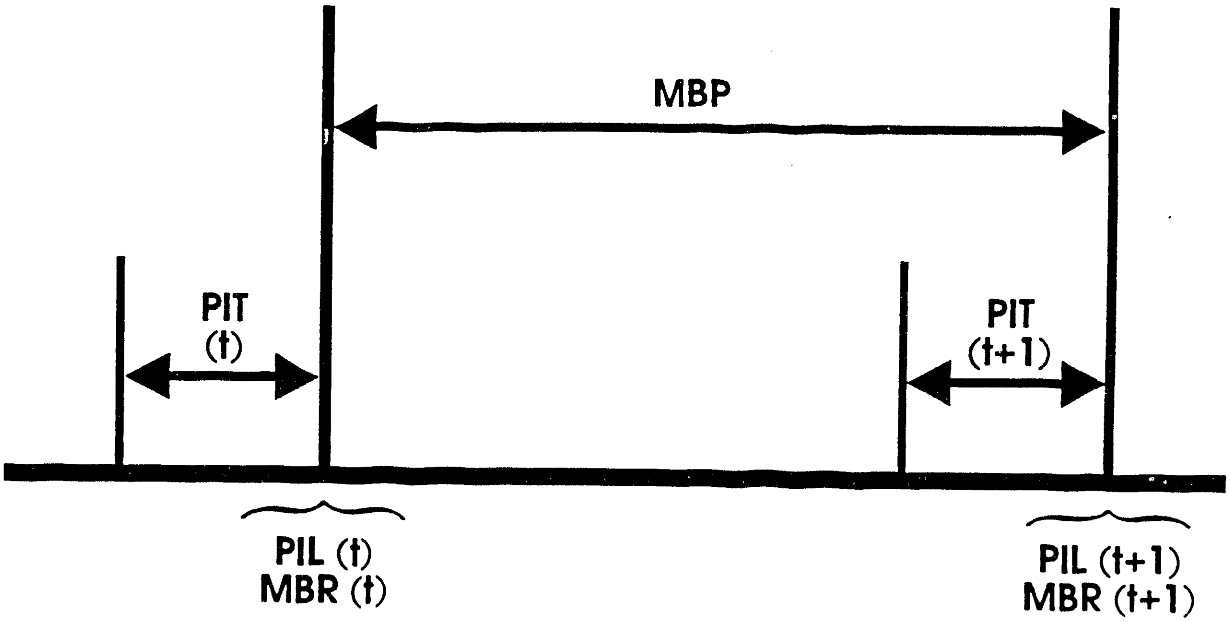

FIGURE 4

MATERIAL BALANCE PERIOD (MBP)

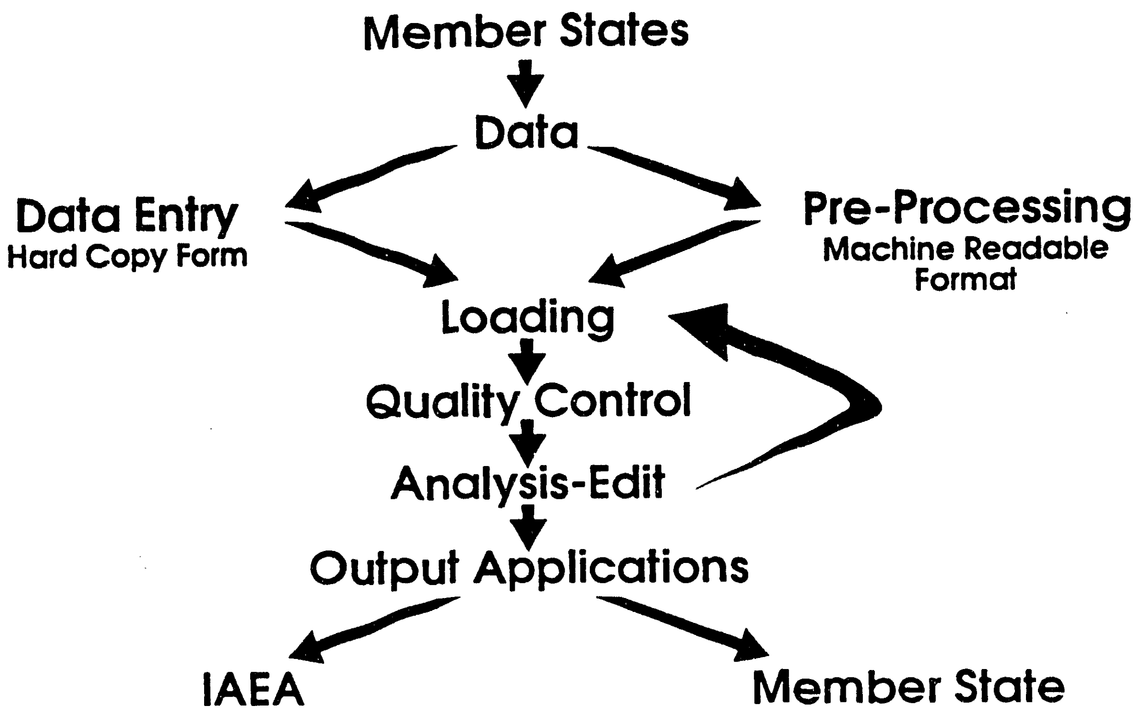

FIGURE 5

FLOW OF NPT
ACCOUNTING DATA

93309-68/WSRR-ARG/OAKBERG/93.03

Annex 3

Board Papers

Annex 3a

IAEA Board of Governors Paper, GOV/2698

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International Atomic Energy Agency

BOARD OF GOVERNORS

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STRENGTHENING THE EFFECTIVENESS AND IMPROVING THE EFFICIENCY OF THE SAFEGUARDS SYSTEM:

Report by the Director General on the Secretariat's programme for assessment, development and testing of SAGSI's recommendations on the implementation of safeguards

Introduction

1. The process of change in the safeguards system has been underway for some time. Statements made at the 1990 NPT Review Conference and the Director General's statement during the February 1991 Board of Governors' meeting spoke of the need for more effective and "cost-efficient" safeguards and identified specific issues which needed to be addressed. During late 1991 and early 1992 the Board made decisions regarding the early provision and use of design information and a voluntary reporting scheme on imports and exports of nuclear material and exports of specified equipment and non-nuclear material. Throughout 1992 the Secretariat carried out technical studies to identify specific areas of safeguards application which might be improved and to identify mechanisms for implementing the Board decisions.

2. In April 1993, the Standing Advisory Group on Safeguards Implementation (SAGSI), acting on a request by the Director General and with the support of the Safeguards Department, reported its recommendations for improving the cost-effectiveness of safeguards to the Director General. The Director General reported to the Board on SAGSI's recommendations in June 1993. The Board requested the Director General to submit to the Board in December 1993 concrete proposals for the assessment, development and testing of measures proposed by SAGSI.

93-04591

Programme of development and testing

3. The Secretariat has initiated a programme to further assess, develop, and test SAGSI's recommendations and other related measures for improving the cost effectiveness of safeguards. The programme provides a basis for the evaluation of SAGSI's recommendations, including their technical, legal, financial and other implications, and ultimately the development of a strengthened and more efficient safeguards system. The legal implications of any proposed measures for strengthening safeguards must await the outcome of the technical and economic evaluations of the various aspects of those measures. Naturally, any strengthening measures that go beyond the scope of the safeguards agreements could only be implemented with agreement of the States concerned. The Secretariat is actively seeking the participation of Member States in the further development of the proposals and in carrying out field trials. Several Member States have already volunteered to assist the Secretariat. Additionally, specific areas have been identified for further clarification by SAGSI and they are currently engaged in that task. The programme is designed such that the Secretariat should be in a position to make proposals for a strengthened and more efficient safeguards system by early 1995.

4. In order to focus the Secretariat's efforts and make optimum use of available resources, a project has been established to carry out the programme. The project has been divided into seven task areas:

- Task 1: Cost analysis of present safeguards implementation
- Task 2: Increased co-operation with State Systems of Accounting and Control
- Task 3: Environmental monitoring techniques for safeguards application
- Task 4: Other measures for improving the cost-effectiveness of safeguards
- Task 5: Improved analysis of information on States' nuclear activities
- Task 6: Enhanced safeguards training
- Task 7: Proposal for strengthening and improving the efficiency of the safeguards system

A short summary of each task is given below.

TASK 1: Cost analysis of present safeguards implementation

5. Task 1 assesses the costs of safeguards implementation as a function of the magnitudes of the various technical safeguards parameters (e.g., timeliness, probabilities of detection, significant quantities). The SAGSI report suggests that if some of the strengthening measures are proven effective, then trade-offs could ultimately be possible between those measures and certain elements of the current safeguards system. For example, SAGSI put forward the proposition that if certain combinations of strengthening measures prove to be effective in providing assurance about the absence of undeclared reprocessing activities, then the implementation of these measures could obviate the need for interim inspections for timeliness purposes, currently required by the safeguards system, at spent fuel storage locations.

6. An important feature in evaluating the merits of any possible trade-off is relative costs. Accordingly, the financial aspects of the strengthening measures will be assessed under other appropriate tasks, as well as their inherent technical merits. However, the specific costs associated with current values of safeguards implementation parameters (e.g., timeliness, probabilities of detection, significant quantities) and the cost sensitivity to changes in the value of those parameters are not sufficiently well known. This cost analysis, drawing upon accumulated experience, is the primary objective of Task 1. Work to date indicates that the cost of implementing safeguards is driven more by the number and kinds of inspections (e.g., interim vs. PIV's) than the activities carried out in any particular inspection.

7. Task 1 also includes the continuing reviews of issues related to strengthening safeguards, such as the starting point of safeguards, safeguards at locations with less than 1 SQ of nuclear material, the Secretariat's verification of design information provided on new, existing, and closed down facilities and exemptions, terminations and suspensions.

TASK 2: Increased co-operation with State Systems of Accounting and Control

8. Task 2 examines the possibilities for increased co-operation with State Systems of Accounting and Control within the current safeguards system. The Secretariat will identify the conditions under which increased co-operation with SSACs could be implemented and define areas where increased co-operation with SSACs may improve cost effectiveness while maintaining the need for the Secretariat to reach its own independent conclusion. One

element of the conditions for increased cooperation will be the effectiveness of the SSAC. The Secretariat has developed a questionnaire for obtaining from SSACs information relevant to effectiveness. Potential areas for increased cooperation already identified on the basis of experience with national and regional systems could include:

(i) greater involvement of the SSAC as foreseen within the existing terms of safeguards agreements, in pre-inspection arrangements and other preparatory activities, such as the provision of material declarations in an automated form and standardized format to increase the efficiency of Agency inspections;

(ii) shared activities and equipment that could incorporate such things as joint research and/or development projects and training programmes, shared laboratory and other measurement equipment, commonly developed and implemented safeguards approaches, sampling plans, calibration and measurement procedures, expanded use of containment and surveillance measures, common evaluation of measurement data and the performance of measurement systems and joint efforts to identify and solve problems; and

(iii) the taking into account by the Secretariat, under defined conditions, of results of SSAC inspection activities with the intent of reducing the extent of Secretariat inspections while maintaining effectiveness and the need for the Secretariat to reach its own independent conclusions.

Task 2 will define the extent of increased cooperation that is possible as a function of the SSAC's effectiveness. Any proposals for significant savings which involve a level of SSAC involvement beyond current safeguards implementation practice will be clearly identified. The proposals must be examined in the context of the strengthening measures to be tested in Task 4. Field trials involving increased cooperation with SSAC's will be incorporated in Task 4 as appropriate. Factors relevant to differentiating between national and regional systems as regards the possibilities for increased cooperation will be examined.

TASK 3: Environmental monitoring techniques for safeguards applications

9. Task 3 evaluates the use of environmental monitoring techniques to enhance the Secretariat's ability to detect undeclared nuclear activities. The further development, assessment and use of environmental monitoring as a strengthening measure was one of

SAGSI's principal recommendations. The programme will involve several field trials and focus on:

(i) evaluating the practicality, effectiveness and cost of the use of environmental monitoring under a variety of conditions;

(ii) establishing and documenting environmental signatures associated with enrichment, reactor, and reprocessing operations at both long and short range;

(iii) establishing and documenting sampling and analytical procedures and quality control requirements; and

(iv) establishing a "clean room" sample handling and screening capability at Seibersdorf, extending the existing network of analytical laboratories to include the capabilities for the analysis of environmental samples and establishing requirements for quality control.

Development work in all these areas is well underway. Advice from consultants (a Consultants Meeting was held on this subject in Vienna, in late March 1993), and experience gained by the Secretariat through environmental sample collections made in several countries, clearly show the value of environmental monitoring where the application is short range (e.g., to provide additional assurance regarding the absence of undeclared activities at a specific site). While the Agency has gained some experience in the use of these techniques for monitoring a country or a region, the effectiveness and cost of their routine use by the Secretariat for such "wide-area" monitoring has yet to be evaluated. The field trials that address this application will be, in effect, calibration exercises where the intent is to define the maximum distances, as a function of sample medium, meteorology, etc., at which signatures of various nuclear operations can be detected.

10. A number of offers of assistance from Member States in the area of environmental monitoring have been received. The sampling for an environmental monitoring field trial around five nuclear facilities in Sweden took place in mid-September. Water sediment and biota samples were collected at 35 locations. This trial will be complete and the results documented by the end of January 1994. Sampling of the Danube River near the Paks power station and in the vicinity of Budapest was carried out under the auspices of the Hungarian

support programme. Video recordings of the sampling operation were made for training purposes. This trial should also be completed by the end of January 1994. Discussions with the Australian, Canadian, Czech, Japanese, United Kingdom, and United States authorities on assistance with the environmental monitoring programme have commenced. Informal discussions with several other interested Member States have also taken place. It is important that facilities of the size and type necessary to fully evaluate these techniques be included in the field trials.

11. It has been determined that it will be necessary to expand the analytical capability available to the Agency in order to facilitate the use of environmental monitoring. This capability will include a "clean-room" facility for environmental sample handling, screening and distribution. Work on the design and siting of this facility has started through an extra-budgetary contribution. An expansion of the existing network of analytical laboratories, to include the capability for routine analysis of environmental samples will also be required and has begun.

TASK 4: Other measures for improving the cost-effectiveness of safeguards

12. Task 4 assesses measures, other than environmental monitoring, intended to strengthen safeguards by providing an increased assurance of the absence of undeclared activities; their contribution to improving cost-effectiveness will also be assessed. The assessment will include the technical and financial implications of the measures. Task 4 will involve several field trials, conducted independently of the routine implementation of safeguards, that will examine a range of measures including:

(i) expanded and more timely declarations (including 'real-time' declaration of nuclear material movements) by States on their nuclear activities;
(ii) extended access and inspection activities at declared facilities as necessary to verify the declarations in (i);
(iii) access to locations outside declared facilities; and
(iv) unpredictability of verification.

Task 4 will develop these and the other ideas addressed by SAGSI to a level where the technical, legal and financial implications can be evaluated in order to identify combinations of the new measures which represent trade offs, beyond those arising from environmental monitoring alone, to some elements of the existing safeguards approach for declared facilities. The evaluation of the proposals will include a comparison with the requirements of the existing safeguards criteria, and a cost-benefit analysis.

13. Items i, ii and iii, and iv, refer, respectively, to SAGSI consideration regarding transparency, openness and unpredictability. The Secretariat is using these terms in the following way. Transparency is a structural element that speaks to the completeness of a State's declaration regarding its overall nuclear programme. This declaration could include all nuclear materials (including ore concentrates), all nuclear related production and processing (including design information beyond that currently provided), training and R&D activities and their locations, regardless of where they are carried out, and a specification regarding the manufacture and export of certain equipment and non-nuclear materials. The information provided will need to be updated periodically with timely reports regarding the production and movement of nuclear materials. Openness refers to the rights of access granted to the Secretariat necessary to verify or confirm the expanded declaration. Unpredictability refers to the extent of advance notice regarding inspection timing, location and range of activities to be carried out. The relationship between unpredictability and Secretariat safeguards conclusions will be assessed. The idea of unpredictability and some elements that could be incorporated in a larger role for the SSAC are not independent and will have to be examined carefully.

14. Tasks 2, 3, 5 (information analysis) and 6 (training) all have elements that directly support the Task 4 field trials. Environmental sampling may be included in Task 4 as part of the verification of a specific activity or activities reported in the expanded declaration.

15. Discussions on field trials of strengthening measures have commenced with Swedish, Canadian and Australian authorities. Field trials in these States will provide a beginning, but additional invitations from Member States are needed to fully evaluate the various measures. It is expected that the major work involved in Task 4, including the necessary field trials, will be well underway by the end of 1994. All field trials associated with the programme will be conducted independently of the routine implementation of safeguards. In addition, SAGSI's alternative methods of safeguarding declared material will be examined in the context of the strengthening measures for the detection of undeclared activities.

TASK 5: Improved analysis of information on States' nuclear activities

16. Task 5 focuses on the analysis of information available to the Secretariat about State's nuclear activities. The objective of the task is to ensure a coherent and comprehensive approach to the acquisition, management and analysis of information from open sources, safeguards inspection data, the reporting scheme on imports and exports of nuclear material and exports of specified equipment and non-nuclear material, and the expanded declarations referred to in Task 4. This should ensure that Secretariat resources are used effectively to identify at an early stage any instance in which the available information about a State's nuclear activities appears to be inconsistent with its declaration to the Secretariat. In this respect, the Secretariat has already established an internal working group to evaluate, on a trial basis, the information, together with the supporting computer data base tools needed to manage the large quantity of data. The areas to be considered within the task include:

(i) the identification of information and of potential information sources;

(ii) the development of criteria and procedures for evaluating the information for confirming a State's declaration or for providing indications of inconsistencies;

(iii) the identification and development of computer hardware and software to assist in carrying out the analysis;

(iv) the determination of the necessary information flow, and organizational responsibilities within the Agency; and

(v) the resources required to acquire and maintain the system.

17. Work has also started, with the considerable co-operation of Member States' support programmes, on a hardware and software system that provides a geographically-referenced data storage and retrieval system for inspection planning purposes. This system will be particularly useful in dealing with the wide range of information expected to be made available to the Secretariat under Task 4. In addition, work has commenced on establishing tele-communication links with SSACs.

TASK 6: Enhanced Safeguards Training

18. Task 6 of the programme is concerned with the identification, development, and implementation of training programmes required to ensure that the staff of the Secretariat have the necessary skills to carry out the new measures to strengthen and improve the cost effectiveness of safeguards and, in general, to deal with expanded safeguards requirements. Completion of the task will ensure that a training base has been established should decisions be made in the future to proceed with routine implementation of some or all of the measures being tested. Training requirements, in addition to the Department's on-going training programme, so far identified include:

(i) the training of SSAC staff on IAEA safeguards;

(ii) the training of IAEA staff who will participate in field trials;

(iii) the training of IAEA staff in design verification; and

(iv) the training of IAEA staff assigned responsibility for systematically analyzing information on States' nuclear activities.

19. A preliminary training needs analysis has been carried out by the Secretariat, and Member States' support programmes have been asked for assistance in developing and conducting training programmes. Positive offers of assistance have been received. Additional support programme assistance will be sought for the development and provision of specific training modules and/or courses, as well as in the provision of training materials, equipment and, as circumstances dictate, facilities in which to conduct training. Additional methods of further improving inspector skills through enhanced training are being explored with Member State support programmes, including training in skills that will generally raise the Department's ability to deal with the issue of undeclared activities, the use of computer-based training, and multi-media techniques of information presentation.

TASK 7: Proposal for strengthening and improving the efficiency of the safeguards system

20. The integration of the results of Tasks 1 to 6 into proposals for more effective and efficient safeguards will be the final part of the programme and will be dealt with in Task 7. The proposals will be assessed for effectiveness, cost and the possible trade-offs among the strengthening measures and certain elements of the current system. The relative merits of the proposals will be fully explored and presented. Task 7 will also incorporate a description of any legal implications of the proposals. Furthermore, new administrative and legal measures will be addressed aimed at facilitating safeguards implementation regarding such issues as designation of inspectors and visa requirements. From this analysis the Secretariat will be in a position to make a detailed proposal to the Board on a strengthened and streamlined system which will cover both the safeguarding of declared material and facilities and the detection of undeclared activities.

Requested Action by the Board

21. The Board is requested to take note of the on-going work in connection with the programme to develop and test measures for the strengthening the effectiveness and improving the cost-efficiency of Agency safeguards. The results of the programme will be reported to the Board periodically.

Annex 3b

Briefing Notes for Missions

Briefing Notes for Missions

15 November 1993

Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System: Additional Details on the Report by the Director General on the Secretariat's Programme for Assessment, Development and Testing of SAGSI's Recommendations on the Implementation of Safeguards

Briefing Notes for Missions

15 November 1993

Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System: Additional Details on the Report by the Director General on the Secretariat's Programme for Assessment, Development and Testing of SAGSI's Recommendations on the Implementation of Safeguards

Introduction

1. Missions have already received GOV/2698, the Report by the Director General on the Secretariat's programme for the assessment, development and testing of SAGSI's recommendations on the implementation of safeguards. These informal briefing notes provide additional detail concerning the programme of activities aimed at developing concrete proposals to put to the IAEA Board of Governors on measures for strengthening the effectiveness and improving the efficiency of the safeguards system and report progress so far.

2. The Secretariat has sought to provide as much useful detail as is possible at this time. However, it should be recognized that the programme will evolve as ideas are developed and tested, so that many details will change. It should also be emphasized that this is a co-operative programme with Member States, a co-operation that will also affect many aspects of the programme.

Programme of development, assessment and testing

3. The programme for the development, assessment and testing of strengthening and efficiency measures, referred to internally as "Programme 93+2", is being managed by a project team established within the Secretariat. Assistance from Member States is being used as appropriate. The programme is divided into the following seven tasks:

Task 1: Cost analysis of present safeguards implementation

Task 2: Increased co-operation with State Systems of Accounting and Control

Task 3: Environmental monitoring techniques for safeguards applications

Task 4: Other measures for improving the cost-effectiveness of safeguards

Task 5: Improved analysis of information on States' nuclear activities

Task 6: Enhanced safeguards training

Task 7: Proposal for strengthening and improving the efficiency of the safeguards system

Programme 93+2 is separate and distinct from the Department of Safeguard's ongoing research and development (R&D) Programme. However, a close connection between the two efforts will be maintained so that any new technical developments coming from the R&D Programme will be factored into the cost-effectiveness assessments carried out within "Programme 93+2".

4. Technical, financial, legal and other implications of the measures will be assessed. The successful completion of the programme will depend to a large extent on the willingness of Member States to assist the Secretariat, particularly in carrying out field trials. Task 7 will integrate the results of the other tasks in such a way that proposals for approaches to a coherent, comprehensive safeguards system, dealing with both declared and undeclared activities, are generated. The relative merits of the approaches will be assessed, resulting in an initial proposal to be put to the Board by early 1995.

TASK 1: Cost analysis of present safeguards implementation

5. Task 1 develops an assessment of the cost sensitivity of various aspects of safeguards implementation and examines additional topics affecting safeguards effectiveness and safeguards resource allocation. It is expected to be completed by mid-1994.

6. The task is to assess the cost of safeguards implementation as a function of the magnitudes of the various technical safeguards parameters, e.g., timeliness, detection probabilities and significant quantities. SAGSI's April 1993 report suggests that if some of the strengthening measures are proven effective, trade-offs could ultimately be possible between those measures and certain elements of the current safeguards system. For example, SAGSI put forward the proposition that if certain combinations of strengthening measures prove to be effective in providing assurance about the absence of undeclared reprocessing activities, the implementation of these measures could obviate the need for interim inspections for timeliness purposes, currently required by the safeguards system, at spent fuel storage locations.

7. An important feature in evaluating the merits of any possible trade-off is relative costs. Accordingly, the financial aspects of the strengthening measures and their inherent technical merits will be assessed under other appropriate tasks. However, the costs associated with current values of safeguards implementation parameters and the cost

sensitivity to changes in the values of those parameters are not presently sufficiently understood.

8. Thus, a cost analysis is the primary objective of Task 1. The analysis will draw upon accumulated experience for the development of estimates of inspection effort, travel costs and total costs for different values (between 4 and 16 kg) of the significant quantity (SQ) of plutonium, for different definitions of HEU (a range from 10-50%), for different values of the timeliness goals (e.g. 3,6 and 12 months) for irradiated direct-use material (spent fuel) and for unirradiated indirect-use material (natural and low enriched uranium) and for detection probabilities both lower and higher than current values. Work to date indicates that the cost of implementing safeguards is driven more by the number and kind of inspections (e.g., interim versus physical inventory verification (PIV)) than the scope of activities carried out in any particular inspection.

9. Task 1 also includes continuing reviews of current practices in several areas related to strengthened safeguards. These include the starting point of safeguards; safeguards at locations with less than 1 SQ of nuclear material; verification of design information provided on new, existing and closed-down facilities; and exemptions, terminations and suspensions. Specifically:

(a) the costs, the legal implications and the contribution to the Agency's capability to detect undeclared nuclear activities, of changing the starting point of safeguards to an earlier point in the uranium purification process will be assessed.

(b) Procedures for strengthening safeguards at locations containing plutonium or HEU in quantities less than 1 SQ were assessed, were found to involve only quite small cost increases and, during 1993, were adopted and incorporated in the 1991-1995 Safeguards Criteria.

(c) In keeping with the Board's decision on the early provision and use of Design Information, procedures for verifying that a facility is operating as indicated by its design information throughout its life time, and that a closed-down (but still functional) facility is not operating, will be developed. Estimates of the inspection effort, equipment and travel costs and total costs for implementing these procedures will be developed.

(d) Concern has been expressed about the possible use of exemption, termination and suspension to conceal activities of proliferation relevance. Reviews of Agency practice on exemption, termination and suspension will be completed, proposals for any necessary revisions prepared and their cost implications assessed.

TASK 2: Increased co-operation with State Systems of Accounting and Control

10. Task 2 examines the possibilities for increased co-operation with State Systems of Accounting and Control (SSAC). The Secretariat will determine the conditions under which increased co-operation with an SSAC could take place, develop criteria for assessing the effectiveness of an SSAC and identify potential areas where increased co-operation with SSACs may improve cost effectiveness. The main conclusions of Task 2 are expected to be available by the third quarter of 1994.

11. An important role for the SSAC is clearly established in INFCIRC/153, Paragraph 7 which requires that "... the Agency, in its verification, shall take due account of the technical effectiveness of the State's system." This concept is reinforced in Paragraph 81 of INFCIRC/153, which states that, subject to the preceding paragraphs 78-80,"... the criteria used for determining the actual number, intensity, duration, timing and mode of routine inspections of any facility shall include ... (b) the effectiveness of the State's system...". An essential element, therefore, in proceeding with this task, is the development of criteria for evaluating the effectiveness of any given SSAC.

12. The Secretariat has developed a list of factors, based on its experience with national and regional systems and consistent with SAGSI's recommendations, that should be considered in the development of the effectiveness criteria for SSACs:

(a) existence of a fully established SSAC;
(b) independence of the SSAC from nuclear operators;
(c) experience of the SSAC;
(d) size and resources of the SSAC in relation to the size of the nuclear industry;
(e) capability of the SSAC to perform inspections and maintain continuous or intermittent presence of its inspectors;
(f) documentation of SSAC criteria and inspection procedures;
(g) compatibility of documented SSAC criteria and inspection procedures with Agency criteria;
(h) availability of SSAC documentation to the Agency; and
(i) capability of the SSAC to perform safeguards related activities, including those required by Agency criteria, e.g.:
   - NDA and DA measurements;
   - safeguards related research and development; and
   - training.

The Secretariat has developed a draft questionnaire for collecting this information from SSACs. Work to develop criteria is also underway to provide for consistency in utilizing the collected information for assessing the effectiveness of a SSAC.

13. The extent of increased cooperation and the resulting savings which could accrue depend not only on the effectiveness of the SSAC but also on certain conditions with respect to Agency rights and obligations. The Agency must be enabled to retain all

rights regarding the conduct of activities necessary to fulfill its obligations, to set safeguards inspection goal criteria and to draw independent conclusions. These include the rights to verify material independently and to authenticate data as necessary, to satisfy itself that the SSAC meets the necessary quality assurance standards, and to have access to all relevant information and data maintained by the SSAC. Guidelines will be developed to indicate the extent of co-operation possible with the SSAC according to each facility type.

14. Areas for increased co-operation to be assessed will include:

(a) greater involvement of the SSAC within the existing terms of safeguards agreements to improve the efficiency of Agency inspections, including:
- preparation for inspections,
- more efficient procedures (e.g., electronic) for making available facility records and information,
- improved performance of facility measurement systems, and
- field support of Agency inspections;

(b) commonly agreed safeguards approaches;

(c) common inspection planning and procedures, including:
- provision to the IAEA of full advance information and comprehensive reports on all SSAC inspections,
- use of common sampling plans and random selection of items for verification, and
- one-job-one-person arrangements for verification and audit activities, supplemented by quality control measures;

(d) increased common use of instruments, methods and techniques with agreed authentication procedures (the systems would include tamper-resistant and tamper-indicating devices, unattended mode of measurement, monitoring and containment and surveillance equipment);

(e) common evaluation of containment and surveillance records and of the results of other inspection activities, while satisfying the respective obligations of the IAEA and the SSAC;

(f) joint research and development on safeguards equipment and techniques and computer technology for data acquisition and transmission;

(g) co-ordinated procurement of safeguards equipment;

(h) common training programmes for safeguards inspectors;

(i) use of shared laboratories and other facilities for destructive and non-destructive analyses;

(j) use of common measurement results and exchange of analytical results with joint evaluation to identify and resolve problems; and

(k) increased use of regional offices;

15. Task 2 will define the possible extent of increased cooperation, based on the areas listed above, as a function of the SSAC's effectiveness. Any proposals for significant savings which involve a level of SSAC involvement beyond current Agency implementation requirements or practice will be clearly identified. Field trials involving increased cooperation with SSAC's will be incorporated in Task 4 as appropriate. Factors relevant to differentiating between regional and State systems as regards the possibilities for increased cooperation will be examined.

TASK 3: Environmental monitoring techniques for safeguards applications

16. Task 3 assesses the effectiveness, costs, practicality and other aspects of Agency use of environmental monitoring techniques to detect undeclared nuclear activities at declared and undeclared sites. The further development, assessment and use of environmental monitoring as a strengthening measure was one of SAGSI's principal recommendations. The assessment of environmental monitoring is closely related to the assessment of other strengthening measures being carried out in Task 4. However, the management complexity associated with the organization of field trials, sample collection and analysis and the evaluation of the resulting data dictated that the assessment of environmental monitoring be dealt with as a separate task. The results of Tasks 3 and 4 will be fully integrated in defining options for more effective and efficient safeguards. It is expected that the effectiveness and cost evaluation for at least five field trials, together with the work on the legal aspects (to be carried out under Task 7), will be completed in 1994.

17. The use of environmental monitoring will be examined for three types of applications:

(a) use for short-range (a few kilometres) monitoring during inspections and visits investigating sites of possible undeclared nuclear activities as one means of assessing the initial indications or suspicions of nuclear activities;

(b) use for short-range monitoring during ad hoc and routine inspections for the purpose of enhancing assurance of the absence of undeclared nuclear activities at or in the vicinity of safeguarded nuclear activities; and

(c) use for long-range monitoring, in the absence of any indication of undeclared nuclear activities, for the purpose of enhancing assurance of the absence of such activities on a country-wide basis.

18. The effectiveness of environmental monitoring techniques in each of these applications will be assessed, particularly in terms of their capabilities for detecting:

(a) enrichment, by any process, of uranium in the isotope ^{235}U;

(b) reactor operations for the production of plutonium and uranium-233; and

(c) reprocessing of spent reactor fuel to recover plutonium and uranium-233

19. Task 3 includes the following efforts:

(a) evaluating the practicality, effectiveness and costs of Agency use of environmental monitoring under a variety of conditions;

(b) establishing and documenting environmental signatures associated with uranium enrichment, reactor and reprocessing operations at both long and short ranges:

(c) establishing and documenting sampling, analytical and data evaluation procedures and quality control requirements; and

(d) establishing a "clean room" sample handling, screening and distribution capability at Seibersdorf, extending the existing network of analytical laboratories to include capabilities for the analysis of environmental samples and establishing requirements for quality control.

20. The primary mechanism for assessing the applicability of environmental monitoring to safeguards will be the conduct of field trials during which environmental samples will be collected at varying ranges from a variety of types of declared nuclear facilities. The facility types of highest importance for the field trials are enrichment facilities (LEU, HEU or both); small scale reprocessing and, possibly, large scale hot cell operations; and low power reactors, possibly graphite moderated with uranium metal fuel. The testing will need to include other fuel cycle facilities, such as power reactors and fabrication plants, to determine the ability of environmental monitoring techniques to distinguish among the various types of nuclear operations. The field trials will include, inter alia, calibration exercises to define the maximum distances, as a function of facility type and size, sample type and medium, meteorology, hydrology, etc., at which selected signatures of the various nuclear operations can be detected. The assessment will also involve a literature survey and consultations with Member State experts in the fields of production of materials for nuclear weapons and environmental sampling and analysis.

21. Work in all these areas is well underway. Advice from consultants at a meeting

convened by the Agency in March 1993, and experience gained by the Secretariat through environmental sample collections made in several countries, clearly show the value of environmental monitoring where the application is short range, i.e. , at a specific site. Experience in using the techniques for wide area monitoring of a country or region is limited; thus the effectiveness and costs of routine Secretariat use of the techniques for this purpose have yet to be determined. Based on current information, wide area monitoring for reprocessing and reactor operation appears to be feasible but may not be in the case of enrichment.

22. A number of offers of assistance from Member States in the area of environmental monitoring, including field trials, have been received. Specific activities have included the following :

(a) Samples of sea water, sediment and biota were collected between 14 and 24 September 1993 at 29 sampling points in the vicinity of three power reactors, a 50-MW research reactor and an LEU fuel fabrication facility in Sweden. Sample analyses are being carried out in Sweden, the United States and IAEA laboratories. Sample collection and analysis and Secretariat participation in the planning, conduct and evaluation of the trial are being funded by Sweden and the United States. The trial will be completed and the results documented by the end of January 1994.

(b) Samples of water, sediment and biota were collected in October 1993 along the Danube River near the Paks power reactor station and near research facilities in the vicinity of Budapest under the auspices of the Hungarian support programme. Sample analyses will take place in Hungary, the United States and IAEA laboratories. This trial should also be completed by the end of January.

(c) Discussions have commenced with Australian, Canadian, Czech, Japanese, United Kingdom and United States authorities regarding assistance for the environmental monitoring programme. Informal discussions with several other interested Member States have also taken place. It is important that facilities of the size and type necessary to evaluate fully the techniques be included in the field trials. Member States are particularly requested to offer to host field trials at enrichment and reprocessing facilities.

(d) It will be necessary to expand the sample handling and analytical capability available to the Agency in order to facilitate the use of environmental monitoring. This will include a "clean-room" facility for handling, screening and distributing environmental samples. Work on the technical requirements, design and siting of this facility has been started through experts provided by Member States. The construction costs of the facility will be borne by extra-budgetary contributions. Expansion has begun of the existing network of analytical laboratories to include capabilities for routine analysis of the various types of environmental samples. Laboratories in several Member States, and the IAEA Marine Environment laboratory at Monaco, are being evaluated for inclusion in the network. Protocols governing the certification of laboratories, the distribution of samples, quality assurance measures and the reporting of results are being developed.

TASK 4: Other measures for improving the cost-effectiveness of safeguards

23. Task 4 assesses measures, other than environmental monitoring, intended to strengthen safeguards by providing an increased assurance of the absence of undeclared activities. The assessment will include the technical and financial implications, as well as the overall cost-effectiveness of various combinations of measures. Task 4 will involve several field trials, conducted independently of the routine implementation of safeguards, which will examine a range of measures including:

(a) expanded and more timely declarations (including 'real-time' declarations of nuclear material movements) by States of their nuclear activities;
(b) extended access and inspection activities at declared facilities as necessary for verification of the declarations in (a);
(c) access to locations outside declared facilities; and
(d) unpredictability of verification.

24. Increased transparency through expanded declarations would result in greater depth of knowledge of the fuel cycle, its dynamics and its constituent facilities and provide the opportunity to ascertain that the operation of facilities and the flow of nuclear material therein are consistent with the declared design objectives and performance of the fuel cycle as a whole. The fundamental component of transparency would be a declaration by the State of the current status of its nuclear fuel cycle and associated nuclear activities and the provision of timely notifications of any planned changes in the number, purpose or mode of operation of the facilities comprising the fuel cycle, planned transfers of nuclear material and equipment, anticipated changes in the manner of usage of nuclear material and any other changes in its nuclear programme. The declaration could also include training and R&D activities, their locations and a specification regarding the manufature and export of certain equipment and non-nuclear materials.

25. It is foreseen that the scope of the declaration and subsequent notifications would extend beyond the traditional confinement of nuclear material specifics and would be sufficiently comprehensive to enable the Agency to assess the mutual consistency of information received in respect of the entire nuclear programme. The declaration would be in addition to information provided under current Subsidiary Arrangements and would include a description of the scope and purpose of the national fuel cycle

(e.g. number and types of facilities, power generation targets, percentage of national power consumption, indigenous nuclear resources and status of exploitation) and for each facility, using power reactors as an example, its name, location, type, status of design information (e.g., valid/under revision (with details)/in preparation), operational status (e.g., operational/design phase/under construction/defunct) and its operational programme. The latter would cover:

(a) shutdown periods,
(b) open core periods,
(c) core loadings,
(d) fresh fuel receipts (suppliers, amounts and dates),
(e) spent fuel shipments (destinations, amounts and dates),
(f) receipts of spent fuel shipping containers (supplier, capacity and dates),
(g) shipments of spent fuel shipping containers (supplier, capacity and dates),
(h) planned dates of SSAC interim inspections,and
(i) planned date of the SSAC PIV.

26. Extended access at declared facilities is interpreted to mean extended access both to locations and to information. Extended access to locations would mean access to any place within a declared facility as necessary to verify the correctness and assess the completeness of the expanded declaration. Extended access to information could mean access to any information in SSAC or operator files relevant to the expanded declaration.

27. Extended access to locations outside declared facilities would include access to locations through which nuclear material may transit together with any other locations relevant to the verification of the correctness and assessment of the completeness of the expanded declaration. Procedures for managing access to sensitive locations would be developed, possibly drawing upon relevant provisions of the Chemical Weapons Convention.

28. Under the concept of unpredictability of verification, the Agency would have freedom to vary inspections in terms of both the timing and scope. The assurance that would be gained from varying the scope and depth of inspection activities would need to be determined through study and practical experience. The assurance that would be gained through unpredictability in timing of inspections is, at least in some aspects, measurable, particularly if the conditions for randomisation and statistical inference are included. Studies into the cost-effectiveness of unpredictability for verifications and its implications for safeguards conclusions, will be included in the task.

29. Traditionally, operating and accounting records have been subject to audit during scheduled inspections at which time there are well established records. This practice with well established records could not be followed if advantage is to be taken of unpredictability. Greater effort will be required from both the SSAC and the operator

to provide the Agency with access to "mailbox protected" data which will record current or imminent plant operations. These data could be literally mail-box hard copy, but the implementation of computer data transfer would clearly be highly advantageous.

30. Task 4 will develop these and other ideas addressed by SAGSI and test them through a series of field trials. Some of the ideas for increased co-operation with SSACs developed in Task 2 will be incorporated into the Task 4 field trials as appropriate. Discussions on field trials have commenced with Swedish, Canadian and Australian authorities. Field trials in these States will provide a beginning, but additional invitations from States are needed to evaluate fully the various measures. It is expected that the major work involved in Task 4, including the necessary field trials, will be well underway by mid - 1994. All field trials associated with the programme will be conducted independently of the routine implementation of safeguards. In addition, SAGSI's alternative ways of safeguarding declared material will be examined in the context of the strengthening measures for the detection of undeclared activities.

TASK 5: Improved analysis of information on States' nuclear activities

31. Task 5 focuses on the analysis of information available to the Secretariat about States' nuclear activities. The objective of the task is to ensure a coherent and comprehensive approach to the acquisition, management and analysis of information available to the Secretariat regarding a State's nuclear activities. This includes, but is not limited to, information from open sources.e.g., publicly available information, safeguards data, the reporting scheme on imports and exports of nuclear material and exports of specified equipment and non-nuclear material, other information provided by States and the expanded declaration by the State referred to in Task 4. The purpose is to ensure that Secretariat resources are used effectively and efficiently to identify at an early stage any instance in which the available information about a State's nuclear activities appears inconsistent with its declaration to the Agency.

32. The main areas of work within the task are to:

(a) Identify and assess types of information, and their potential sources, for relevance in determining the consistency of the State's declaration. This will take into account critical paths and check lists, to be developed, that would be involved in the acquisition of weapons usable nuclear material and the associated development and procurement activities.

(b) Develop criteria and procedures for analyzing and evaluating the information for confirming the State's declaration or for providing indications of inconsistencies. The form and content of required output reports will also be established.

(c) Identify and develop the computer hardware and software needed for processing and analyzing the information. This will include systems with capabilities for information filtering, for dealing with information uncertainties and inferences and for combining analytical results from disparate sources.

(d) Determine the necessary information flows and organizational responsibilities within the Secretariat. This will include organizational needs for information and timeliness and content requirements.

(e) Determine the resources required to acquire and maintain the information system. This includes determining the expertise necessary for the various analyses and for interpreting the diverse information in the system. For example, the need has already been identified for expertise in the analysis of open source information, i.e., in selecting, categorizing and assessing the information for indicators of inconsistencies with a State's declaration.

33. This work has started, and the Secretariat has already established an internal working group to evaluate, on a trial basis, available information together with the supporting computer data base tools for managing a large quantity of data. A data base of public information from the media has been started. Some assessments have been made of the potential contribution of parts of this data base to providing indications of undeclared nuclear activities. The Secretariat has begun receiving some information on the nuclear imports and exports referred to in paragraph 31 above.

34. Work has also started, with the considerable support and co-operation of Member States, on a computer system that provides a geographically-referenced information storage and retrieval system for inspection planning. This system, the International Safeguards Inspection Support Tool, has also been acquired for assessing its use as one of the platforms for information analysis. An early application will be for the field tests of environmental monitoring for storing reference information on geography, hydrology and existing environmental monitoring data, for planning and preparations for sampling operations and for assistance in evaluating field test data. The system will also be examined for its possible uses under Task 4 and should be particularly useful in dealing with the wide range of information expected to be made available to the Secretariat for the field trials under that task.

35. The expanded declarations by States on their nuclear activities are expected to include considerably more information than is now received from States and to involve more frequent and timely updates of information. Improved communication means for the flow of information from States to the Secretariat will, therefore, be needed, and work has commenced on establishing telecommunication links with SSACs.

TASK 6: Enhanced Safeguards Training

36. Task 6 is concerned with identification, development and implementation of the training programmes required to ensure that the staff of the Department of Safeguards have the necessary skills to carry out the various measures and activities being developed under Tasks 1 - 5 and, in general, to deal with expanded safeguards requirements.

37. A preliminary training needs analysis has been carried out by the Secretariat, and Member States' support programmes have been asked for assistance in developing and conducting training programmes. Positive offers of assistance have been received. Additional support programme assistance will be sought for the development and provision of specific training modules and/or courses, as well as in the provision of training materials, equipment and, as circumstances dictate, facilities in which to conduct training. Additional methods of further improving inspector skills through enhanced training are being explored with Member State support programmes, including training in skills that will generally raise the Department's ability to deal with the issue of undeclared activities, the use of computer-based training, and multi-media techniques of information presentation.

38. Training requirements already identified include:

(a) training on continuing design information verification;
(b) training of SSAC personnel on IAEA safeguards;
(c) training in environmental monitoring;
(d) training for testing of other elements of alternative safeguards approaches; and
(e) training on analysis of information on States' nuclear activities.

39. Training on continuing design information verification will include developing the skills for design information verification (DIV) throughout the life time of a facility. The generic principles of DIV for safeguards purposes will first be developed. The next level of DIV will address facility specific problems. An integral part of DIV exercises will be to increase the observational skill of IAEA inspectors. A special emphasis will be given to the DIV of temporarily shut down and permanently closed down facilities, in accordance with the policy to be developed under Task 1.

40. Some experience has been accumulated recently through the organization of the training course "Safeguards at Reprocessing Facilities" and a series of DIV workshops at a plutonium recovery plant in Dounreay and THORP in Sellafield. Early in 1994 a training course from the regular Safeguards Training Programme "Placement of new facilities under IAEA safeguards" in Russia will be used as a basis of development and application of new procedures for DIV.

41. The next step in programme implementation will be the development of an in-house training module describing the basic concept and procedures of DIV planning, performance and analysis of the results. This module will include generic skills

required for DIV. At the same time field exercises for different types of facilities, primarily those of a complicated nature, are planned. Priority is to be given to the exercises on closed down facilities. Implementation of the above programme requires appropriate facilities for DIV exercises to be identified through the Member States Support Programmes.

42. Training of SSAC personnel on IAEA safeguards can be considered as a basis for further improved co-operation between SSACs and the IAEA. Better knowledge of IAEA safeguards will allow SSAC personnel to be prepared for closer co-operation with the IAEA and make IAEA safeguards more transparent for Member States. The programme may include NDA and DA measurements, planning of inspections, advanced provision of design information, application of containment/surveillance measures, Safeguards Criteria and organization of physical inventory verifications. It is planned to develop the programme within the next six months and, depending on the availability of funds, to implement it beginning in October-November 1994.

43. Training in environmental monitoring will include:

(a) training on environmental sampling for the IAEA staff who will participate in field trials; and

(b) performance-based training for specific environmental measurement techniques selected by the IAEA with emphasis on sampling planning procedures, quality control, etc.

The training will be implemented in two phases. The first phase, which has begun, is training of the IAEA staff for field trials. The second phase, training of IAEA inspectors for regular use of environmental monitoring, will be implemented only after the approval of environmental techniques selected by the Agency. The training material will be documented and training manuals prepared. Manuals will consist of training modules relating to different types of environmental sampling. "Hands-on" exercises will be prepared whenever possible. All sampling technique procedures will be videotaped. Video recordings of the environmental sampling operations in the field trial in Hungary have already been made. The first formal training of staff for field trials is scheduled for January 1994.

44. Training for testing of other elements of alternative safeguards approaches is needed to enable the IAEA inspectors to perform the necessary new activities in field trials under Task 4. These activities may include expanded access for verification, unpredictability of inspections, etc. An important component of such training will be to increase inspectors' ability to recognize technical indications of possible undeclared nuclear-related activities and analyse information received in the course of test inspections. A list of skills which might be required by IAEA inspectors for these tests is being prepared.

45. Training on analysis of information on States' nuclear activities covers the acquisition, management and analysis of information available to the Agency on States' nuclear activities. The first training course "Initial Country Officers Training" was organized in May-June 1993. The objective of this training was to familiarize country officers with their responsibilities and the scope of the activities to be performed for analysis of nuclear-related information from open sources. The training on the use of computer based information systems will be arranged later.

TASK 7: Proposal for strengthening and improving the efficiency of the safeguards system

46. The integration of the results of Tasks 1 to 6 into comprehensive safeguards approaches, dealing with both declared and undeclared activities, will be the final part of the programme and will be dealt with in Task 7. The various approaches will be assessed for their effectiveness and cost. The rationale, benefits and impact on overall effectiveness of any trade-offs among the strengthening measures and certain elements of the current system will be fully described. The relative merits of the approaches will be fully explored and presented. Task 7 will also incorporate a description of legal and other implications of the approaches. From this analysis the Secretariat will be in a position, by early 1995, to make an initial proposal to the Board on a strengthened and streamlined system which will cover both the safeguarding of declared material and facilities and the detection of undeclared activities.

doc20.nt

SAGSI-Recommendation
"More effective and efficient safeguards"

↓

Director General

↓

Board of Governors (June 1993)
"...assess in more detail technical, financial and legal aspects of SAGSI's proposals..."

↓

PROGRAMME 93 + 2
(Initial objectives)
Integrated programme plan that establishes:

⇒ schedules
⇒ priorities and resources
⇒ identifies gaps
⇒ provides basis for reporting progress

↓

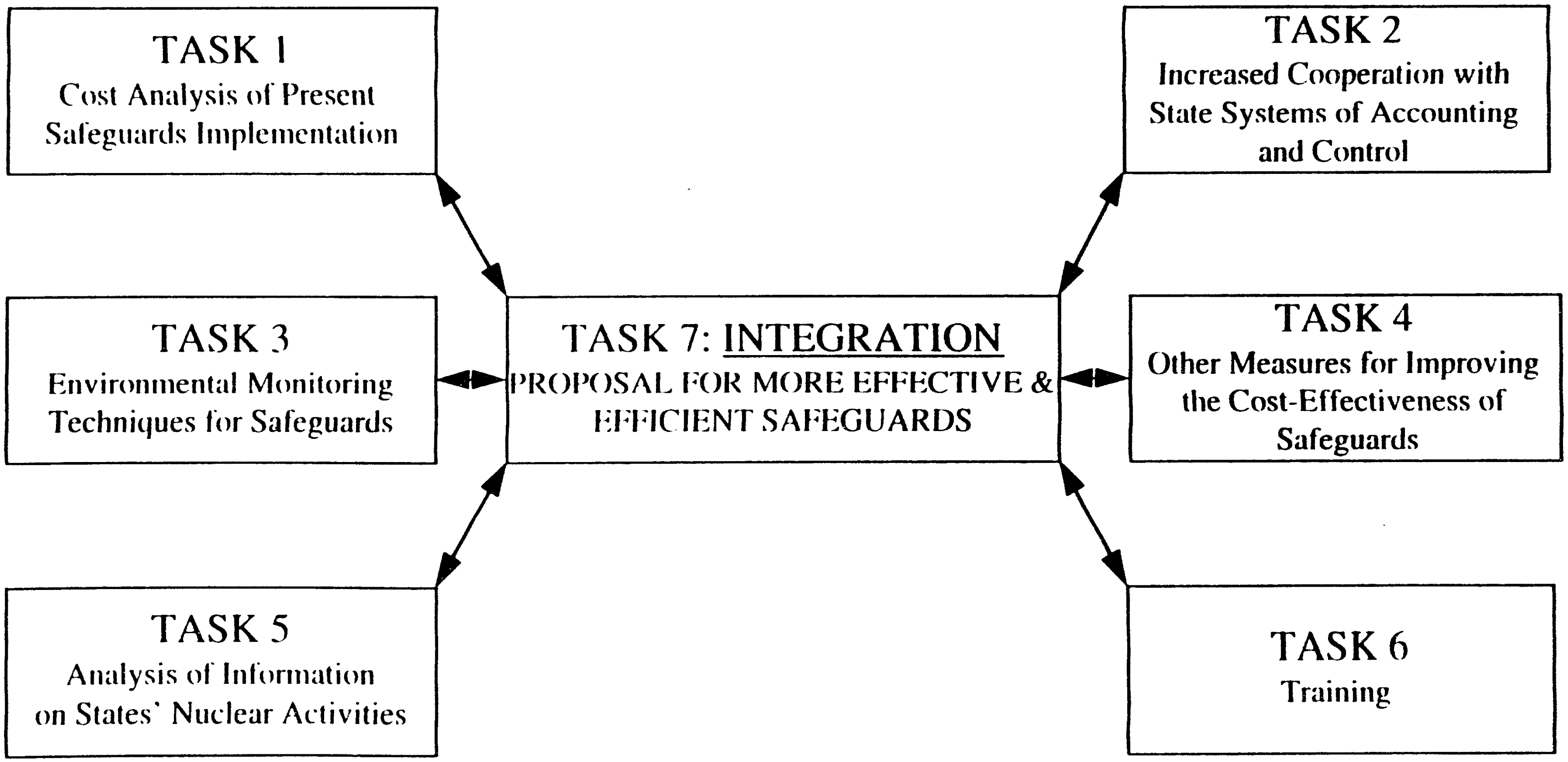
Director General
⇒ report to Board of Governors (Dec.1993)

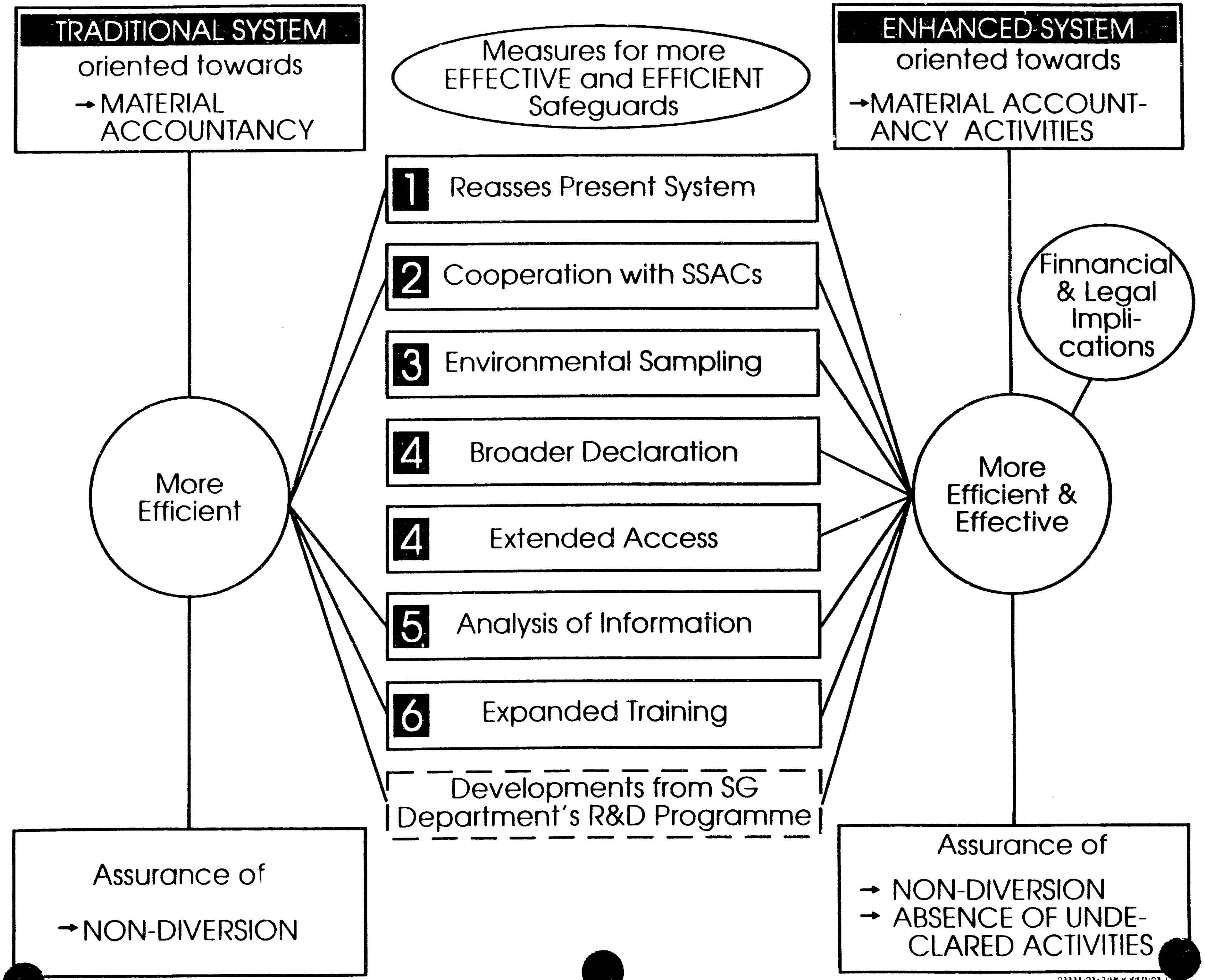
↓

PROGRAMME 93 + 2
(93 + 2 ⇒ 1995)

⇒ Field trials (define, carry out, evaluate)
⇒ Training needs, security measures
⇒ DEFINE OPTIONS

PROGRAMME 93+2





TRADITIONAL SYSTEM
oriented towards
→ MATERIAL ACCOUNTANCY
Measures for more EFFECTIVE and EFFICIENT Safeguards
ENHANCED SYSTEM
oriented towards
→ MATERIAL ACCOUNTANCY ACTIVITIES
1 Reasses Present System
2 Cooperation with SSACs
3 Environmental Sampling
4 Broader Declaration
4 Extended Access
5 Analysis of Information
6 Expanded Training
Developments from SG Department's R&D Programme
Finnancial & Legal Impli-cations
More Efficient
More Efficient & Effective
Assurance of
→ NON-DIVERSION
Assurance of
→ NON-DIVERSION
→ ABSENCE OF UNDECLARED ACTIVITIES

TASK 1

"Assessment of Cost Sensitivity of
Safeguards Implementation Parameters and
Additional Topics Affecting
Resource Allocation in Safeguards Activities"

TASK 1 WORKPLAN
INCLUDES

- Cost sensitivity of implementing safeguards to alternative values of basic implementation parameters
- Review policy on exemption/termination and suspension of safeguards - papers to the Board on exemption, termination and suspension (June '94)
- Change in the starting points of safeguards - legal opinions and proposals
- Procedures for continuing design verification (including closed-down facilities)
- Technical reassessment of safeguards implementation parameters

TASK 2

"... to assess how, and under what circumstances,
increased use could be made of SSAC's
and what savings would result"

TASK 2 WORKPLAN
INCLUDES

- The development of criteria for assessing the effectiveness of an SSAC
- The identification of areas for increased cooperation with SSAC's per the assessed effectiveness
- The differentiation between state and regional systems
- The assessment of savings that could accrue through increased cooperation

TASK 3

"... to assess the effectiveness and costs of environmental monitoring for safeguards to detect undeclared activities at declared sites and undeclared activities at sites not declared"

TASK 3 WORKPLAN
INCLUDES

- The identification and documentation of environmental signatures for uranium processing, enrichment, reactor and reprocessing operations
- The extension of the Network of Analytical Laboratories for the analysis of environmental samples including appropriate sample distribution and QA protocols
- The establishment of a clean room capability for the handling, screening and distribution of environmental samples
- The development and documentation of sampling, data storage and analysis procedures
- The conduct of demonstration field trials including quantification of cost factors

TASK 4

"... the introduction of new measures to enhance the Agency's confidence in the absence of undeclared nuclear activities is a most important aspect of the strengthening of Agency safeguards and would be a precondition for some of the other measures addressed by SAGSI for the purpose of improvements in the cost-effectiveness of safeguards. The goals of this task are:

(1) The field testing of measures other than environmental monitoring for gaining assurance regarding the absence of undeclared activities and to assess their contribution to cost-effectiveness

(2) Examine in the context of strengthening measures the ideas expressed in SAR-15, Appendix III, on a different way of conducting safeguards on declared material

TASK 4 WORKPLAN
INCLUDES

- The conduct of field trials, independent of the routine implementation of safeguards, that examine a broad range of measures, e.g.,
    - expanded and more timely declaration (material, activities, design information)
    - extended access within declared facilities and at other locations
    - no prior announcement regarding inspector activities
    - environmental sampling
    - systematic and enhanced information analysis
    - broader role for SSAC

  to strengthen safeguards and to examine alternatives to the current system
- Identify and evaluate tradeoffs

TASK 5

"... to ensure a coherent and comprehensive approach across the Department of Safeguards to the acquisition, management and analysis of information such that Agency resources are effectively used to provide input to the inspection planning process and to provide early indication of findings inconsistent with a State's declaration"

TASK 5 WORKPLAN
INCLUDES

- Establish and manage an interim data evaluation group with the objective of defining data and analysis requirements (e.g., criteria and procedures for evaluating the consistency of available information with a State's declaration)
- The acquisition and implementation of the INSIST code as a data storage and retrieval platform for Tasks 3 and 4
- Further develop INSIST as a pre-inspection training tool for participants in Task 4
- Coordinate with the developers of the SIMS to assure a timely product consistent with Agency needs
- Identify and develop additional software as required

TASK 6

"...to identify, develop and implement training programmes necessary to carry out the work of Tasks 1-5 and establish the basis for the broader training effort that will be necessary as various new measures become part of routine safeguards"

TASK 6 WORKPLAN
INCLUDES

- Training on design information verification activities
- Training of SSAC personnel on IAEA safeguards
- Environmental monitoring training programme
- Training for testing alternative safeguards approaches
- Training on analysis of information on States' nuclear activities

TASK 7

"... to provide overall management of Programme 93+2, to integrate the results of Task 1-6 options for a more effective and efficient safeguards system and to asses the relative merits of those options including the legal and other implications"

Annex 3c

IAEA Board of Governors Paper, GOV/INF/737

GOV/INF/737
12 May 1994

International Atomic Energy Agency
BOARD OF GOVERNORS

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THE SECRETARIAT'S DEVELOPMENT PROGRAMME FOR A STRENGTHENED AND MORE COST-EFFECTIVE SAFEGUARDS SYSTEM

A progress report by the Director General

FOREWORD

The process of strengthening and otherwise improving the safeguards system has been underway for some time. Statements made at the 1990 NPT Review Conference and the Director General's statement during the February 1991 Board of Governors' meeting spoke of the need for more effective and "cost-efficient" safeguards and identified specific issues which needed to be addressed. During 1991 the Board considered, and in 1992 confirmed the right of the Agency to use the right of special inspection as provided for in comprehensive safeguards agreements. In 1992 the Board made decisions regarding the early provision and use of design information. Throughout 1992 the Secretariat carried out technical studies to identify specific areas of safeguards application which might be improved and to identify mechanisms for implementing the Board decisions. In February 1993 the Board endorsed a reporting scheme on imports and exports of nuclear material and exports of specified equipment and non-nuclear material.

This process of improving the safeguards system is a continuing one. This document reports on progress to date in the major effort in the process, the Secretariat's programme ("Programme 93+2") for assessment, development and testing of SAGSI's recommendations on improving the implementation of safeguards. This report is part of the continuing dialogue between the Secretariat and Member States which is essential for the successful completion of the programme.

94-01759

INTRODUCTION

1. In April 1993, the Standing Advisory Group on Safeguards Implementation (SAGSI), acting on a request by the Director General and with the support of the Safeguards Department, reported its recommendations for improving the cost-effectiveness of safeguards to the Director General. The Director General reported to the Board on SAGSI's recommendations in June 1993 (GOV/2657). The Board requested the Director General to submit to the Board in December 1993 concrete proposals for the assessment, development and testing of the measures proposed by SAGSI.

2. At the meetings of the Board in December 1993, the Deputy Director General for Safeguards introduced document GOV/2698 describing the Secretariat's development programme for a strengthened and more cost-effective safeguards system. The programme (called "Programme 93+2") provides for the evaluation of the technical, legal and financial implications of SAGSI's recommendations. It was emphasized that any strengthening measures that go beyond the scope of safeguards agreements can only be implemented with the agreement of the States concerned. The Chairman of the Board, in summing up the Board's December 1993 discussion of the proposed programme, said that "the Board had reiterated its support for strengthening of the Agency's safeguards system and for the Secretariat's efforts and initiatives aimed at increasing the effectiveness and improving the efficiency of that system", and that, "the Board had welcomed the Secretariat's intention to submit regular progress reports to it and provide regular opportunities for it to express its views". Further progress in the programme was reported to the Board in February 1994 (GOV/INF/729).

3. The ideas and proposals being considered in "Programme 93+2" are broad in scope and diverse in nature. They cover all of the four areas considered by SAGSI for improving the cost-effectiveness of safeguards. They deal with both declared and undeclared nuclear activities. They include possible new measures for strengthening safeguards; further efficiencies in how current safeguards activities are carried out; alternative procedures and techniques that may be more efficient or effective in carrying out safeguards; and possibilities for replacing some current safeguards procedures by alternative procedures which maintain the effectiveness of safeguards but which can be implemented with less effort and lower cost. The further recommendations of SAGSI at its November 1993 and March 1994 (see GOV/INF/739) meetings are being taken into account.

4. The criterion for inclusion of a measure in "Programme 93+2" was that it be identified as having potential for one or more of the following:

(i) reducing the cost of implementing safeguards while maintaining or improving their effectiveness;

(ii) increasing the capabilities of the Agency to detect undeclared nuclear activities;

(iii) increasing the effectiveness and/or efficiency of safeguards through greater cooperation with State Systems of Accounting and Control (SSACs);

(iv) improving the effectiveness and/or efficiency of the acquisition, processing and analysis of safeguards relevant information; and

(v) improving the capabilities of inspectors, other Agency safeguards staff and SSAC staff to carry out new measures as required for field testing the measures or for their subsequent implementation as may be decided at some future point.

Effectiveness is a measure of the extent to which Agency safeguards are able to achieve the safeguards objectives. Efficiency is a measure of the productivity of Agency safeguards, i.e., how well the available resources (staff, equipment, money) are used to fulfill the Agency's part in the implementation of safeguards.

5. The Secretariat's reports (GOV/2698 and GOV/INF/729) to the Board in December 1993 and February 1994 described the work of the Programme as organized into six task areas with a seventh task for overall management and integration of the results. These are:

Task 1:	Cost analysis of present safeguards implementation
Task 2:	Assessment of potential cost saving measures
Task 3:	Environmental monitoring techniques for safeguards application
Task 4:	Increased co-operation with State Systems of Accounting and Control (SSAC) and other measures for improving the cost-effectiveness of safeguards
Task 5:	Improved analysis of information on States' nuclear activities
Task 6:	Enhanced safeguards training
Task 7:	Proposal for strengthening and improving the efficiency of the safeguards system

The core "Programme 93+2" team is comprised of a programme manager, six task officers and representatives from the Legal and External Relations Divisions. The work is being accomplished through a series of internal working groups, drawing from expertise throughout the Secretariat, and extensive support from Member States (Member State Support Programme tasks and technical assistance in connection with field trials).

6. Past reports to the Board have emphasized the importance of Member State participation in testing measures being investigated under the programme. To date, 17 Member States (Argentina, Australia, Canada, Czech Republic, Finland, France, Germany, Hungary, Indonesia, Japan, Netherlands, Russia, South Africa, South Korea, Sweden, the United Kingdom, and the United States) have offered their assistance in the conduct of environmental monitoring field trials and related technical areas and in field trials of other strengthening and more cost-effective measures involving alternative safeguards procedures and increased cooperation with SSACs. Additional offers, particularly relating to the application of environmental monitoring techniques in the vicinity of reprocessing operations and to the broader field trials, would be welcomed.

7. At this stage there is an advantage in discussing the various proposals side by side in one document, showing the work done in each of them. It allows overview and an assessment of possible trade-offs and synergies. Nevertheless, in the past few years, measures for the strengthening of safeguards have been advanced to the Board as and when they were ready. To the extent that measures now contemplated are not organically linked with others, there is no reason why they should have to await presentation to the Board until a whole package becomes ready. As before, they may be advanced when they are adequately explored and developed. When they require commitments by governments going beyond existing safeguards agreements, they clearly must be subject to the agreement of the States concerned. Not all proposals, however, are of this kind. For instance, the creation of additional regional safeguards offices would not require modification of safeguards agreements.

8. The timing and content of field trials are decisive for developing the specificity of many of the proposals. These trials are resource intensive both for the Secretariat and for the Member States participating in the trials. Scarcity of Secretariat staff is one factor in scheduling the trials. Whenever possible, Support Division personnel are used. However, some field trial activities are much more efficiently and effectively carried out by experienced inspectors knowledgeable about the facilities involved. The scheduling of field trials that makes effective use of experienced staff is complicated by the requirement that "Programme 93+2" development activities not interfere with routine implementation of safeguards.

9. Although the presentation in this status report will follow the seven tasks in which the work has been divided, it is also possible to view new proposals together with measures already adopted in clusters that relate to main areas of reform.

A. One major area concerns measures to strengthen the Agency's access to information, which could contribute to making safeguards more effective. Measures already taken in this area are:

a) early provision of design information,

b) greater use of data that are available publicly, in-house or otherwise, and

c) the reporting scheme on export and import of nuclear material, non-nuclear material and specified equipment.

The major additional elements contemplated for this area are:

d) broader information on States' nuclear activities, resulting in greater nuclear transparency and

e) environmental monitoring.

B. Another major area of measures relates to access to sites and the effectiveness of the access. Measures already taken in this area are:

a) the Board's expressed positions regarding special inspections, both in general terms and in a concrete case and

b) voluntary offers by some governments to accept Agency visits "any time, any place".

Development of this very important area may comprise proposals regarding:

c) routine access to nuclear-related sites beyond "strategic points".

d) "managed access" to sensitive sites under a scheme of "any time, any place", and

e) expanded right to prompt access on short notice or no notice.

C. A third area of measures might be termed <u>administrative streamlining and rationalization</u>. Measures already taken are inter alia:

a) the expanded regional use of the two safeguards offices in Toronto and Tokyo,

b) the partnership agreement with Euratom,

c) the proposal for simplified designation procedures for inspectors and

d) the computerised log sheets.

Further measures in this area might be:

e) reduction in the inspection frequency to LWRs,

f) greater use of unattended, remote readout equipment in lieu of some inspections,

g) additional regional safeguards offices to save travel costs and facilitate short notice/no notice safeguards.

h) multiple-entry visas for inspectors, reducing red tape and administrative burden,

i) expanded capability for inspectors to freely communicate with headquarters,

j) retraining of inspectors, and

k) joint use by SSACs and the Agency of equipment and laboratories.

10. The aim of "Programme 93+2" is to develop proposals for a strengthened and cost-effective safeguards system, together with an accompanying evaluation of the technical, legal and financial implications, for presentation to the Board of Governors. The progress summaries for each of the tasks are given below, including an assessment of the progress expected by the end of 1994.

Progress Report on "Programme 93+2" Tasks

TASK 1: Cost analysis of present safeguards implementation

11. The primary objective of Task 1 is the assessment of costs of implementing safeguards as a function of the magnitude of the various technical safeguards parameters (e.g., timeliness, significant quantities, probabilities of detection). The specific implementation costs associated with current values of these parameters and the cost sensitivity to changes in the values are not sufficiently well known. A reasonable range in the value of each parameter has been defined for this cost assessment. The SAGSI report suggests that if some of the strengthening measures are proven effective, then trade-offs could ultimately be possible between those measures and certain elements of the current safeguards system. An important factor in evaluating the merits of any possible trade-offs is relative costs. The financial aspects, as well as the inherent technical merits, of the strengthening measures are being addressed under other tasks.

12. The budgeting and cost management system associated with the implementation of safeguards is based on expenditure items. Thus, experience based estimates of the cost to carry out a particular kind of inspection (e.g., physical inventory verification or interim inspection) at a specific facility or the cost to implement safeguards for a year at a specific facility are available. However, even for these cases, assumptions are needed for dealing with the distribution of indirect costs, the amortization of equipment costs, etc. From the standpoint of cost sensitivity, when a change in the magnitude of a technical implementation parameter (e.g. timeliness) results in more or fewer interim inspections, the estimation of the increase or decrease in associated costs is straightforward. When changes in the technical implementation parameters (e.g., significant quantity or probability of detection) result in changes in the level of specific activities integral to an inspection as a whole, the associated changes in cost are difficult to estimate because the costs of a number of unit activities (e.g., an NDA measurement) are facility specific. For example, the costs to carry out a physical

inventory verification (PIV) at two bulk handling facilities with similar inventories may be very different because of the time available. In one case, five inspectors are able to carry out the work distributed over four days where in the other case, ten inspectors are necessary because only two days are made available by the operator. To the extent possible this kind of implicit cost sharing between the Secretariat and the operator will be accounted for in the cost sensitivity analyses.

13. The basic cost data set being constructed for Task 1 includes facility specific figures for:

- travel and subsistence costs;
- costs for the destructive analyses (DA) of safeguards samples (transport and analysis);
- costs (time) for the various kinds of non-destructive analysis (NDA) including equipment procurement and maintenance costs;
- average strata-by-strata material inventories (interim and PIV) and the costs (time) to establish the population of items, select the items for verification and perform the verification measurements;
- average cost per surveillance unit by type - Minolta, MIVS, MUX, etc. (procurement, installation, servicing, review);
- average costs for seals check, replacement and verification;
- average costs (time) for records audit and review; and
- costs (time) related to any design information verification.

14. These cost figures relate primarily to activities carried out in the field, and the data collection work is nearly complete. These are the activities most directly affected by any changes in the assigned values of the technical implementation parameters. However, these figures do not include the costs of the myriad of activities such as the analysis and reporting of inspection data and conclusions, follow-up on discrepant results, maintenance of inspection records and other data bases, quality assurance, training, development of improved equipment and safeguards approaches and the negotiation of subsidiary arrangements that directly or indirectly support the implementation of safeguards. The sensitivity analysis identifies and

quantifies those costs that are affected by a change in the values of the technical implementation parameters.

15. Other work included in Task 1 is well underway. Papers have been prepared on termination, exemption and substitution of safeguards on nuclear material. The policy for the termination of safeguards on nuclear material in waste has been discussed within the Secretariat and is nearing completion. The remaining papers are under consideration by the Secretariat. The costs of any activities deriving from these papers will be assessed. An evaluation of a change in the starting of safeguards to an earlier point in the uranium purification process has been carried out. A concept paper has been prepared by the Secretariat, and a legal opinion on the issue is being prepared. At the Board Meeting in February 1992, a decision was made on the early provision of design information and the continuity of this knowledge through the lifetime of the plant to its shutdown condition. Procedures are being prepared for reviewing and verifying the declared design information throughout the facility life cycle. Criteria for accepting final decommissioning are also being developed. The costs of introducing these measures will be assessed.

16. Task 1 will be completed by the end of 1994.

Task 2: Assessment of potential cost saving measures

17. Task 2 has as its objective the identification and evaluation of a number of technical and administrative measures that have the potential to reduce costs associated with the current implementation of safeguards. The development work associated with these measures is being performed either within the Secretariat or through Member State Support Programmes. This task was added to "Programme 93+2" following the December 1993 Board of Governors Meeting (see GOV/INF/729). This gives greater visibility to these efforts and increases the synergy with related development work within the "Programme 93+2" framework.

18. Major cost sectors associated with the implementation of safeguards, and thus the areas targeted for potential cost savings, are staff costs (60%), equipment (13%) and travel (13%). As the number of facilities and the quantities of nuclear material under IAEA safeguards continue to increase, reduction in trained staff is not realistic. However, staff utilization efficiencies may be improved and travel costs reduced through use of modern technology, through economies in safeguards operational modes, by enlarging existing or establishing new field offices and through efficient use of office automation equipment. Cost savings in the equipment sector may be achieved through greater standardization and the sharing of equipment and analytical services costs with the operator.

19. The measures so far identified for their potential to improve utilization of staff and reduction in travel and equipment costs are described below. The work breakdown structure is provided for sub-task 2.1 to indicate the level and direction of the evaluation. A similar structure is in place for the other sub-tasks.

Sub-task 2.1 Use of equipment capable of functioning in an unattended mode.

To meet increased inspection needs with increasingly limited resources, use of enhanced technology such as assay and monitoring equipment capable of operation in an unattended mode offers the possibility of reducing the physical presence of inspectors in the facilities. Existing cases include Bundle Counters, Core Discharge Monitors, video surveillance, CONSULHA (containment and surveillance for La Hague), NDA measurements at MOX fuel fabrication facilities, etc. Other cases where similar measures can be applied are being identified. Some examples are the verification of inter-bay transfers of spent fuel in OLR's, transfers of spent fuel to canisters for dry storage, transfers of spent fuel between reactors and reprocessing plants and spent fuel storages and shipments of finished fuel from fuel fabrication plants to reactors, tank monitoring and sampling at reprocessing plants.

The work breakdown structure includes the following elements:

(a) Identify all situations where NDA measurements are required to verify inventory/inventory flow, inventory changes or the unreported production of high enriched uranium that are potential candidates for the use of equipment functioning in an unattended mode.

(b) Estimate the inspection effort currently used to fulfill the relevant Safeguards Criteria requirements (PDI's/year).

(c) Identify NDA systems or combinations of NDA and C/S systems that could be installed to do the verification activity in an unattended mode.

(d) Evaluate for each such system:

i) technical feasibility including authentication requirements,

ii) safeguards effectiveness,

iii) the costs for equipment, its installation, maintenance and how the costs are amortized, and

iv) resources needed for data review and analysis at site and at headquarters (equipment and effort).

(e) List all assumptions and difficulties (technical, financial and legal) in realizing the unattended system.

(f) Estimate the time schedule for implementation of such systems.

(g) Estimate annual savings in inspection effort and inspection travel and determine the cumulative net costs.

(h) Reporting of the results and recommendations.

Sub-task 2.2 Mail-in of data collected through equipment functioning in an unattended mode

The Agency, in 1992-93, successfully conducted field tests for mail-in by the SSAC of the surveillance video tapes (STR-297). The broad application and associated cost implications are being evaluated.

Sub-task 2.3 Remote interrogation of NDA and C/S equipment

The present safeguards criteria requires periodic verification of inventories of, inter alia, spent fuel at reactor installations or at away from reactor installations. In the majority of cases the nuclear material is kept under C/S measures. Routine inspections are made to service the cameras or replace/verify seals. With the development of enhanced technologies, remote interrogation or transmission of C/S data to headquarters or a field office for review and analysis offers savings in inspection effort. Other examples include the Bundle Counters and Core Discharge Monitors at Candu Stations and NDA (with C/S) measures operating in an unattended mode.

Sub-task 2.4 Use of commercially available (standard) equipment

The current practice of relying on equipment with unique or specialized configuration requires the maintenance of more than 100 types of instruments. This entails extensive and costly support services. Use of standard off-the-shelf equipment in modular form may permit rapid assembly of the equipment needed to meet the ever changing demands and at a lower cost (with assurance of sufficient support for maintenance/upgrading). The cost saving potential of a program designed to consolidate and optimize the use of instrument development and support resources with an emphasis on commercially available equipment is being evaluated.

Sub-task 2.5 Sharing equipment and installation costs with the operator

There are increasing instances where the State System of Accounting and Control (SSAC) and the nuclear plant operator have an interest - beyond the mutual interest in the assurance regarding the non-diversion of nuclear material - in Secretariat owned and installed equipment (e.g., for resolving facility accountancy problems or for plant operation reasons). The objective of this sub-task is to identify the specific instances (existing and planned) where the Secretariat and operator/State have agreed on the joint use of safeguards equipment and to do a cost-benefit analysis of a programme where the equipment, installation and maintenance costs are shared.

Sub-task 2.6 Sharing State's chemical analytical services

The high throughput of existing and future bulk handling facilities requires that the Secretariat increase its capability to carry out highly accurate chemical analysis (DA) at the Safeguards Analytical Laboratories at Seibersdorf. The possible savings in the analytical costs and the costs for the shipment of the samples, if the operator owned and run analytical services can be authenticated and thereby used, will be evaluated.

Sub-task 2.7 Expanded application of certain current safeguarding schemes

The Agency has experience in the application of safeguards schemes such as the zone approach, dual C/S and NRTA (near-real-time accountancy) to increase the effectiveness of safeguards and to optimize Secretariat resources, and substantial savings in inspection effort have resulted, while fulfilling the requirements of the safeguards criteria. The cost saving potential of a broader application of these schemes, given certain technical problems are solved, is being evaluated.

Sub-task 2.8 Enlargement of the Regional Offices and the establishment of new offices

The safeguards operations in States/Regions far away from Vienna and with large inspection effort requirements imply heavy travel costs. The Agency has established a Regional Office at Tokyo and at Toronto in order to make inspections in Japan and Canada more cost effective. In addition, the regional offices offer better possibilities for performing inspections at short notice. The increasing inspection work in South America, CIS and the Far East due to new safeguards agreements and additional facilities/nuclear material under safeguards will result in substantial financial commitments on the part of the Secretariat. Cost benefit analyses regarding the expansion of existing Regional Offices and the establishment of new field/regional offices will be performed.

In addition to sub-task 2.8, a number of other administrative measures will be reviewed where changes have the potential to reduce the costs of safeguards implementation. Examples include streamlining of procedures for States' radiation protection requirements for inspectors in the field where the State accepts the Agency's radiation protection and monitoring system, the incorporation of Chemical Weapons Convention provisions such as the right to use Agency means of communication in the field, multiple entry visas and universal designations in the safeguards system and the expanded use of electronic data processing (at Headquarters and in the field) and local area networks.

20. Task 2 is scheduled to be complete by the end of 1994.

Task 3: Environmental monitoring techniques for safeguards application

21. Task 3 evaluates the use of environmental monitoring techniques to enhance the Secretariat's ability to detect undeclared nuclear activities. The further development, assessment and use of environmental monitoring as a strengthening measure was one of SAGSI's principal recommendations. The task, which will involve a number of field trials, is focused on:

(i) evaluating the practicality, effectiveness and cost of the use of environmental monitoring under a range of conditions;

(ii) establishing and documenting environmental signatures associated with a variety of nuclear activities (with an emphasis on uranium enrichment, reactor and reprocessing operations) at both long and short range;

(iii) establishing and documenting sample collection and analytical procedures and quality control requirements; and

(iv) establishing a "clean room" sample handling and screening capability at Seibersdorf (see paragraph 29), extending the existing network of analytical laboratories to include the capabilities for the analysis of environmental samples and establishing certification requirements for laboratories added to the network.

Substantive progress has been made in all areas.

22. Any production or manufacturing process loses some small fraction of the process materials to the immediate environment. The extent of the losses depends on a wide variety of things including the nature of the process, the material, the control measures to limit losses and the migration of losses beyond the immediate environment. Control measures depend primarily on the value of the material and the risk losses represent to human health and the environment. The processing of nuclear materials is no exception, and even though great care is taken to limit losses, they inevitably occur and migrate beyond the immediate environment where the loss took place. Further, nuclear materials have specific physical properties (e.g., radioactivity) that make it possible to detect and characterize losses that may be present in the environment in only very small quantities. This capability together with the possibility that specific signatures can be unambiguously correlated with specific nuclear processes is why environmental monitoring is seen as having promise with respect to the detection of undeclared activities. The goal of the environmental monitoring field trials is to demonstrate and, where possible, calibrate the utilization of these methods for safeguards application.

23. Following the December 1993 Board of Governors Meeting a number of additional Member States responded to the Secretariat's request for help with offers to host field trials and provide other related technical assistance. Consultations with the Member States identified potential sites and in late February 1994, a detailed planning exercise was carried out to schedule the sample planning and collections. The field trials and their schedules are as follows:

Country	Facility Types	Schedule
Sweden	reactors	13-27 Sept. 1993
Hungary	reactors	27-29 Oct. 1993
U.S.A.	enrichment	22-25 March 1994
Japan	reprocessing	11-15 April 1994
South Africa	enrichment	11-19 April 1994
Argentina	enrichment	6-13 May 1994
Indonesia	research center	17-20 May 1994
South Korea	research center	23-27 May 1994
Russian Federation	reprocessing	20-25 June 1994

24. Additional environmental samples will be collected in connection with the broader field trials in Australia, Canada, Finland and Sweden being planned under Task 4. Decisions have not yet been made regarding the location and schedule for field trials in the Czech Republic, Germany and The Netherlands. The sample analysis capacity of the expanded network of laboratories in combination with reporting requirements of "Programme 93+2" dictated that the sample collections be organized and carried out as quickly as possible. The number of samples collected in each field trial varies considerably depending on the sample medium being examined and the type of facility. The overall sample volume is high. For example, in the South African field trial nearly 600 samples (smears, vegetation, soil and water) were collected at 57 sampling points.

25. The emphasis in the scheduled field trials is on short range monitoring in that all planned sample collections are in the vicinity of nuclear facilities. The sample collection plans are being constructed in a manner to provide information on the distances away from facilities that various signatures can still be detected. This will allow some inferences regarding the long range detection problem, however, currently planned field trials do not include the evaluation of long range monitoring through the collection of high volume air samples or the sampling for gaseous effluents.

26. Some results from the field trial in Sweden carried out in mid September 1993 were reported (IAEA-SM-333/69) on during the March 1994 Safeguards Symposium in Vienna. Water, sediment and biota samples were collected in coastal waters in the vicinity of five nuclear facilities. A total of 30 locations were selected for sampling. The sampling locations were chosen to extend from the outfall of each facility to 20-30 kilometers in each direction along the coast. Results from the trial show that nuclear operations in coastal areas can be detected in water and sediment samples up to 20 kilometers from the facility depending on

local transport and mixing conditions. Nuclear reactor operations can be detected by the presence of activation products. A minute quantity of plutonium (~ 10^{-15} grams/liter) isolated from a high volume water sample taken near a research facility showed high burn-up isotopics consistent with spent fuel characterization studies being conducted there. Sediment samples, taken in the same area, show the presence of lower burn-up Pu which represent an integrated history of the activities at this facility. Sediments from other locations showed only fallout plutonium and were clearly distinct from those collected in the vicinity of the facility. Preliminary results from the Hungarian field trial show the presence of Cs-isotope signature in sediments taken at and downstream (40 kilometers) of the reactor site. No such signature was observed upstream from the site.

27. Technical assistance being provided by Member States in support of the evaluation of the applicability of environmental monitoring to safeguards includes the analysis of environmental samples, the use of advanced analytical methods and sample collection technologies, training in sample collection techniques and detailed literature reviews.

28. The United States has nominated five laboratories for inclusion in the expanded network of laboratories to assist the Secretariat in the measurement of environmental samples. Specialized laboratories in other Member States (e.g., France, Russian Federation, UK, and in the European Union) have also been used for the analysis of environmental samples. A sample distribution and reporting protocol that protects the identity of the samples is in place. Member States hosting environmental monitoring field trials under Task 3 have been invited to participate in the analysis of parallel samples. Laboratories in these Member States will be considered for inclusion in the Secretariat's expanded network. An Agency procedure has been developed for auditing the quality assurance programmes of candidate laboratories before accepting their participation in the expanded network.

29. The clean laboratory for safeguards is being handled as a separate Agency project by a Management Overview Committee and a Task Force with established terms of reference. The Agency has solicited and received a quotation for the planning and design of the clean laboratory from the Austrian Research Centre in Seibersdorf. A cost-free expert from a Member State has been recruited to assist in the design and installation of the clean laboratory and in the transfer of sample handling and measurement techniques.

30. The results from the currently scheduled field trials should provide a basis for at least an initial evaluation of the applicability of environmental monitoring to safeguards. The field trials have been scheduled such that the evaluation, together with the identification of any open questions, will be complete by the end of 1994. Cost information necessary to support a cost-benefit analysis will also be available. The clean laboratory is expected to be in operation before the end of 1995.

Task 4: Increased co-operation with State Systems for Accounting and Control (SSAC) and other measures for improving the cost-effectiveness of safeguards

31. Task 4 has three objectives:

(i) to assess measures other than environmental monitoring to strengthen safeguards by providing an increased assurance of the absence of undeclared nuclear activities in a State;

(ii) to assess how, and under what conditions, increased co-operation with SSACs could be achieved and what savings could result; and

(iii) to assess the possibilities for cost savings in traditional safeguards activities resulting from the strengthening of the safeguards system.

These three objectives reflect the merger of the original tasks 2 and 4 as reported in GOV/INF/729. Progress is reported below for each of the three objectives.

Strengthening measures

32. The strengthening measures being assessed in Task 4 are based primarily on increased transparency which involves two complementary features - increased physical access (openness) and increased access to information (broader declaration). Current requirements regarding a State's declaration to the Secretariat are limited to nuclear material (from the starting point of safeguards), associated processes (to the extent the process related information is needed to safeguard the nuclear material), and nuclear facilities and design information (for facilities containing or expected to contain declared nuclear material) within a State's territory or under its control. Board of Governors decisions regarding the early provision of design information and the voluntary reporting scheme have strengthened the declaration process. The broader declaration being considered in this task, in combination with certain verification activities, is intended to make a State's nuclear fuel cycle and

associated activities as "transparent" as possible. Current thinking regarding the contents of this broader or expanded declaration is that it should include, in addition to all nuclear material, a description and the location of all nuclear related processes, production, research and development and training. A model expanded declaration has been developed as a programme working paper and is being used by the Secretariat in preparatory consultations with Member States hosting field trials. Suggestions on the further development of an expanded declaration have been received by the Secretariat from three Member States.

33. Inspector access has been a key issue since the beginning of safeguards. Access for routine inspections, under a comprehensive safeguards agreement, is limited to specific points (called "strategic points") deemed necessary for the Secretariat to meet its safeguards obligations. Wider access will be tested in the course of the field trials, defined in terms of:

(i) access at any time and without advance notice, and

(ii) "managed" access for the purpose of protecting sensitive information.

This will include access based on specific information or the need to implement a technical measure (e.g., environmental monitoring). The level of access may vary from one field trial to the next. However, a number of access related elements have been identified which provide the Secretariat with a consistent position in the preparatory consultations with Member States. The access requirements do not involve, literally, "any time, any place", without notice, but they do involve very broad access both within and outside facilities containing nuclear material subject to safeguards and other locations identified in the expanded declaration - and at short or no notice. "No notice" is taken to mean no advance notification regarding the timing, activities or location of an inspection. The access arrangements are intended to permit the Agency to be able to gain the necessary access and carry out the necessary activities while recognizing the State's right to protect non-relevant sensitive information.

34. Access is absolutely key. Even without a high quality expanded declaration, wider access would still represent an improvement over the current system with respect to increased assurance regarding the absence of undeclared activities. "Transparency" is an acquired state achieved through a high level of cooperation between the Member State and the Secretariat involving access - access to information and physical access. The field trials in Australia, Canada, Finland and Sweden are being defined and carried out in this spirit. Field trials in three of the four States are under way. The role of the SSAC in facilitating the strengthening measures and the costs of implementing them are being assessed as part of the programme.

Increased co-operation with SSACs

35. Co-operation between a State System of Accountancy for and Control of nuclear material (SSAC) and the Secretariat is a necessary condition for achieving effectiveness of safeguards implementation. In most cases the SSAC's role in such co-operation has involved the provision of information required under the safeguards agreement with regard to inventories of nuclear material and their changes, the securing of access to facilities and to nuclear material and the establishment of an accountancy system at facility and State levels. The approach under Task 4 is to evaluate the possible degree of increased co-operation, commensurate with SSACs resources and capabilities and with the Secretariat's need to maintain effectiveness and draw its own independent conclusions. The experience gained in developing the New Partnership Approach with Euratom has been used in developing the approach under Task 4. Some technical elements from the New Partnership Approach are to be tested in the field trials in Sweden.

36. The first step was to devise a questionnaire, to be completed by SSACs, to establish the technical and manpower resources, operational capability, legal powers, information holdings and administrative structure of the SSAC. The questionnaire has been completed and sent out to a few SSACs on a trial basis and some revisions made on the basis of comments received.

37. The next step was to devise a model pattern of increased co-operation by listing all of the candidate activities, largely, but not entirely, related to inspections, which a SSAC could perform, either by itself or jointly with the Agency, in order to increase the efficiency of Agency verification activities, and hence reduce the Agency's costs, or to reduce the extent of Agency activities. The critical requirement against which all of the candidate SSAC activities are tested is that safeguards effectiveness and the Agency's ability to draw independent conclusions are maintained. A subdivision into three levels of cooperation, as identified by SAGSI, is being used. These levels include forms of cooperation for which no decision has been taken.

enabling activities

- greater involvement of the SSAC as foreseen within the existing terms of safeguards agreements, in pre-inspection arrangements and other preparatory activities, such as the provision of material declarations in an automated form and standardized format to increase the efficiency of Agency inspections;

joint or shared activities

- shared activities and equipment that could incorporate such things as

  (i) joint research and/or development projects and training programmes,

  (ii) shared laboratory and other measurement equipment,

  (iii) commonly developed and implemented safeguards approaches, sampling plans, calibration and measurement procedures,

  (iv) expanded use of containment and surveillance measures,

  (v) common evaluation of the performance of measurement systems (using data identified by the Secretariat), and

  (vi) joint efforts to identify and solve problems; and

SSAC inspection activities

- the taking into account by the Secretariat, under specified conditions, of results of SSAC inspection activities with the intent of reducing the extent of Secretariat inspections while maintaining effectiveness and the need for the Secretariat to reach its own independent conclusions.

Co-operation arrangements, and the conditions needed to ensure the Agency's effectiveness and independence, are being tested in field trials with the States mentioned above.

38. Based on the revised questionnaire, the structure, capabilities and resources of the SSACs for all non-nuclear weapon States having a comprehensive safeguards agreement and a significant nuclear fuel cycle will be evaluated. Each SSAC will be fitted into the model described above, according to its capabilities, and an estimate made of the cost savings that would arise if the increased cooperation were implemented. Finally, the issue of regional systems (RSACs) is being addressed. The features which might be characteristic of a regional system, along with some initial criteria, are being examined.

Cost-savings in traditional safeguards activities

39. An increased assurance in the absence of undeclared activities, advances in technology and new approaches could lead to the possibility of reducing the present costs of safeguards aimed at detecting the diversion of declared nuclear material. Task 4 will assess the effectiveness of the strengthening measures in increasing the assurance of the absence of undeclared activities. In the context of this increased assurance, elements of the present safeguards system, e.g., timeliness inspection activities for irradiated fuel, will be assessed to see if they can be done differently (possibly with the aid, also, of advanced technology), or less often, or not at all. The cost savings and impact on effectiveness of such approaches can then be assessed.

40. Wherever possible, approaches will be designed to be equally applicable in all States with comprehensive safeguards agreements, i.e., to generic facility types or broad categories of nuclear material, but it should be noted that the effort required to produce the same level of assurance of the absence of the undeclared nuclear activities, particular with respect to using environmental monitoring techniques, may vary among States depending, for example, on the extent of their nuclear activities. It is planned to test approaches at light water reactors, on-load reactors, fuel fabrication plants, irradiated fuel storage facilities and research reactors in field trials in the States mentioned above.

41. By the end of 1994, all of the elements described above will have been tested under field trial conditions. This should provide sufficient data to give an initial indication of the costs and effectiveness of strengthening measures and of the cost savings, and any impact on effectiveness, achievable through increased co-operation with SSAC or through new approaches. It is likely that further trials continuing well into 1995 will be required to refine the approaches tested.

Task 5: Improved analysis of information on States' nuclear activities

42. Task 5 focuses on the analysis of information available to the Agency about a State's nuclear activities. The objective of the task is to ensure the development and establishment of a coherent and comprehensive approach to the acquisition, management and analysis of information from open sources, safeguards inspection data (including results from environmental monitoring), the reporting scheme on imports and exports of nuclear material and exports of specified equipment and non-nuclear material, design information and the expanded declarations referred to in Task 4. A highly disciplined and phased approach is being taken to ensure that the resulting information system will use Secretariat resources

effectively to identify at an early stage any instance in which the available information about a State's nuclear activities appears to be inconsistent with its declaration to the Secretariat.

43. Work underway in this task is focused on three areas:

(i) development of a diversion critical path structure,

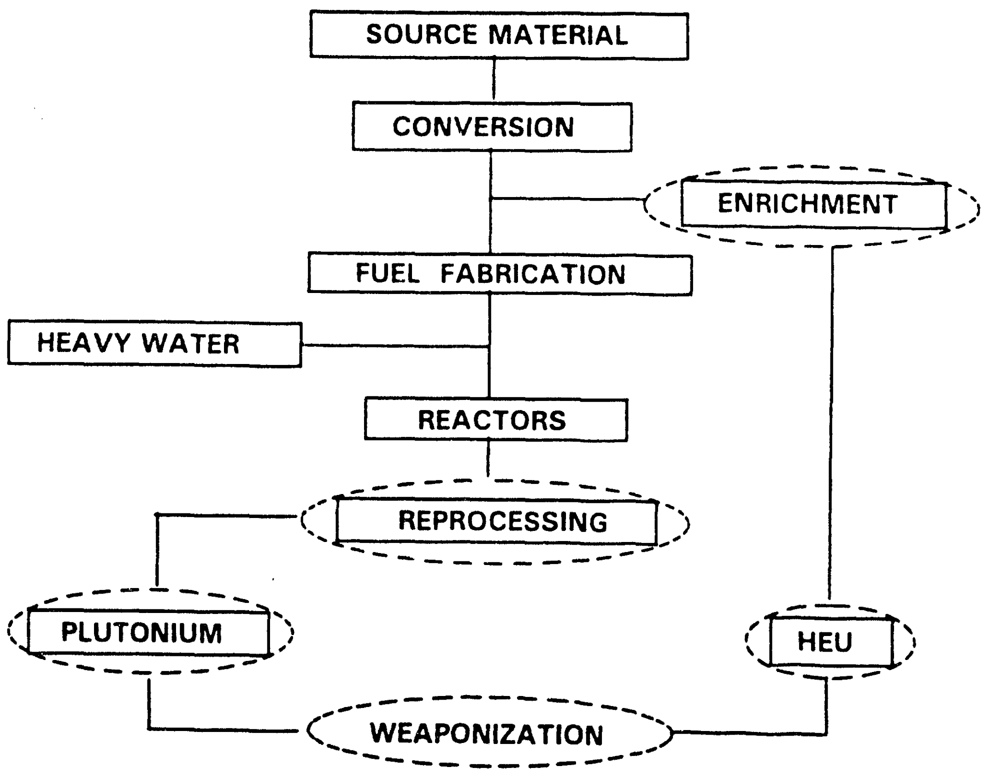
(ii) the identification and evaluation of potential information sources, and

(iii) the identification and development of computer hardware and software for information management and analysis.

Diversion critical path

44. With expert assistance from Member States, a diversion critical path is being developed as a means to structure both the information and analysis requirements. A highly simplified representation of the diversion critical path is depicted below:

DIVERSION CRITICAL PATH



The objective is to define all known pathways for the production of weapons usable material and subsequent weaponization. For example, the conversion block would include all known processes for the conversion of ore concentrates to the chemical forms required for feed to the various enrichment processes, for the fabrication of reactor fuels and the production of metal and all intermediate conversion steps. Each process is identified as a node in the pathway and any combination of nodes that could result in weapons usable material is a viable part of a critical path. Each node, in addition to the process description, is characterized by any special equipment, infrastructure and non-nuclear material requirements and the potential environmental signatures (e.g., from the detailed literature reviews carried out under Task 3). The weaponization block will be largely comprised of equipment and material signatures. The process identification and descriptors for this block will be limited to such things as the production of tritium, enriched lithium and alpha-emitting radionuclides.

45. The diversion critical path will provide a structure for the analysis of environmental monitoring results, import-export data, design information, etc. and give a basis for the evolution of the model expanded declaration (Task 4) in terms of process details and associated equipment. The critical path structure also provides a template for the expanded declaration to guide the inspection process. It will take into account the possibilities for shortening any of the paths to weaponization at each of the fuel-cycle steps through external procurement and assistance. The activities declared by a State as constituting their nuclear related research and development programme will be placed in this same critical path structure.

Potential information sources

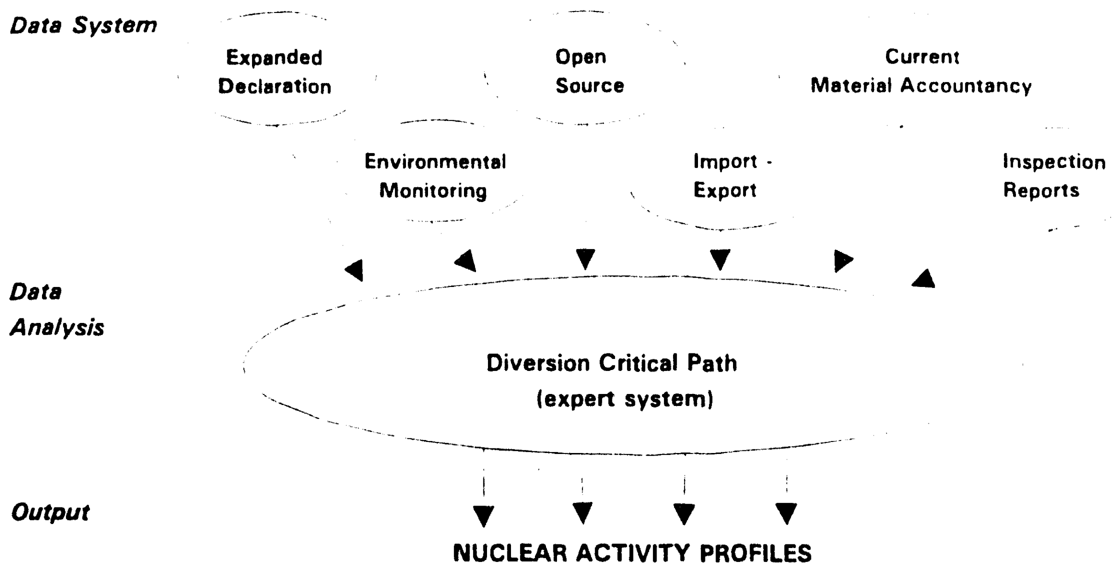
46. This task element has thus far identified, evaluated and attempted to utilize information from Secretariat data bases and from certain open sources. A computerized system for storage and retrieval of safeguards-relevant information derived from open sources (e.g., public media, scientific publications) has been established and periodically updated. The system incorporates safeguards-relevant information from existing Secretariat databases on power (PRIS) and research reactors (RRDB) and nuclear fuel cycle facilities (NFCIS). It also contains a broad spectrum of information on State's nuclear regulations, energy requirements, production and resources, nuclear and nuclear-related programmes, States' international cooperation, companies, firms and organizations working in nuclear field. The system also includes openly published information on exports and imports of nuclear material, technologies, facilities, equipment, including dual use items, that complement the corresponding information provided to the Agency by the State officially (e.g., the reporting scheme and the expanded declaration). The transfer of information to the relevant users in the Department of Safeguards is already being improved. The analysis of collected

information is being used for further assessment of the expanded declarations provided by the States participating in field trials of measures to strengthen the safeguards system.

47. A number of other open information sources have been identified and are being evaluated. Examples include the International Nuclear Information Systems (INIS) - this is a Secretariat data base containing approximately 1.5 million documents covering a broad spectrum of nuclear related subjects, and the information published as part of the Emerging Nuclear Suppliers Project (ENSP). Assessment of the potential contribution of the various types and sources of information is part of Task 5. Information from exporting States on actions on export license applications (e.g., denials) for dual-use commodities has been identified as a potentially valuable addition to the information provided under the reporting scheme.

Identification and development of computer hardware/software capabilities

48. The work in this area has been to identify commercially available software necessary to meet the information management and analysis needs being identified in Tasks 3, 4 and other parts of Task 5. Examples include a geo-referenced data management system for the environmental monitoring data and parts of the expanded declaration and text processing capability for the open source data base. The intent is to maintain a high level of flexibility through a modular structure such as that depicted below.



The work in this task element, as in others in Task 5, is being heavily supported by Member State Support Programmes.

49. The work on the diversion critical path and the procedures for evaluation of open source information are expected to be complete by the end of 1994. Organizational elements and work on computerization, together with estimates of the resources necessary to fully implement the system, will continue well past that time.

Task 6: Enhanced safeguards training

50. Task 6 of the programme is concerned with the identification, development and implementation of training programmes required to ensure that the staff of the Secretariat have the necessary skills to carry out the new measures to strengthen and improve the cost effectiveness of safeguards and, in general, with training to deal with expanded safeguards requirements. Completion of the task will ensure that a training base has been established should decisions be made in the future to proceed with routine implementation of some or all of the measures being tested.

51. Training, either as elements added to existing training courses or as new training courses, dealing with design information review, increased co-operation with SSACs, and environmental monitoring has been incorporated in the Secretariat's overall training programme. Training on measures to strengthen safeguards and on the analysis of information on State's nuclear activities is being planned.

52. Training on design information review, with an emphasis on reprocessing and enrichment facilities, for operating, shut down and permanently closed facilities has been prepared and incorporated in training courses ("Safeguards at Reprocessing Facilities" and "Placement of New Facilities under IAEA Safeguards"). Special exercises and workshops on design information review are being held at Member States' facilities. Several Member States (Belgium, Germany, the USA) have been requested to identify some permanently closed down facilities to be available for the IAEA training exercise on design information review activities. Positive response has been received from Belgium, and a technical visit is planned for June 1994.

53. In addition to traditional IAEA training courses for State systems organized at different levels, a new training course, "IAEA safeguards for SSAC personnel", is being developed which will emphasize different aspects of the IAEA activities in the field of international safeguards directly related to co-operation with State Systems. The new course will be given for the first time in October 1994 at Headquarters, Vienna. The part of the

completed questionnaires on SSACs, prepared within Task 4, that deals with training activities or training needs of State systems is being analyzed to identify other opportunities for co-operative or joint training programmes. As an example of increased co-operation between EURATOM and the IAEA, a joint training programme based on the New Partnership Approach is now being developed. The training programme will be implemented by both organizations on an annual basis.

54. The environmental monitoring field trial carried out in the vicinity of an enrichment facility in the U.S. during March 1994 was organized as a joint sample collection and training exercise. Eleven Secretariat staff were trained in effective sample collection planning, sample media and sample collection and handling techniques. Emphasis was placed on methods to avoid cross-contamination. Procedures that incorporate the elements of this training exercise have been developed and are being utilized in the on-going field trials. The staffing of the field trials is being organized in a way to expand the base of trained personnel (i.e., on-the-job training). The Secretariat, with the help of two Member State Support Programmes, is developing a more formal and extensive training course to support environmental monitoring.

55. Other training being planned in support of "Programme 93+2" must necessarily await developments elsewhere in the Programme. A training exercise that generally supports the strengthening measures of Task 4 through a broadening of inspector observational skills is being developed through a Member State Support Programme. Other, more specific training needs will be identified in the course of the Task 4 field trials. A similar situation exists with respect to the information analysis task. Training on a multi-media geo-referenced information storage and retrieval system is underway, and training on other commercially available software has been requested. The training necessary to implement the systematic analysis of information on State's nuclear activities has yet to be identified.

56. In addition to the training described above, the work of Task 4 and 5 will be far enough along by the end of 1994 that the training elements necessary to implement the proposed measures can be identified. The costs associated with training support for the proposed measures will be assessed.

Task 7: Proposal for strengthening and improving the efficiency of the safeguards system

57. The integration of the results of Tasks 1 to 6 into proposals for more effective and efficient safeguards will be the final part of the programme and will be dealt with in Task 7. The proposals will be assessed for effectiveness, cost and the possible trade-offs among the

strengthening measures and certain elements of the current system. The relative merits of the proposals will be fully explored and presented. Task 7 will also incorporate a description of any legal implications of the proposals. Furthermore, new administrative and legal measures will be addressed aimed at facilitating safeguards implementation regarding such issues as designation of inspectors and visa requirements. From this analysis the Secretariat will be in a position to make a detailed proposal to the Board on a strengthened and more cost-effective system which will cover both the safeguarding of declared material and facilities and the detection of undeclared activities.

58. An element of each of the tasks is the assessment of the legal issues associated with the measures under consideration. This analysis

(i) addresses the scope of the IAEA's existing authority within the terms of current safeguards agreements to carry out the measures considered by the various task groups,

(ii) identifies the extent to which additional authority is necessary to permit the IAEA to implement such measures, and

(iii) describes, where necessary, legal arrangements or instruments for securing the Agency's right to do so.

59. It is possible even at this stage to identify a number of basic issues related to the Agency's right of access to various categories of locations, the purposes or activities for which such access may be requested and the role of the Board of Governors and of individual Member States party to safeguards agreements in effectuating the various proposals. Apart from ascertaining the Agency's right to carry out activities as they are developed in the course of "Programme 93+2", and proposing mechanisms for securing, where necessary, additional legal authority, it is anticipated that other corollary legal issues might arise, for example, in the context of contractual matters, administration (e.g., travel arrangements, regional offices), health and safety, and liability. These issues will also be addressed.

Annex 4

Country Officer Responsibilities, 1993-02-05

1993-02-05

Country Officer Responsibilities

1. General

A Country Officer and Alternate for each State is nominated by the Director of the Division of Operations, and both have the same level of responsibilities. In implementing her/his activities the Country Officer follows Departmental and Divisional instructions and guidelines. The functions and responsibilities assigned to the Country Officers are additional to the current safeguards activities, and they will not replace any functions and responsibilities currently assigned to sections/units in the Divisions of Operations.

The basic responsibilities of the Country Officers are to have at all times an up-to-date knowledge about safeguards- and other proliferation-relevant situations, and nuclear and nuclear-related activities, that are directly relevant to the implementation of safeguards, for each designated State. Such information may give an early indication of nuclear and nuclear-related activities in the State which may be inconsistent with the State's safeguards and non-proliferation undertakings. The Country Officer should be conversant with the current and anticipated safeguards implementation in the designated State as well as nuclear and nuclear-related activities using all available data sources including those required to perform an enhanced analysis.

2. Country Officer Responsibilities

The Country Officer has the following responsibilities:

a. Prepare and maintain the country file.
b. Inform line management about activities which might be inconsistent with the State's safeguards and non-proliferation undertakings, and other problems related to safeguards implementation.
c. Prepare contributions to the divisional Country Status Reports and to prepare specific reports, as requested.

The following activities are conducted by the Country Officer to fulfill these responsibilities:

- Monitor, review, analyze, document and follow-up, as necessary, information available from non-safeguards sources on safeguards, on other non-proliferation-related matters, and on nuclear activities; and, where appropriate, compare this information with that available through routine safeguards implementation activities.

- Compile and analyze information which might indicate possible inconsistencies with the State's safeguards undertakings and safeguards-related problems identified through safeguards implementation activities, including:

    - material accountancy,

- transit matching,
- timeliness of reporting,
- nuclear material exempted, terminated, suspended or substituted in the course of safeguards implementation,
- inspection goal attainment,
- other information obtained by inspectors in the field,

or through other additional or special reporting arrangements with the Agency.

- Maintain records concerning anticipated facilities, locations, materials and other items which may be subject to safeguards.

- Document information on the SSAC and assess its functionality and effectiveness.

3. **Reporting Procedures**

To serve as the basis for up-to-date status summary the Country Officer will prepare a comprehensive country status report in January each year, covering the previous year. The format of the comprehensive report, which is to be developed, will include the following elements:

- findings, if any, in respect of possible inconsistencies with the State's safeguards or non-proliferation undertakings;
- nuclear and nuclear-related activities in the State with special emphasis on activities related to the acquisition or construction of new facilities, and/or development of new elements of the nuclear fuel cycle;
- acquisition of sensitive nuclear and non-nuclear materials; or nuclear technologies and equipment;
- matters related to anticipated facilities, locations, materials and other items which may be under safeguards;
- developments in respect of safeguards and proliferation-relevant situations.

The report will be completed by the Country Officer, reviewed by the Section Head and submitted to the Head of Procedures and Support Section. The latter will ensure its accuracy, completeness and consistency and use it as part of a divisional Country Status Report on all relevant States to be provided to the Director of the Division of Operation for subsequent submission to the DDG-SG.

The comprehensive report will be routinely up-dated through the year and will be available at short notice for the Director.

In cases where inconsistencies and problems related to a State's safeguards or non-proliferation undertakings have been identified, a report by the Country Officer through the Section Head to the Director of the Division of Operations, with a copy to the Section Head of the Procedures and Support Section, shall be made without delay.

The reports are to be classified as "Safeguards Confidential".

4. Support of the Activities of Country Officers

It is envisaged that the Support Divisions, SEE, SPR and the Procedures and Support Sections in Operations will assist Country Officers and Alternates in handling and analyzing the information on safeguards and non-proliferation undertakings and the nuclear and nuclear-related activities of each State. In particular, the support will be provided in the following tasks:

- Collection, review, preliminarily analysis, and documentation of the information from open publications and documents on safeguards and non-proliferation issues and nuclear and nuclear-related activities in States on a continuous basis and preparation of such information for entry into computer data bases (SGCP, SGIT).

- Preparation of initial sets of information on nuclear and nuclear-related activities in States based on open publications and documents for Country Officers' analytical purposes (SGCP).

- Provision of specific sets of safeguards data and information on nuclear and nuclear-related activities in States for use by Country Officers in their analytical activities, as required (SGIT, SGCP, SEE, SGDE).

- Establishment and enhancement of data processing environments (e.g., local and wide area networks, information computer systems and data bases), and data entry, storage, retrieval and organization to facilitate analysis (SGIT in cooperation with SGOs, SGCP, SEE).

- Conduct, as required, of enhanced analyses of nuclear and nuclear-related activities of States (SGCP, SEE, SGIT, SGDE).

- Forecast of nuclear material and facilities expected to be under safeguards, and estimation of plutonium and highly enriched uranium production at facilities (SGCP).

- Training and support of Country Officers in information handling, including the operation of relevant computer information systems and the use of specialized methods of analysis (SGDE, SGCP, SGIT).

5. Structure and Content of a Country File

For the purposes of analysis of nuclear and nuclear-related activities in each State, the following scope of information is recommended for use by Country Officers and Alternates for documentation, review and, if necessary, investigation.

In order to standardize the structure of information assembled for each country and to facilitate subsequent input of this information into computer data bases it is recommended that all information selected for documentation will be grouped on a country basis into data categories (subjects), as specified in the Table. The Table also shows the particular set of information associated with each data category. Pending availability of a country file computer system it is recommended to create and keep a hard-copy file for each data category.

The open information listed in the Table (data categories 1-11) in respect of nuclear and nuclear-related activities in a State are mainly collected, reviewed and preliminarily analyzed by the Support Divisions (SGCP, SGIT).

Information listed in data category 12, as a rule, is safeguards confidential and already part of ISIS and will be reflected in the Country Officer's file, as needed for analytical purposes. Specific information will be provided by SGIT at the request of the Country Officers. Information on SSAC (data category 13) will be collected by inspectors and/or was reported by the State. Information referred in data category 14 is compiled by the Country Officers as the result of their analytical activities.

The structure and content of the country file will be revised on the basis of experience gained.

The Annex contains recommended sources of information and data.

TABLE

Structure and Content of a Country File

Data Category/Data Sub-Category	Content
1. Nuclear regulations, safeguards and organization of nuclear activities 1.1 Nuclear law, policies, regulations and organization 1.2 Nuclear export control and licensing 1.3 Safeguards and non-proliferation	Nuclear law; nuclear policies; nuclear regulations; nuclear export control; management of nuclear material, facilities; licensing; safeguards and non-proliferation policies and status; authorities, responsibilities, organization and structure of nuclear activities; responsible bodies and organizations.
2. Energy requirements, production and resources 2.1 Energy requirements production 2.2 Nuclear resources	Energy production, requirements and resources; nuclear energy production; prospects of nuclear energy production; uranium and thorium resources.
3. Nuclear and nuclear-related programmes 3.1 Nuclear power programme 3.2 Nuclear R&D programme 3.3 Nuclear-related R&D programmes	Nuclear power and R&D programmes and activities (e.g. on nuclear fuel cycle, nuclear technologies); nuclear-related R&D programmes and activities (e.g. nuclear physics; fusion; experiments with deuterium, tritium and other sensitive materials; isotope production).
4. New nuclear technologies and elements of nuclear fuel cycle	Summary on the development and acquisition of new nuclear technologies and introduction of new elements of nuclear fuel cycle (with special emphasis on events related to future safeguards implementation and on the sensitive elements).
5. Facilities 5.1 Nuclear facilities 5.2 Nuclear R&D centers, laboratories 5.3 Nuclear-related facilities	Nuclear facilities in operation, under construction or planned, including ore/concentrate production sites, R&D nuclear centers and laboratories. Facilities and installations producing non-nuclear materials and equipment which could be used in nuclear facilities and for nuclear weapons development and manufacturing (e.g., heavy water, graphite, deuterium, tritium, lithium; equipment as listed in GOV/2589; dual-use materials and equipment, e.g. listed in INFCIRC/254/Rev.1/Part 2). Nuclear-related facilities, installations and sites (e.g. accelerators, fusion installations).
6. Exports and Imports 6.1 Exports and imports of nuclear materials 6.2 Exports and imports of specified equipment and non-nuclear material	Exports and imports of nuclear and non-nuclear material, nuclear and nuclear-related technology, equipment, services, with special emphasis to those which are suitable for the development and manufacture of nuclear weapons.
7. Nuclear and technical capabilities 7.1 Nuclear capabilities 7.2 Technology, human and financial resources	Availability of materials, facilities, equipment, enrichment and reprocessing capabilities, financial resources, high-tech and qualified personnel which could be involved in the implementation of nuclear weapons programmes.

Structure and Content of a Country File

Data Category/Data Sub-Category	Content
8. International cooperation 8.1 Cooperation agreements in nuclear and nuclear-related areas 8.2 Nuclear trade partners 8.3 Technical assistance	International cooperation in nuclear and nuclear-related areas (e.g., cooperation agreements; nuclear and nuclear-related trade; R&D cooperation; technical assistance from States, IAEA and other international organizations; trade and cooperation partners).
9. Companies and firms 9.1 Nuclear-related firms 9.2 High-tech firms	Specific companies, firms and enterprises producing or participating in the production of nuclear technology, nuclear or other sensitive materials and equipment, with emphasis to those which are suitable for the development and manufacturing of components of nuclear weapons; high-tech related to control and automated systems, including computer equipment.
10. Media Reports on trafficking in nuclear, non-nuclear materials and specified equipment 10.1 Nuclear material trafficking 10.2 Nuclear-related trafficking	Media Reports on trafficking in nuclear and non-nuclear sensitive materials and equipment, including those suitable for the development and manufacturing of nuclear weapons and its components. Consequent follow-up actions and conclusions on reported events.
11. Accidents and incidents	Accidents and incidents at nuclear facilities which might result in loss or diversion of nuclear and other sensitive material and equipment.
12. Safeguards information and data (safeguards confidential) 12.1 Accounting data 12.2 Verification information 12.3 Anomalies and discrepancies 12.4 Inspector's observations 12.5 Material and equipment transfers 12.6 Exemptions, terminations and substitutions	Portions of safeguards information and data which are required for the conduct of the analysis of safeguards and non-proliferation situations, nuclear and nuclear-related activities in a State, with identification of material type, facility type, facility name, location. Information is available in the Department in the course of safeguards implementation and other safeguards-related arrangements. Some information and data might be required for analytical purposes and could be requested by the Country Officers from SGIT, as needed. Such information may cover the scope as outlined below : Nuclear and non-nuclear material accounting information and data reported under the Safeguards Agreements. Design Information of the facilities and other locations subject to safeguards. Information on nuclear, non-nuclear material and equipment reported by States under additional or special arrangements with the Agency (e.g., imports/exports of nuclear material reported by Nuclear Weapons States (INFCIRC/207), early submission of Design Information, universal reporting). Inspection data and information including results of design information verification and facility records examination. Inspector's observations of nuclear and nuclear-related activities which might be associated with the existence of possible undeclared or clandestine activities. Anomalies and discrepancies. Status of confirmation of transferred nuclear material. Timeliness of reporting on nuclear material and equipment. Nuclear material exempted, terminated or substituted in the course of the safeguards implementation. Nuclear material present at the facility/location which may not be consistent with the operation mode and design of this facility/location.
13. SSAC	SSAC organization, structure and operation; SSAC authorities, responsible bodies. Information on cooperation with SSAC, and the level of SSAC effectiveness and functional independence.

Structure and Content of a Country File

Data Category/Data Sub-Category	Content
14. Analysis results (safeguards confidential) 14.1 Possible inconsistencies and non-compliances 14.2 Possible undeclared activities/facilities/materials 14.3 Analysis conclusions	Basic findings and results of the enhanced analysis : - Analysis of findings, in respect of possible inconsistencies with the Sate's safeguards and non-proliferation undertakings; - Analysis of nuclear and nuclear-related activities in a State; - Analysis of acquisition of sensitive nuclear technologies, equipment,and nuclear and non-nuclear materials; construction of new facilities and development of new elements of the nuclear fuel cycle. - Analysis of matters related to anticipated facilities, locations, materials and other items which may be under safeguards; safeguards and non-proliferation situation. - Identification of possible undeclared activities/facilities/materials.

ANNEX

Information Sources

1. Information obtained in the course of Safeguards implementation

1.1 Accounting and operating reports, Design Information and other information provided by the States under the Safeguards Agreements.

1.2 Inspection information obtained by the Agency in the course of Safeguards implementation (e.g. inspectors reports and working papers, examination of accounting and operating records, inspector's observations, debriefing notes and other information).

1.3 Reports provided by the States under special arrangements with the Agency (e.g., INFCIRC/207, universal reporting, early submission of the Design Information).

1.4 Information provided by the Agency to the States in the course of the Safeguards implementation (e.g., notifications to the States on book inventories, transit matching, timeliness of reporting; 90a and 90b statements).

1.5 Reports on inspector's observations on possible undeclared or clandestine nuclear activities at the inspected or other facilities/locations.

2. Information from open sources and documents

2.1 Information provided by the State to the Agency on its nuclear programme.

2.2 Information available in other Agency Departments, including computer data bases (e.g., INIS, NEFIS, DARE, Technical Cooperation, NFCIS, PRIS, RRDB).

2.3 Publications in the press (e.g., extractions from the press in the IAEA Daily Press Review including information stored in SG Non-Inspection Information System (SNIIS) Data Bases.

2.4 Periodical reports published by a State's Nuclear Authorities.

2.5 Reports and proceedings published by research centers, laboratories, installations.

2.6 Proceedings of conferences, symposia.

2.7 Scientific and technical books, journals.

2.8 Board of Governors and General Conference documents, including those on Technical Cooperation and nuclear activities in States.

2.9 Documents and publications of international organizations, governmental and non-government organizations, companies and firms.

2.10 Travel reports of IAEA staff.

Annex 5

SGCP Country Information System (SCIS)
Users Guide, 1993-11-19

SCIS:
SGCP Country Information System

User Guide

SCIS: SGCP Country Information System

User Guide

Version 1
1993-11-19

Prepared by:
SGCP and Documentation Group SGIT-IDD

Three levels of users for the SGCP Country Information System have been defined: the "normal user" who needs to search and retrieve data from the data base, the "superuser" who can perform data entry and data editing functions, and the system administrator who is responsible for maintaining the system, i.e., making changes to the system itself.

This manual is intended for the "normal user" of SCIS: the Staff in the IAEA Safeguards Operations Divisions who need to retrieve information from the SCIS data base. It provides a concise overview of the system and the data base and describes in detail how to use the data retrieval and printing functions.

The *SCIS: SGCP Country Information System, Superuser Guide* describes the functions performed by "superusers", and the *SCIS: SGCP Country Information System, System Manual* describes elements relevant to system maintenance.

In order to improve this guide, comments by users are welcome! Please use the "User's Comments" form included at the end of this manual.

This system was developed in SGCP.

Table of Contents

Association for Information and Image Management

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Silver Spring, Maryland 20910

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Centimeter

Inches

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3 of 4

1 System Description

1.1 Purpose

The Department of Safeguards needs to have easy access to comprehensive information on nuclear and nuclear-related activities, safeguards, and non-proliferation concerns of States in order to be able to implement the systematic analysis of information on nuclear and nuclear-related activities in each State. The Safeguards Section for System Studies (SGCP-PSS) has been collecting and analyzing information on nuclear related activities in States for many years. This information has traditionally been stored in hardcopy format

The SGCP Country Information System (SCIS) was established to facilitate the activities of PSS in collecting, storing, and processing information on nuclear and nuclear-related activities in states. The system may be used to support the activities of the Country Officers and to facilitate the effective analysis of the available data.

The Data bases of the system contain information for each State on its nuclear and nuclear-related activities, in particular:

- Nuclear Legislation/Non_proliferation/SG
- Nuclear energy: Production/resources
- Program: Nuclear/Nuclear_related
- Development: new NFC elements/technologies
- Facilities: NFC
- Facilities: Nuclear_related
- E/I: Nuclear material
- E/I: Specified equipment/material
- E/I: D_use equipment/material
- E/I: Nuclear_related equipment/material
- Capabilities: Nuclear/Technical
- Cooperation: International
- Firms/Organizations
- Trafficking
- Accidents/Incidents: Nuclear facilities
- Weaponization

The information contained in the data base is extracted from open publications, documentation, and other open information available to the Agency.

1.2 System Overview

The SGCP Country Information System is implemented using Mini-micro CDS/ISIS[1]. CDS/ISIS is a menu-driven generalized Information Storage and Retrieval system designed specifically for the computerized management of structured non-numerical data. This system has been modified to present a user-friendly interface for the specific functions required of the system. You do not need to be familiar with the CDS/ISIS system to be able to understand this

[1] Mini-micro CDS/ISIS was developed in UNESCO, Division of Software Development and Applications, Office of Information Programmes and Services

manual or to use SCIS.

The system is implemented via a set of menus and "pick lists" which support data entry, data editing, data retrieval, displaying, copying, and printing (in various sort orders) the data.

General principles for operating the system are described in the Section, "Operating the System", page 7.

How to retrieve and view the data is described in Chapter 3, page11.

How to print and copy retrieved data is described in Chapter 4, page 19.

Data Entry and Editing functions are described in the manual *SCIS: SGCP Country Information System, Superuser Guide* which describes the functions performed by "superusers".

Information relevant to maintaining and tailoring the system are described in the *SCIS: SGCP Country Information System, System Manual.*

1.3 Security and data access

The data in the SCIS data base is collected from open sources, the data is not confidential data. However, to provide controlled access to the data base, a system of passwords has been introduced. When you start the system, the system first prompts you to specify the access level (search, update, or admin) which you are authorized to use; the system then prompts you for your own password; see "Starting the System", section 2.4, page 7.

1.4 The Data Base

All the data of the SCIS system is stored in one "file" or logical data base: SCIS. When starting the system, the data base is allocated by the system and you can only access this one data base. Although various data formats exist according to the category of data, they are completely transparent to users. The format of the various data base records is self-defined and the system automatically uses the correct format (for retrieval, display, printing).

SGCP is responsible for maintaining the data in the data base.

The data stored in the system is indexed by country and according to a set of "main categories" and "subcategories". Each data category is associated with particular group of "attributes" and "keywords". These terms are all available online in the system and can be selected to define the retrieval criteria as described in chapter 3, page 11.

1.4.1 Main Categories

Main Categories are terms related to main elements of States' Nuclear and nuclear-related activities (see the list on page 3and also Appendix 1, page 1).

1.4.2 Sub-Categories

Sub-category items are a further refinement of main category concepts (see Appendix 1, page 1).

1.4.3 Attributes

Attributes are terms which identify the general substance of information related to main data categories and sub-categories. For each data category there is a set of pre-defined attributes (see Appendix 3, page 1).

1.4.4 Keywords

Keywords are lower level attributes; they identify the content of the particular record more precisely (see Appendix 4, page 1).

2 Getting Started

2.1 Installing the System

You need the following minimum configuration to be able to install/use the system:

IBM PC or compatible
640 K RAM
30 Mb disk space

To install the system, please contact Mr. Pouchkarev, ext. 2295.

This is still a test system; it will be installed on your own PC in directory SCIS on any hard disk drive; this documentation will assume that drive c: has been used.

2.2 User Support

If you need help or encounter a problem using the system, please contact Mr. Pouchkarev, ext. 2295.

2.3 Operating the System

The SGCP Country Information System is menu driven. Menu selection is done by moving the cursor, by using the up and down arrow keys, to highlight the desired option and pressing [Enter].

In general, when you press [Esc], the system will cancel the current operation and return you to the previous screen.

To assist you in specifying search criteria, the system displays lists relevant to the criteria you have selected, e.g., when you select **Country** on the Search menu, the system opens a box containing a list of countries, if you select **Data Main Category**, the box will contain a list of main categories. These lists may vary according to values you have selected for other criteria; for example, once you have selected a **Data Main Category**, the list displayed when you subsequently select a **Sub-category** will include only those sub-categories relevant to the main category.

The system, on many screens, will list the various options available to you. These options include, for example, pressing [Enter] to select or de-select an item, pressing [Esc] to exit the screen, or a list of function keys and their description.

2.4 Starting the System

Follow the steps below to start the system:

1. go to the DOS prompt on your computer; when you start your PC, you will generally be at the DOS prompt in drive c: (C:>);

2. type "scis";

3. the system prompts you to "Enter access code ..."; type "srch" and press [Enter] (note that the characters are not displayed as you type them);

4. the Micro CDS/ISIS title screen appears; press any key to start the system;

5. the SCIS Data Base Sign On screen appears, figure 2.1;

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+-----------------------------Data Base Sign On------------------------------+

+-------------------------SELECTION OF DATA BASE-------------------------+
|                                                                         |
+--------------------------- DEFINED DATA BASES --------------------------+
|                                                                         |
|      _ SCIS   - Data Base of SGCP Country Information System             |
|      _ xxxxx  - possible other data bases                                |
|                                                                         |
+-------------------------------------------------------------------------+
|                                                                         |
|                                                                         |
+-------------------------------------------------------------------------+

                    Press ENTER to select,  ESC - cancel
```

Figure 2-1: Country File Computer system, Data Base Sign On

6. the cursor is blinking on the SCIS data base; since all data you will need has been stored in the SCIS data base; press [Enter] to select the SCIS data base (other data bases may be made available in the future);

7. the system now prompts you to "Enter data search password:";

   Note: you will have been given your own password when your system was installed!

   type this password now and press [Enter] (again, the characters are not displayed as you type them);

8. the system opens the Country File Computer System main menu, figure 2-2;

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+-------------------------------------------------------------------------+

+-------------------------------------------------------------------------+
|                                                                         |
|                   _   S E A R C H/VIEW                                   |
|                                                                         |
|                   _   P R I N T   R E C O R D S                          |
|                                                                         |
|                   _   E X I T                                            |
|                                                                         |
+-------------------------------------------------------------------------+
```

Figure 2-2: Country File Computer System, main menu

10. you are now ready to work with the system: use the up or down arrow keys to select one of the three options available; turn to the chapter in this manual where

the options are described in detail: the **search/view** option is described in Chapter 3, page 11; the **print records** option is described in Chapter 4, page 19.

2.5 Exiting the system

To exit the system, press [Esc] repeatedly until the Country File Computer System main menu, figure 2-2, appears; select the option **exit** and press [Enter]; press [Esc] when the Data Base Sign On screen, figure 2-1, is displayed; the system returns you to the DOS prompt.

3 Data Retrieval

When you have selected the **search/view** option from the SCIS main menu, figure 2-2, the system displays the Country File computer System Search screen, figure 3-1.

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+----------------------------------Search-----------------------------------+

 SEARCH/VIEW

 COUNTRY :

 DATA MAIN CATEGORY :

 SUB-CATEGORY :

 Attributes :

 Keywords :

 Text (free search) :
```

Figure 3-1: Country File computer System, Search screen

3.1 Viewing Records

The system has automatically placed the cursor on the **search/view** option. If you press [Enter] at this point - without having specified any search criteria - you can view all records in the data base. If you have retrieved a subset of all records (described in Section "Entering Search Criteria", page 12), the system will display only those records selected as a result of the last retrieval which you have executed. The system displays the first record which has been entered into the data base, or the first record of the set you have retrieved, figure 3-2, in its default format.

```
+SCIS----------------------------    1 of    27------page   1   20 lines------+
|     Rec. No. 00001                                                         |
|     Country:             Argentina                                         |
|     Data Category:       Facilities: NFC                                   |
|     Data Sub_Category:   Facilities: Power reactors                        |
|     Facility name:       CAREM-15                                          |
|     Facility type:       LWR type.                                         |
|     Capacity:            25 MWe                                            |
|     Location:            Unclear                                           |
|     Material used:       LEU with less than 5% enrichment                  |
|     Supplier:            Argentina                                         |
|     Start-up:            Under construction (?), construction of one       |
|                          prototype unit should have been started inArgentina|
|                          in 1991                                           |
|     Safeguards:          No IAEA SG                                        |
|                                                                            |
|     Reference/Date:      Nucleonics Week, 91-04-11; Nucleonics Week,       |
|                          90-10-25.                                         |
|                                                                            |
|                                                                            |
|    **********                                                              |
|                                                                            |
+----------------------------------------------------------------------------+
  Esc - quit,  /PgUp - prev. page,  /PgDn - next page,  F2 - Format, F3 - GOTO
```

Figure 3-2: SCIS data base viewer

On the top line, the system indicates the name of the data base you are using, the number of the displayed record and the total number of records in the data base; it also indicates the number of lines and pages of the current record.

To navigate within the displayed records, use the following keys:

[Esc]	exit the viewer and return to the Search screen, figure 3-1,
[PgUp]	scroll to the previous record or to the previous page of the current record,
[↑]	scroll to the previous record,
[PgDn]	scroll to the next record or to the next page of the current record,
[↓]	scroll to the next record,
[F2]	use a different format,
[F3]	enter the sequential record number of the record you wish to view, for example, you can enter the number of the last record to go to the record which has been most recently added to the data base.

3.2 Entering Search Criteria

You can select records by any of the criteria, or combination of criteria, available on the Search screen, figure 3-1: **Country**, **Data Main Category**, **Sub-category**, **Attributes**, or **Keywords**. When you use a combination of retrieval criteria, they are logically connected by the boolean operator "AND". The details are given where relevant.

In addition to these pre-defined search criteria, you can also perform a **Text** search where you scan fields which contain descriptive information ("Text" field) for a specified text string; this option is described in Section 3.3, "Free Text Search", page 17.

3.2.1 Search by Country, Region, or Organization

You can make a pre-selection of records according to countries, regions, or organizations in which you are interested. Move the cursor to **Country** by using the up or down arrow keys and press [Enter]. The system opens a window containing a list of countries, regions, and organizations, figure 3-3.

```
+-------------------------COUNTRY FILE COMPUTER SYSTEM-------------------------+
+-----------------------------------Search-------------------------------------+

SEARCH/VIEW        +------COUNTRY--------------------------+
                   | Afghanistan                           |
                   | Africa                                |
COUNTRY :          | Albania                               |
                   | Algeria                               |
                   | Andorra                               |
DATA MAIN CATEGOR  | Angola                                |
                   | Antigua and Barbuda                   |
                   | Arab League                           |
SUB-CATEGORY :     | Arab World                            |
                   | Argentina                             |
                   | Armenia                               |
Attributes :       | ASEAN                                 |
                   | Asia                                  |
                   | Atomic Energy Forum                   |
Keywords :         | Australia                             |
                   | Austria                               |
                   | Azerbaijan                            |
Text (free search  | Bahamas                               |
                   | Bahrain                               |
                   +---------------------------------------+
           Press F10 when done, ENTER - select/deselect, ESC - quit
```

Figure 3-3: list of countries, regions, organizations

Move the cursor to the country, region, or organization for which you wish to retrieve records from the data base. You can do this either with the up and down arrow keys, by using [PgDn] or [PgUp].

Since the list is quite long, a short-cut to scroll directly to a specific item is available: simply start typing the country, region, or organization name on the keyboard. When you have typed the first letter of the name, e.g., "G", the system immediately scrolls to the first item in the list starting with "G". Note that the system also displays what you are typing in the bottom line of the box. If you type a further letter, e.g., "E", the system scrolls to the first item starting with "GE", etc. You can use the back space character to remove what you have typed; the system will reposition the list appropriately.

To actually select the country, region, or organization, press [Enter]. The system indicates that the list item is selected by inserting an asterisk, "*", in front of the name. To de-select an item, cursor to the selected item and again press [Enter], the asterisk disappears.

You can select one or more countries, regions, or organizations as your search criteria. When you are finished, press [F10]; the system returns you to the Search menu, listing the countries you have selected.

When you have used a combination of criteria to select records, they are connected by the following boolean logical operator AND.

To change your country, region, or organization selection once you have returned to the Search menu, simply select **Country** once more; repeat the selection, your new selection criteria will replace what you have selected previously.

If you request the **Search/View** option at this point, all the records containing information on the combination of countries, regions, and organizations you have selected will be displayed.

3.2.2 Search by Subject

You can use the search by subject option after you have selected one or more countries, or independently of a country selection. If you have not selected any country, all records in the data base will be searched for the subject category you have specified; if you have selected one or more countries, only that subset of records in the data base will be searched: the operator connecting the country and subject selection criteria is the logical "AND".

The option to search the data base by subject consists of two parts; you <u>must</u> first select a **Data Main Category**, then you can optionally select a **Sub-category**.

When you select **Data Main Category**, the system opens the data main category window from which you can select the category on which you wish to search, figure 3-4.

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+---------------------------------Search----------------------------------+

+---------------------------- MAIN DATA CATEGORY ----------------------------+
| Nuclear Legislation/Non_proliferation/SG                                  |
| Nuclear energy: Production/resources                                      |
| Program: Nuclear/Nuclear_related                                          |
| Development: new NFC elements/technologies                                |
| Facilities: NFC                                                           |
| Facilities: Nuclear_related                                               |
| E/I: Nuclear material                                                     |
| E/I: Specified equipment/material                                         |
| E/I: D_use equipment/material                                             |
| E/I: Nuclear_related equipment/material                                   |
| Capabilities: Nuclear/Technical                                           |
| Cooperation: International                                                |
| Firms/Organizations                                                       |
| Trafficking                                                               |
| Accidents/Incidents: Nuclear facilities                                   |
+---------------------------------------------------------------------------+
                  Press ENTER to select,  ESC - cancel
```

Figure 3-4: Main Data Category

Use the up and down arrow keys to cursor to the category you wish to select as your retrieval criteria and press [Enter] to select it. You only have one choice for this selection criteria; when you press [Enter] the system selects your choice and automatically returns you to the main Search menu. To enter a different main category, simply again select **Data Main Category** and select a new category.

If you do not select a sub-category and request a **search/view** at this point, records will be retrieved from the data base as though all sub-categories of the main category had been selected.

When you select **Sub-category** from the Search main menu, the system opens the sub-category window listing all sub-categories relating to the main category you have specified, figure 3-5. You can not select a sub-category without first having selected a main category. Note that in this case, the main category selected was "Facilities: NFC".

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+---------------------------------Search----------------------------------+

 SEARCH/VIEW

 COUNTRY :

 DATA MAIN CATEGORY :   Facilities: NFC
+-------------------------------- SUB-CATEGORY ------------------------------+
| Facilities: Conversion                                                    |
| Facilities: Enrichment                                                    |
| Facilities: Fuel fabrication                                              |
| Facilities: Heavy water                                                   |
| Facilities: Ore processing                                                |
| Facilities: Power reactors                                                |
| Facilities: Reprocessing                                                  |
| Facilities: Research reactors                                             |
| Facilities: Storages                                                      |
| Facilities: Waste processing                                              |
| Facilities: Nuclear R&D centres/laboratories                              |
| Facilities: Other locations                                               |
+---------------------------------------------------------------------------+
                  Press ENTER to select,  ESC - cancel
```

Figure 3-5: Sub-Category

Again you can select only one sub-category to further qualify your search criteria; and again the system automatically returns you to the Search main menu when you select an item.

Select **search/view** to look at all records in the data base for the sub-category (or, if you have selected combination of countries, all records for the countries and sub-category).

If you should select a different main category at this point, the system automatically blanks out the sub-category which you have selected.

If you wish to perform a more general search, e.g., facility type, programme type, etc., it is recommended that you perform the search by data main category and data sub-category.

3.2.3 Attributes Search Criteria

You may use the **attributes** search criteria either by itself, or in combination with any other search criteria. Attributes provide possibilities for searching for more general information, for example, facility type: "Facilities enrichment", "Facilities power reactors", etc.; facility status: "SG_no", "SG_yes", "Facility planned", etc. It is recommended to search with attributes when you would like to have information of a general nature (classes of information).

When you select **attributes** from the Search main menu, the system opens the attributes window listing the attributes search criteria, figure 3-6. The attributes relate to sub-categories but provide more possibilities for search.

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+----------------------------------Search-----------------------------------+

+Attributes---------------------------+
| FACILITIES                          |
| FACILITIES MILITARY                 |
| FACILITIES NFC                      |
| FACILITIES NUCLEAR                  |
| FACILITIES NUCLEAR-RELATED          |
| FACILITIES POWER REACTORS           |
| FACILITIES R&D NUCLEAR              |
| FACILITIES STORAGES                 |
| FACILITIES _CONSTRUCTION            |
| FACILITIES _OPERATING               |
| FACILITIES _PLANNED                 |
| LEGISLATION                         |
| SG-NO                               |
| SG-YES                              |
| TRAFFICKING                         |
| TRAFFICKING NUCLEAR MATERIAL        |
|                                     |
+-------------------------------------+
              Press ENTER to select, F10 - when done, ESC - cancel
```

Figure 3-6: Attributes list

You can select any number of attributes from the list: cursor to the one you desire and press [Enter]; they will be logically connected by "AND".

As for the Country selection option, a short-cut to scroll directly to a specific item is also available to perform the attributes selection: simply start typing the name of the attribute you wish to select. As soon as you have typed the first letter of the name, e.g., "F", the system immediately scrolls to the first item in the list starting with "F". Note that the system also displays what you are typing in the bottom line of the box. If you type a further letter, the system scrolls to the first item starting with the first two letters you have typed, etc. You can use the back space character to remove what you have typed; the system will reposition the list appropriately.

The system opens a further window to the right of the attributes window indicating which attributes search criteria you have selected, figure 3-7.

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+---------------------------------Search---------------------------------+

+Attributes--------------------------++selected: --------------------------+
| FACILITIES                          ||FACILITIES MILITARY                 |
| FACILITIES MILITARY                 ||FACILITIES _OPERATING               |
| FACILITIES NFC                      ||                                    |
| FACILITIES NUCLEAR                  ||                                    |
| FACILITIES NUCLEAR-RELATED          ||                                    |
| FACILITIES POWER REACTORS           ||                                    |
| FACILITIES R&D NUCLEAR              ||                                    |
| FACILITIES STORAGES                 ||                                    |
| FACILITIES _CONSTRUCTION            ||                                    |
| FACILITIES _OPERATING               ||                                    |
| FACILITIES _PLANNED                 ||                                    |
| LEGISLATION                         ||                                    |
| SG-NO                               ||                                    |
| SG-YES                              ||                                    |
| TRAFFICKING                         ||                                    |
| TRAFFICKING NUCLEAR MATERIAL        ||                                    |
|                                     ||                                    |
+-------------------------------------++------------------------------------+
              Press ENTER to select, F10 - when done, ESC - cancel
```

Figure 3-7: selected attributes

The attributes which you have selected will be connected by a logical AND when you execute the search (only records will be retrieved which meet all criteria specified). When you press [F10] the system returns you to the Search main menu, inserting your selected attributes. Then press [Enter] to retrieve selected records.

3.2.4 Keywords Search Criteria

Specifying keyword search criteria functions similarly as specifying attribute search criteria. Note that you can search by keyword alone, or in combination with other criteria.

Search by keywords provides you with the possibility to retrieve information on a particular subject, for example, you can search on facilities such as BWR type power reactors, laser enrichment facilities, exports/imports of tritium, etc.

When you select keywords from the Search main menu, the system opens the keywords window listing all keywords on which you can search, figure 3-8.

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+---------------------------------Search---------------------------------+

+Keywords----------------------------+
| FAC                                |
| FAC_NFC                            |
| FAC_NFC_COM                        |
| FAC_NFC_COM ALLOYS                 |
| FAC_NFC_COM OXIDES                 |
| FAC_NFC_COM PU                     |
| FAC_NFC_COM PU METAL               |
| FAC_NFC_COM PU OXIDES              |
| FAC_NFC_COM U                      |
| FAC_NFC_COM U MOX                  |
| FAC_NFC_COM U OXIDES               |
| FAC_NFC_COM U UF4/UF6              |
+L-----------------------------------+
              Press ENTER to select, F10 - when done, ESC - cancel
```

Figure 3-8: keyword list

Note that in the figure above, the initial letter "F" was entered at the keyboard, causing the system to position the keyword list at the first keyword starting with "F". You can also use the up and down arrow keys to scroll within the page of the list and the [PgDn] key to scroll to the next page. At the end of the list, using the down arrow key or [PgDn] will wrap back to the beginning of the list. To select a keyword, cursor to the desired keyword and press [Enter]; you can repeat this process for as many keywords as you require, however, keep in mind that, when you execute the search, the keywords you have selected are coupled by a logical AND, i.e., records will be retrieved only if they are indexed under all the keywords you have specified, and, of course, if the search criteria has a meaning.

The keywords you select are displayed in the Selected window which the system opens to the right of the keyword list window. When the list is complete, press [F10] to return to the Search main menu. If you re-select the **keyword** option, the new keyword list will replace your current list.

3.3 Free Text Search

In addition to any combination of search criteria (Country, Data Main Category, Sub-category, Attributes, Keywords), you can search for a specific text string. Although you can also use the free text search facility without specifying additional search criteria, it is not recommended that you do so. The system will read all records in the data base and this may take exceedingly long.

A text field has been defined for all records in the data base which contains relevant information in free text form. When you request a free text search, the system automatically scans the contents of this text field for the occurrence of the string you have entered on the screen.

Enter the desired search criteria as described in the sections above, then cursor to the **Text (free search)** option on the Search menu and press [Enter]. The system enters the edit mode and positions the cursor where you can enter your search text, Figure 3-9.

```
+-------------------------COUNTRY FILE COMPUTER SYSTEM-------------------------+
+-----------------------------------Search-----------------------------------+

 SEARCH/VIEW

 COUNTRY :  Argentina

 DATA MAIN CATEGORY :

 SUB-CATEGORY :

 Attributes :

 Keywords :

 Text (free search) :  █

EDIT: Replace
```

Figure 3-9: entering free text search criteria

You are now ready to type the text string which the system should use for searching.

Attention! It is important to type exactly the characters that should be used to scan the data base text fields. This means that you must be aware of the significance of using blanks (␣) in your search string. If, for example, you wish to search for the word "accident", enter the string ␣accident␣ (the word "accident" preceded and followed by a blank); in this case, the system will select only those records containing the word "accident". If you entered the string ␣accident (without a trailing blank), the system would retrieve also records which contain, for example, the string "accidental", "accident/incident", etc.You can, of course also include a group of words to be used in searching, for example, ␣nuclear␣accident␣.

When you have entered the text string as you require it, press [Enter]. The system places the cursor on the **Search/View** option of the Search menu. When you again press [Enter] the search is executed and you may view the retrieved records. **Note** that the text string which you have used as your free text search criteria appears highlighted wherever it occurs in the retrieved records (although the system only performs the search on the data base "text" field).

4 Printing Functions

The printing function allows you to make, not only a paper copy, but also a disk file copy of records. You can print or copy all records in the data base, or indicate a range of records in the data base; or, you can print or copy the records retrieved as a result of the last **search/view** that you have executed.

You also have the option to sort the records by country or subject, or to print the records in a concise format. To use the **print records** function, you must select the Country File computer System main menu, figure 2-2, which is displayed when you start the system. If you are currently in the **search/view** function, press [Esc] to return to the main menu. When you select the **print records** function, the system opens the print function print selection menu, figure 4-1.

```
+------------------------COUNTRY FILE COMPUTER SYSTEM------------------------+
+---------------------------------Print---------------------------------+

+---------------------------- PRINTOUT SELECTION ----------------------------+
|        _ eyplu  -  Standard printout of records (NO sort)                   |
|        _ eyplc  -  Standard printout of records (sorted by Country)         |
|        _ eypls  -  Standard printout of records (sorted by Subject)         |
|        _ eypcu  -  Concise  printout of records (NO sort)                   |
|        _ eypcc  -  Concise  printout of records (sorted by Country)         |
|        _ eypcs  -  Concise  printout of records (sorted by Subject)         |
|                                                                             |
|                                                                             |
+-----------------------------------------------------------------------------+

                    Press ENTER to select,  ESC - cancel
```

Figure 4-1: SGCP Country Information System, Printout Selection Menu

Select any of the options in the list. In each case, the system will present you with a further screen where you must specify precisely what you wish to print or copy, figure 4-2.

```
+---------------------- COUNTRY FILE COMPUTER SYSTEM ------------------------+
+-----------------------------------------------------------------------------+

                                 PRINT
 RECORDS FROM LAST SEARCH RESULT (Y/N) : Y

                                 or/and

 LIMITED TO RECORDS OF RANGE:  from : 1____        to : 999999

 PRINTOUT DIRECTED: to printer (Y/N): Y  or  to file : _________

 PRINTOUT SORTED (if any sorted selected) (Y/N) : Y

Enter the parameters as needed and then press X/ENTER to run print - wait please
 ENTER - next field |        TAB - previous field      | PgDown - print menu
 EDIT: Replace                   Last page
```

Figure 4-2: Print options definition screen

You must first fill in the information on this screen. To move from one field to the next, press [Enter], to move to the previous field, press [Tab].

The information you must provide is the following:

records from the last search result (Y/N) enter "N" in this field if you wish to print or copy all or a range of records from the entire data base; enter "Y" (the system inserts this parameter by default) if you wish to print or copy the records selected as a result of the last search/view you have executed;

limited to records of range: from :__ to: __ enter the logical record number from which and to which the printing/copying should be limited; note that the system has inserted 1 and 999999 as the range of records; in general, if you are printing/copying retrieved records, you will want to process all of them - you do not need to change these values;

printout directed: to printer (Y/N): Y or to file : the system enters "Y" to default directing the printout to your local printer on LPT1; if you wish to make a copy of the specified records, enter any file name in the field provided; the system will create a DOS text file with the name you enter (you can use a file extension if you desire, e.g., TEST or TEST.TXT) and place it into the \WORK sub-directory of your SCIS directory (e.g., c:\scis\work\test, d:\scis\work\test.txt, etc.) from which you may subsequently retrieve it for further processing;

printout sorted (if any sorted selected) (Y/N) :

When all fields contain the values you require, press [PgDn] to display the menu bar, figure 4-3. Note, the system automatically displays this menu bar when you have entered the last field.

```
| - Execute | M - Modify data | C - Cancel | X - Execute |
```

Figure 4-3: print menu bar

You can, at this point, return to the top of the screen if you wish to change one of the values you have entered by typing "M".

If you type "C", the system will abort the whole print/copy operation and return you to the Country Information system Main Menu.

To initiate the print/copy request which you have just formulated, either press [Enter] or type "X". The system informs you, at the bottom of the screen, how many records are to be printed and gives you a further chance to abort the operation with [Esc] if you so desire, figure 4-4.

```
| - Execute    | M - Modify data   | C - Cancel   | X - Execute      |   x
          11 record(s) found - press ENTER to continue, ESC to cancel
```

Figure 4-4: print prompt

To then actually execute the function, again press [Enter]. If you have selected to print your records, the system will start printing the selected records.

Note: make sure that your printer is turned on and online; if this is not the case, the SCIS will abend, and you must restart the whole system and first repeat any retrieval you may have done to re-execute the printing/copying operation.

If you requested to direct the printout to a file, the system proceeds with the copying.

In both cases, when finished, the system returns you to the SCIS main menu (figure 2-2).

Note that if you just press [Enter] repeatedly, an unsorted printout of the last set of records which you have retrieved will be performed.

4.1 Standard printout, no Sort

The printouts will be in the format of the original record, as it is located in the data base. All fields, as they appear on your screen when you view them, are included in the printout.

4.2 Standard printout, sorted by Country

As above, except that the records in the printout will be sorted alphabetically by country name. Records in the data base may be indexed under more than one country. These records will be included in the printout under each country under which they are indexed.

4.3 Standard printout, sorted by Subject

As in 4.1 above, except that the records in the printout will be sorted by subject. If there are several subjects under which the record is indexed, it will be printed under each subject.

4.4 Concise printout, no Sort

Not all fields of the selected records are printed. The format used for this printout reduces the information printed to several predefined fields of the record only. These fields are: country, main category, sub-category, facility name, facility type, items involved in export/imports, exporting/importing countries. The records are printed in the order they have been entered into the data base.

4.5 Concise printout, sorted by Country

As in 4.4 above, except that the records are sorted alphabetically by country name, and, as in the standard printout described in 4.2 above, they are included in the printout under each country under which they are indexed.

4.6 Concise printout, sorted by Subject

As in 4.4 above, except that the records are sorted by subject, and, as in the standard printout described in 4.3 above, they are included in the printout under each subject under which they are indexed.

5 Appendix 1: Description of Data Categories

All data aɩ̃ grouped into data categories, as specified below. Each dta category is associated with pre-defined attributes (specified) and keywords, which will be used for indexing and search purposes. Complete sets of attributes and keywords are specified in the course of the creation of the data bases (see also Appendix 2, page 2).

Status as of 92-10-29

Table:
Structure and Content of a the SGCP Country Information System

Data Category/Data Sub-Category	**Content of Information** (open sources of information for Data Categories 1-11)
1. **Nuclear regulations, non-proliferation/SG, and organization of nuclear activities** 1.1 Nuclear law, policies, regulations and organization 1.2 Nuclear export control and licensing 1.3 Safeguards and non-proliferation	- Nuclear law; nuclear policies; nuclear regulations; nuclear export control; management of nuclear material, facilities; - Licensing of nuclear, dual-use and specified materials and equipment; - Regulation coverage of nuclear activities (peaceful/military); - Level of independence of military nuclear activities from State nuclear authorities; - Authorities, responsibilities, organization and structure of nuclear activities; responsible bodies and organizations, personalities; - Interaction between civil nuclear authorities and military entities; - Policy in respect of the transparency of nuclear activities; - Safeguards and non-proliferation policies and status; - Cooperation with IAEA, support of steps on strengthening of non-proliferation; attitude to nuclear weaponization.
2. **Energy requirements, production and resources** 2.1 Energy requirements production 2.2 Nuclear resources 2.3 Nuclear-related resources	- Energy production, requirements and resources, nuclear energy production, prospects of nuclear energy production; - Balance between conventional and nuclear energy production and resources; - Uranium and thorium resources and its exploration; - Resources of accumulated and separated plutonium and HEU; - Resources of sensitive and dual-use non-nuclear material (deuterium, tritium, lithium(-6), hafnium, heavy water, zirconium, beryllium, graphite, hard alloys, etc.) - see Trigger List of INFCIRC/254/Rev.1/Part 2.

Table:
Structure and Content of a the SGCP Country Information System

Data Category/Data Sub-Category	Content of Information (open sources of information for Data Categories 1-11)
3. Nuclear and nuclear-related programmes 3.1 Nuclear power programme 3.2 Nuclear R&D programme 3.3 Nuclear-related R&D programmes and activities	- **Nuclear power and R&D programmes and activities on:** fuel conversion, fabrication, enrichment, power reactors, reprocessing, spent fuel storage and treatment, waste processing, introduction of new elements of nuclear fuel cycle and technologies. - **Nuclear-related and R&D programmes and activities on:** nuclear physics; fusion; experiments with deuterium, tritium and other sensitive materials; isotope production; - **Programmes and activities on the production of dual-use materials:** lithium, beryllium, deuterium, tritium, hafnium, heavy water, hard alloys, zirconium, graphite, explosive chemicals, ceramics, fibre optics, etc.; - **Programmes and activities on the production of dual-use equipment:** neutron generators, compressors, forgings, furnaces, leak detectors, presses, pumps, robots, mass-spectrometers, vacuum systems, coating and welding machines, etc. (For further details see Trigger Lists of INFCIRC/254/Rev.1/Parts 1&2)
4. New nuclear technologies and elements of nuclear fuel cycle	- **Summary on the development and acquisition of:** new nuclear technologies and introduction of new elements of nuclear fuel cycle (with special emphasis on events related to future safeguards implementation and nuclear weapons sensitive elements and technologies).
5. Facilities 5.1 Nuclear facilities 5.2 Nuclear R&D centers, laboratories 5.3 Nuclear-related facilities	- **Nuclear facilities in operation, under construction, planned, standby or deferred:** fuel conversion, fabrication, enrichment, power and research reactors, reprocessing, spent fuel storages, radwaste storages, ore/concentrate production sites, R&D nuclear centers, laboratories and universities. - **Nuclear-related facilities and installations producing:** non-nuclear materials and equipment which could be used in nuclear facilities and for nuclear weapons development and manufacturing (e.g., heavy water, graphite, deuterium, tritium, lithium; equipment as listed in INFCIRC/254/Rev.1/part 2; dual-use materials and equipment, e.g. listed in INFCIRC/254/Rev.1/Part 2). - **Nuclear-related facilities, installations and sites:** accelerators, fusion and plasma installations, etc.

Table:
Structure and Content of a the SGCP Country Information System

Data Category/Data Sub-Category	Content of Information (open sources of information for Data Categories 1-11)
6. Exports and imports 6.1 Exports and imports of nuclear materials 6.2 Exports and imports of specified and dual-use equipment/materials	- **Exports and imports of:** - nuclear material, technologies, facilities, equipment; - specified and dual-use materials, facilities, machinery, technologies, equipment, services, with special emphasis to those which are suitable for the development and manufacture of nuclear weapons, in particular, as specified in INFCIRC/254/REV.1/Parts 1 and 2. - nuclear-related equipment and facilities which might be used in nuclear programmes: e.g. accelerators, fusion and plasma installations and their parts, lasers, destructive and non-destructive laboratory equipment, computers, electronics, robots, power supply, etc.
7. Nuclear and technical capabilities 7.1 Nuclear capabilities 7.2 Technology, human and financial resources	- Availability of materials, facilities, equipment, know-how to conduct nuclear activities such as uranium enrichment and chemical reprocessing; - Capabilities in production of HEU and in Pu separation; - Availabilities of uranium resources or acquired uranium ore or concentrates; capabilities in production materials and equipment (specified/dual-use as specified above and in INFCIRC/254/Rev.1/Parts 1 and 2); - Financial resources, high-tech and qualified personnel which could be involved in the implementation of nuclear weapons programmes.
8. International cooperation 8.1 Cooperation agreements in nuclear and nuclear-related areas 8.2 Nuclear trade partners 8.3 Technical assistance	- **International cooperation in nuclear and nuclear-related areas:** cooperation agreements; nuclear and nuclear-related trade; R&D cooperation; technical assistance from States, IAEA and other international organizations; trade and cooperation partners. - **Substance and scope of cooperation with special emphasis on ares relevant to:** uranium enrichment, spent fuel reprocessing, reactors capable to produce plutonium; nuclear material (especially Pu, MOX and HEU); Specified and dual-use materials and equipment. - **Denied attempts** to cooperate in the area of sensitive nuclear and nuclear-related technology.

Table:
Structure and Content of a the SGCP Country Information System

Data Category/Data Sub-Category	**Content of Information** (open sources of information for Data Categories 1-11)
9. Companies, firms, organizations 9.1 Nuclear-related firms 9.2 High-tech firms	Specific companies, firms and enterprises producing or participating in the production of nuclear technology, nuclear or other sensitive materials and equipment, with emphasis to those which are suitable for the development and manufacturing of components of nuclear weapons; high-tech related to control and automated systems, including computer equipment. Companies and firms producing or supplying facilities, equipment and materials, in particular, those specified in INFCIRC 254/Rev.1/Parts 1 and 2.
10. Media Reports on trafficking in nuclear, non-nuclear materials and specified equipment 10.1 Nuclear material trafficking 10.2 Nuclear-related trafficking	- Media Reports on trafficking in nuclear and non-nuclear sensitive materials and equipment, including those suitable for the development and manufacturing of nuclear weapons and its components. - Illegal supply of nuclear, sensitive and dual-use non-nuclear materials and equipment, in particular, those specified in INFCIRC/254/Rev.1/Parts 1 and 2. - Consequent follow-up actions and conclusions on reported events.
11. Accidents and incidents	Accidents and incidents at nuclear facilities which might result in loss or diversion of nuclear and other sensitive material and equipment.

6 Appendix 2: Structure and Content of the SCIS data base

Tag	Field Name	Contents
10	Country	Country name
20	Main Data Category	Main data category of information
25	Data Sub-Category	Sub-category of information
30	Reference/Date	Reference date and date of publication
40	Title	Title of publication
50	Attributes	Attributes selected for the record
60	Keywords	Keywords selected for the record
70	Text	substance of the record, i.e., summary of the article from the press, communication, facility operation, description of activities at the site, etc - it is this field on which the free text search operates
90	Facility Type	
100	Facility Name	
105	Operator/Owner	Operator or owner of the facility
110	Location	location of the facility
120	Capacity	capacity of the facility; throughput
130	Material used	materials used at the facility
135	Process	processes used at the facility
140	Inventory	inventory of nuclear material at the facility
150	Supplier	supplier of the facility
160	Start-up	facility start-up
170	Close-down	facility close-down
180	Fuel/Mat.Source	source of the nuclear material and fuel of the facility
200	Safeguards	Safeguards applied at the facility

270	Importing Country	name of cointries importing items
280	Exporting country	name of countries exporting items
290	Items of import/export	items imported or exported
300	Date of event	date of import or export
310	Agreement Name	Cooperation agreement name
330	Firm Name	Name of the firm involved in the import or export
400	Rec_No	Number of the record (MFN: Master File Number)
999	worksheet number	name of the format used for displaying the record

7 Appendix 3: Attributes

LIST OF ATTRIBUTES FOR SCIS DATA BASE

No.	Number of Rec.	Attribute (Item of Information)
1	249	A CAPABILITIES
2	242	A CAPABILITIES NUCLEAR
3	15	A CAPABILITIES NUCLEAR WEAPONS
4	229	A CAPABILITIES SUMMARY
5	15	A CAPABILITIES TECHNICAL
6	1099	A COOPERATION AGREEMENTS
7	1655	A COOPERATION INTERNATIONAL
8	585	A COOPERATION NUCLEAR
9	410	A COOPERATION TECHNICAL ASSISTANCE
10	2	A DEVELOPMENT NEW NFC/TECHNOLOGY
11	1750	A E/I
12	72	A E/I D_USE
13	1427	A E/I EQUIPMENT
14	5	A E/I EQUIPMENT CONVERSION
15	224	A E/I EQUIPMENT D_USE
16	172	A E/I EQUIPMENT ENRICHMENT
17	1	A E/I EQUIPMENT FABRICATION
18	65	A E/I EQUIPMENT FUEL FABRICATION
19	15	A E/I EQUIPMENT HEAVY WATER
20	26	A E/I EQUIPMENT MILITARY
21	159	A E/I EQUIPMENT NUCLEAR_RELATED
22	25	A E/I EQUIPMENT ORE PROCESSING
23	873	A E/I EQUIPMENT REACTORS
24	57	A E/I EQUIPMENT REPROCESSING
25	1131	A E/I EQUIPMENT SPECIFIED
26	14	A E/I EQUIPMENT STORAGES
27	439	A E/I MATERIAL
28	69	A E/I MATERIAL D_USE
29	352	A E/I MATERIAL NUCLEAR
30	19	A E/I MATERIAL NUCLEAR_RELATED
31	36	A E/I MATERIAL SPECIFIED
32	2836	A FACILITIES
33	58	A FACILITIES CONVERSION
34	56	A FACILITIES ENRICHMENT
35	3	A FACILITIES EQUIPMENT NUCLEAR
36	94	A FACILITIES FABRICATION
37	26	A FACILITIES HEAVY WATER
38	29	A FACILITIES LABSCALE
39	155	A FACILITIES MILITARY
40	1264	A FACILITIES NFC
41	1278	A FACILITIES NUCLEAR
42	807	A FACILITIES NUCLEAR_RELATED
43	241	A FACILITIES ORE PROCESSING
44	23	A FACILITIES PILOT
45	753	A FACILITIES POWER REACTORS
46	102	A FACILITIES R&D NUCLEAR
47	70	A FACILITIES REPROCESSING
48	592	A FACILITIES RESEARCH REACTORS
49	71	A FACILITIES STORAGES
50	50	A FACILITIES SUMMARY
51	2	A FACILITIES WASTE PROCESSING
52	166	A FACILITIES _CONSTRUCTION
53	92	A FACILITIES _DEFERRED
54	1978	A FACILITIES _OPERATING
55	103	A FACILITIES _PLANNED
56	486	A FACILITIES _SHUT_DOWN
57	185	A FIRMS
58	63	A FIRMS NUCLEAR

59	112	A FIRMS NUCLEAR_RELATED
60	463	A LEGISLATION
61	2	A LEGISLATION ACTIVITIES
62	17	A LEGISLATION EXPORTS/LICENSING
63	476	A NON_PROLIFERATION
64	294	A NON_PROLIFERATION/SG
65	381	A ORGANIZATIONS
66	90	A ORGANIZATIONS NUCLEAR
67	299	A ORGANIZATIONS NUCLEAR_RELATED
68	428	A PROGRAM
69	312	A PROGRAM NUCLEAR ENERGY
70	8	A PROGRAM NUCLEAR MILITARY
71	10	A PROGRAM NUCLEAR_RELATED
72	79	A PROGRAM R&D NUCLEAR
73	417	A PROGRAM SUMMARY
74	118	A RESOURCES NUCLEAR ENERGY
75	62	A RESOURCES NUCLEAR MATERIAL
76	37	A RESOURCES NUCLEAR MILITARY
77	18	A RESOURCES PU SUMMARY
78	4	A RESOURCES U SUMMARY
79	1494	A SG_NO
80	516	A SG_YES
81	109	A TRAFFICKING
82	58	A TRAFFICKING D_USE
83	1	A TRAFFICKING EQUIPMENT
84	18	A TRAFFICKING EQUIPMENT D_USE
85	14	A TRAFFICKING EQUIPMENT SPECIFIED
86	14	A TRAFFICKING MATERIAL
87	50	A TRAFFICKING MATERIAL D_USE
88	74	A TRAFFICKING MATERIAL NUCLEAR
89	53	A WEAPONIZATION
90	53	A WEAPONIZATION NUCLEAR

8 Appendix 4: Keywords

LIST OF KEYWORDS FOR SCIS DATA BASE

No.	Number of Rec.	Keywords (Items of Information)
352	251	K CAPAB
353	119	K CAPAB_NFC
354	12	K CAPAB_NFC CONVERSION
355	24	K CAPAB_NFC ENRICHMENT
356	29	K CAPAB_NFC FACILITIES
357	22	K CAPAB_NFC FUEL FABRICATION
358	21	K CAPAB_NFC HEU PRODUCTION
359	10	K CAPAB_NFC HW PRODUCTION
360	29	K CAPAB_NFC POWER REACTORS
361	19	K CAPAB_NFC PU PRODUCTION
362	20	K CAPAB_NFC REPROCESSING
363	1	K CAPAB_NFC WEAPONS
364	15	K CAPAB_NUC
365	2	K CAPAB_NUC WEAPONS
366	27	K CAPAB_TECH
367	1	K CAPAB_TECH EQUIPMENT
368	9	K CAPAB_TECH EXPERTS
369	4	K CAPAB_TECH MILITARY
370	18	K CAPAB_TECH NUCLEAR WEAPONS
371	1	K CAPAB_TECH RESOURCES
372	2	K CAPAB_TECH TECHNOLOGY
373	2	K CAPAB_TECH TRITIUM
374	2	K CAPAB_TECH TRITIUM PRODUCTION
375	1647	K COOP
376	1087	K COOP_AGREEM
377	1105	K COOP_AGREEM NUCLEAR
378	584	K COOP_NUC
379	415	K COOP_NUC ASSISTANCE
380	9	K COOP_NUC EXPERTS
381	406	K COOP_NUC IAEA
382	402	K COOP_NUC INTERNATIONAL
383	7	K COOP_NUC MILITARY
384	42	K COOP_NUC NFC
385	20	K COOP_NUC R&D
386	36	K COOP_NUC RESEARCH
387	311	K COOP_NUC SERV
388	30	K COOP_NUC SERV_ENR
389	17	K COOP_NUC SERV_FABR
390	49	K COOP_NUC SERV_REPR
391	44	K COOP_NUC TECHNOLOGY
392	73	K COOP_NUC TRAINING
393	11	K COOP_NUC WEAPONS
394	2	K DEVEL_NEW NFC
395	2	K DEVEL_NEW NFC ELEMENTS
396	2	K DEVEL_NEW NFC POWER REACTORS
397	1416	K E/I EQUIP
398	6	K E/I EQUIP_CONV
399	1	K E/I EQUIP_CONV FACILITIES
400	5	K E/I EQUIP_CONV TECHNOLOGY
401	227	K E/I EQUIP_D_USE
402	1	K E/I EQUIP_D_USE ANALYSERS
403	1	K E/I EQUIP_D_USE BALANCING
404	3	K E/I EQUIP_D_USE CALUTRONS
405	6	K E/I EQUIP_D_USE CAPACITORS
406	1	K E/I EQUIP_D_USE COATING
407	32	K E/I EQUIP_D_USE COMPUTERS

408	6	K	E/I	EQUIP_D_USE	CONTROL SYSTEMS
409	12	K	E/I	EQUIP_D_USE	DELIVERY SYSTEMS
410	2	K	E/I	EQUIP_D_USE	DETECTORS
411	14	K	E/I	EQUIP_D_USE	ELECTROMAGNETS
412	11	K	E/I	EQUIP_D_USE	ELECTRONICS
413	2	K	E/I	EQUIP_D_USE	EXPLOSIVES
414	6	K	E/I	EQUIP_D_USE	FORMING
415	22	K	E/I	EQUIP_D_USE	FURNACES
416	1	K	E/I	EQUIP_D_USE	GENERATORS
417	2	K	E/I	EQUIP_D_USE	HIGH_TECH
418	2	K	E/I	EQUIP_D_USE	INITIATORS
419	18	K	E/I	EQUIP_D_USE	INSTALLATIONS
420	7	K	E/I	EQUIP_D_USE	INSTRUMENTS
421	6	K	E/I	EQUIP_D_USE	KRYTRONS
422	2	K	E/I	EQUIP_D_USE	LASERS
423	11	K	E/I	EQUIP_D_USE	LATHES
424	73	K	E/I	EQUIP_D_USE	MACHINERY
425	3	K	E/I	EQUIP_D_USE	MELTING
426	3	K	E/I	EQUIP_D_USE	MILITARY
427	1	K	E/I	EQUIP_D_USE	MIXERS
428	1	K	E/I	EQUIP_D_USE	MOTORS
429	10	K	E/I	EQUIP_D_USE	OSCILLOSCOPES
430	16	K	E/I	EQUIP_D_USE	PHOTO
431	1	K	E/I	EQUIP_D_USE	PLASMA SYSTEMS
432	18	K	E/I	EQUIP_D_USE	POWER SUPPLY
433	4	K	E/I	EQUIP_D_USE	PRESSES
434	12	K	E/I	EQUIP_D_USE	PUMPS
435	2	K	E/I	EQUIP_D_USE	ROBOTS
436	1	K	E/I	EQUIP_D_USE	SEPARATORS
437	9	K	E/I	EQUIP_D_USE	SPECTROMETERS
438	26	K	E/I	EQUIP_D_USE	TECHNOLOGY
439	2	K	E/I	EQUIP_D_USE	TESTING
440	22	K	E/I	EQUIP_D_USE	TOOLS
441	7	K	E/I	EQUIP_D_USE	TRIGGERS
442	11	K	E/I	EQUIP_D_USE	TRITIUM
443	1	K	E/I	EQUIP_D_USE	TRITIUM HANDLING
444	1	K	E/I	EQUIP_D_USE	VACUUM
445	4	K	E/I	EQUIP_D_USE	VACUUM SYSTEMS
446	2	K	E/I	EQUIP_D_USE	VIDEO SYSTEMS
447	21	K	E/I	EQUIP_D_USE	WEAPONS
448	8	K	E/I	EQUIP_D_USE	WEAPONS COMPONENTS
449	1	K	E/I	EQUIP_D_USE	WEAPONS TECHNOLOGY
450	1	K	E/I	EQUIP_D_USE	WEAPONS TRIGGERS
451	5	K	E/I	EQUIP_D_USE	WELDING
452	2	K	E/I	EQUIP_D_USE	X_RAY SYSTEMS
453	181	K	E/I	EQUIP_ENR	
454	3	K	E/I	EQUIP_ENR	AUTOCLAVES
455	13	K	E/I	EQUIP_ENR	BAFFLES
456	4	K	E/I	EQUIP_ENR	BEARINGS
457	1	K	E/I	EQUIP_ENR	BELLOWS
458	13	K	E/I	EQUIP_ENR	CALUTRONS
459	102	K	E/I	EQUIP_ENR	CENTRIFUGES
460	26	K	E/I	EQUIP_ENR	COMPONENTS
461	2	K	E/I	EQUIP_ENR	DIFFUSION
462	13	K	E/I	EQUIP_ENR	E/M UNITS
463	17	K	E/I	EQUIP_ENR	ENDCAPS
464	1	K	E/I	EQUIP_ENR	FACILITIES
465	14	K	E/I	EQUIP_ENR	FREQUENCY CHANGERS
466	3	K	E/I	EQUIP_ENR	LASER
467	1	K	E/I	EQUIP_ENR	LASER UNITS
468	2	K	E/I	EQUIP_ENR	MACHINERY
469	24	K	E/I	EQUIP_ENR	MAGNETS

470	11	K	E/I	EQUIP_ENR NOZZLE UNITS
471	6	K	E/I	EQUIP_ENR PUMPS
472	6	K	E/I	EQUIP_ENR ROTATING COMPO
473	2	K	E/I	EQUIP_ENR ROTOR TUBES
474	2	K	E/I	EQUIP_ENR ROTORS
475	2	K	E/I	EQUIP_ENR STATIC COMPONE
476	142	K	E/I	EQUIP_ENR TECHNOLOGY
477	5	K	E/I	EQUIP_ENR VACUUM SYSTEMS
478	21	K	E/I	EQUIP_ENR VALVES
479	10	K	E/I	EQUIP_ENR VORTEX UNITS
480	68	K	E/I	EQUIP_FABR
481	1	K	E/I	EQUIP_FABR COMPONENTS
482	2	K	E/I	EQUIP_FABR FACILITIES
483	62	K	E/I	EQUIP_FABR TECHNOLOGY
484	15	K	E/I	EQUIP_HW
485	10	K	E/I	EQUIP_HW COMPONENTS
486	2	K	E/I	EQUIP_HW PLANTS
487	3	K	E/I	EQUIP_HW TECHNOLOGY
488	182	K	E/I	EQUIP_NUC_REL
489	30	K	E/I	EQUIP_NUC_REL ELECTRONICS
490	1	K	E/I	EQUIP_NUC_REL FOR R&D
491	1	K	E/I	EQUIP_NUC_REL ISOT.
492	2	K	E/I	EQUIP_NUC_REL ISOT. FACILITIES
493	1	K	E/I	EQUIP_NUC_REL ISOT. HANDLING
494	8	K	E/I	EQUIP_NUC_REL RADWASTE
495	83	K	E/I	EQUIP_NUC_REL RADWASTE FACILITIES
496	26	K	E/I	EQUIP_ORE_
497	1	K	E/I	EQUIP_ORE CONCENTRATE FACILITIES
498	1	K	E/I	EQUIP_ORE FACILITIES
499	22	K	E/I	EQUIP_ORE MILLING
500	24	K	E/I	EQUIP_ORE MINING
501	1	K	E/I	EQUIP_ORE PROCESSING
502	1	K	E/I	EQUIP_ORE PURIFICATION
503	1	K	E/I	EQUIP_ORE U3O8
504	1	K	E/I	EQUIP_ORE U3O8 FACILITIES
505	878	K	E/I	EQUIP_REACT
506	108	K	E/I	EQUIP_REACT ADVANCED
507	1	K	E/I	EQUIP_REACT ASSEMBLIES
508	3	K	E/I	EQUIP_REACT CHARGING
509	14	K	E/I	EQUIP_REACT CLADDING
510	17	K	E/I	EQUIP_REACT COMPONENTS
511	1	K	E/I	EQUIP_REACT CORE
512	10	K	E/I	EQUIP_REACT FBR
513	68	K	E/I	EQUIP_REACT HWR
514	263	K	E/I	EQUIP_REACT LWR
515	837	K	E/I	EQUIP_REACT POWER
516	7	K	E/I	EQUIP_REACT PUMPS
517	58	K	E/I	EQUIP_REACT RESEARCH
518	16	K	E/I	EQUIP_REACT RODS CONTROL
519	21	K	E/I	EQUIP_REACT SIMULATORS
520	391	K	E/I	EQUIP_REACT TECHNOLOGY
521	6	K	E/I	EQUIP_REACT TUBES
522	167	K	E/I	EQUIP_REACT TURBINES
523	13	K	E/I	EQUIP_REACT VESSELS
524	4	K	E/I	EQUIP_REACT ZR TUBES
525	57	K	E/I	EQUIP_REPR
526	4	K	E/I	EQUIP_REPR COMPONENTS
527	16	K	E/I	EQUIP_REPR HOT CELLS
528	1	K	E/I	EQUIP_REPR STORAGE VESSELS
529	40	K	E/I	EQUIP_REPR TECHNOLOGY
530	13	K	E/I	EQUIP_STOR
531	11	K	E/I	EQUIP_STOR SPENT FUEL

532	3	K	E/I	EQUIP_STOR TECHNOLOGY
533	385	K	E/I	MATER
534	63	K	E/I	MATER_D_USE
535	1	K	E/I	MATER_D_USE ALLOYS
536	2	K	E/I	MATER_D_USE ALUMINIUM
537	11	K	E/I	MATER_D_USE BERYLLIUM
538	2	K	E/I	MATER_D_USE BORON
539	1	K	E/I	MATER_D_USE CHEMICALS
540	1	K	E/I	MATER_D_USE CRUCIBLES
541	1	K	E/I	MATER_D_USE DEUTERIUM
542	7	K	E/I	MATER_D_USE FIBROUS
543	3	K	E/I	MATER_D_USE FILAMENTARY
544	2	K	E/I	MATER_D_USE HAFNIUM
545	2	K	E/I	MATER_D_USE ISOTOPES
546	1	K	E/I	MATER_D_USE LITHIUM
547	22	K	E/I	MATER_D_USE MARAGING STEEL
548	2	K	E/I	MATER_D_USE NICKEL
549	1	K	E/I	MATER_D_USE RADIOACTIVE
550	1	K	E/I	MATER_D_USE RED MERCURY
551	1	K	E/I	MATER_D_USE SPENT FUEL
552	14	K	E/I	MATER_D_USE TRITIUM
553	1	K	E/I	MATER_D_USE TUNGSTEN
554	1	K	E/I	MATER_D_USE WEAPONS
555	11	K	E/I	MATER_D_USE ZIRCONIUM
556	363	K	E/I	MATER_NUC
557	1	K	E/I	MATER_NUC CONCENTRATE
558	37	K	E/I	MATER_NUC FUEL
559	22	K	E/I	MATER_NUC PU
560	53	K	E/I	MATER_NUC SPENT FUEL
561	7	K	E/I	MATER_NUC TH
562	233	K	E/I	MATER_NUC U
563	44	K	E/I	MATER_NUC U CONCENTRATE
564	7	K	E/I	MATER_NUC U DU
565	39	K	E/I	MATER_NUC U HEU
566	92	K	E/I	MATER_NUC U LEU
567	7	K	E/I	MATER_NUC U MOX
568	50	K	E/I	MATER_NUC U NU
569	5	K	E/I	MATER_NUC U ORE
570	5	K	E/I	MATER_NUC U OXIDES
571	1	K	E/I	MATER_NUC U PU
572	49	K	E/I	MATER_NUC U U3O8
573	13	K	E/I	MATER_NUC U UF4/UF6
574	4	K	E/I	MATER_NUC U WEAPONS
575	7	K	E/I	MATER_NUC WASTE
576	19	K	E/I	MATER_NUC_REL
577	1	K	E/I	MATER_NUC_REL ISOT.
578	1	K	E/I	MATER_NUC_REL ISOT. RADIACTIVE
579	1	K	E/I	MATER_NUC_REL ISOT. RARE_EARTH
580	17	K	E/I	MATER_NUC_REL RADWASTE
581	40	K	E/I	MATER_SPEC
582	16	K	E/I	MATER_SPEC GRAPHITE
583	28	K	E/I	MATER_SPEC HEAVY WATER
584	1	K	E/I	MATER_SPEC ZIRCONIUM
585	70	K	E/I	_IRAQ_SUMMARY
586	68	K	EXP.	ARGENTINA
587	18	K	EXP.	AUSTRALIA
588	2	K	EXP.	AUSTRIA
589	35	K	EXP.	BELGIUM
590	39	K	EXP.	BRAZIL
591	2	K	EXP.	BULGARIA
592	117	K	EXP.	CANADA
593	1	K	EXP.	CHILE

594	55	K	EXP. CHINA
595	18	K	EXP. CZECHOSLOVAKIA
596	1	K	EXP. DENMARK
597	1	K	EXP. EGYPT
598	3	K	EXP. EUROPE
599	13	K	EXP. FINLAND
600	250	K	EXP. FRANCE
601	2	K	EXP. GDR
602	475	K	EXP. GERMANY
603	2	K	EXP. HONG KONG
604	6	K	EXP. HUNGARY
605	2	K	EXP. IAEA
606	8	K	EXP. INDIA
607	26	K	EXP. IRAQ
608	1	K	EXP. ISRAEL
609	32	K	EXP. ITALY
610	111	K	EXP. JAPAN
611	3	K	EXP. KAZAKHSTAN
612	3	K	EXP. KOREA/NORTH
613	13	K	EXP. KOREA/SOUTH
614	1	K	EXP. LIECHTENSTEIN
615	1	K	EXP. LITHUANIA
616	1	K	EXP. LUXEMBOURG
617	2	K	EXP. MOZAMBIQUE
618	3	K	EXP. NAMIBIA
619	5	K	EXP. NETHERLANDS
620	3	K	EXP. NIGER
621	17	K	EXP. NORWAY
622	11	K	EXP. PAKISTAN
623	1	K	EXP. PERU
624	1	K	EXP. PHILIPPINES
625	2	K	EXP. POLAND
626	3	K	EXP. PORTUGAL
627	3	K	EXP. ROMANIA
628	24	K	EXP. RUSSIA
629	1	K	EXP. SEYCHELLES
630	7	K	EXP. SOUTH AFRICA
631	28	K	EXP. SPAIN
632	65	K	EXP. SWEDEN
633	45	K	EXP. SWITZERLAND
634	10	K	EXP. TAIWAN
635	4	K	EXP. TURKEY
636	109	K	EXP. UK
637	1	K	EXP. UKRAINE
638	1	K	EXP. UNITED ARAB EMIRATES
639	6	K	EXP. UNKNOWN STATE
640	2	K	EXP. URENCO
641	526	K	EXP. USA
642	58	K	EXP. USSR
643	1	K	EXP. UZBEKISTAN
644	6	K	EXP. YUGOSLAVIA
645	3	K	FAC_EQUIP_NUC
646	2	K	FAC_EQUIP_NUC ENRICHMENT
647	2	K	FAC_EQUIP_NUC SPECIFIED
648	1	K	FAC_EQUIP_NUC WEAPONS
649	1251	K	FAC_NFC
650	1	K	FAC_NFC MILITARY
651	58	K	FAC_NFC_CONV
652	1	K	FAC_NFC_CONV OXIDES
653	41	K	FAC_NFC_CONV U
654	7	K	FAC_NFC_CONV U METAL
655	7	K	FAC_NFC_CONV U U3O8

656	27	K	FAC_NFC_CONV U UF4/UF6
657	19	K	FAC_NFC_CONV U UO2/UO3
658	56	K	FAC_NFC_ENR
659	24	K	FAC_NFC_ENR CENTRIFUGE
660	3	K	FAC_NFC_ENR CHEMICAL
661	14	K	FAC_NFC_ENR DIFFUSION
662	2	K	FAC_NFC_ENR ELECTROMAGNETIC
663	6	K	FAC_NFC_ENR LASER
664	12	K	FAC_NFC_ENR MILITARY
665	2	K	FAC_NFC_ENR NOZZLE
666	2	K	FAC_NFC_ENR VORTEX
667	1	K	FAC_NFC_ENR WEAPONS
668	100	K	FAC_NFC_FABR
669	1	K	FAC_NFC_FABR ALLOYS
670	1	K	FAC_NFC_FABR MILITARY
671	4	K	FAC_NFC_FABR OXIDES
672	6	K	FAC_NFC_FABR PU
673	2	K	FAC_NFC_FABR PU OXIDES
674	83	K	FAC_NFC_FABR U
675	1	K	FAC_NFC_FABR U ALLOYS
676	1	K	FAC_NFC_FABR U HEU
677	30	K	FAC_NFC_FABR U LEU
678	9	K	FAC_NFC_FABR U MOX
679	18	K	FAC_NFC_FABR U NU
680	10	K	FAC_NFC_FABR U OXIDES
681	25	K	FAC_NFC_HW
682	1	K	FAC_NFC_HW ELECTROLYZE
683	2	K	FAC_NFC_HW MILITARY
684	242	K	FAC_NFC_ORE
685	9	K	FAC_NFC_ORE CONVERSION
686	2	K	FAC_NFC_ORE FERTILIZERS
687	184	K	FAC_NFC_ORE MILLS
688	62	K	FAC_NFC_ORE MINES
689	24	K	FAC_NFC_ORE PHOSPHATES
690	29	K	FAC_NFC_ORE PROCESSING
691	1	K	FAC_NFC_ORE TH
692	208	K	FAC_NFC_ORE U
693	3	K	FAC_NFC_ORE U U3O8
694	755	K	FAC_NFC_POWER
695	15	K	FAC_NFC_POWER AGR
696	139	K	FAC_NFC_POWER BWR
697	41	K	FAC_NFC_POWER CANDU
698	24	K	FAC_NFC_POWER FBR
699	48	K	FAC_NFC_POWER GCR
700	6	K	FAC_NFC_POWER HTGR
701	3	K	FAC_NFC_POWER HWGCR
702	12	K	FAC_NFC_POWER HWR
703	46	K	FAC_NFC_POWER LWGR
704	72	K	FAC_NFC_POWER LWR
705	13	K	FAC_NFC_POWER MAGNOX
706	33	K	FAC_NFC_POWER MILITARY
707	1	K	FAC_NFC_POWER OMR
708	64	K	FAC_NFC_POWER PHWR
709	34	K	FAC_NFC_POWER PU PRODUCTION
710	382	K	FAC_NFC_POWER PWR
711	18	K	FAC_NFC_POWER RBMK
712	1	K	FAC_NFC_POWER SUBMARINES
713	1	K	FAC_NFC_POWER T PRODUCTION
714	71	K	FAC_NFC_REPR
715	1	K	FAC_NFC_REPR AGR
716	5	K	FAC_NFC_REPR FBR
717	3	K	FAC_NFC_REPR GCR

718	1	K	FAC_NFC_REPR HOT CELLS
719	8	K	FAC_NFC_REPR HWR
720	5	K	FAC_NFC_REPR LABORATORIES
721	19	K	FAC_NFC_REPR LWR
722	2	K	FAC_NFC_REPR MAGNOX
723	2	K	FAC_NFC_REPR METAL
724	16	K	FAC_NFC_REPR MILITARY
725	7	K	FAC_NFC_REPR MOX
726	2	K	FAC_NFC_REPR MTR
727	30	K	FAC_NFC_REPR OXIDES
728	20	K	FAC_NFC_REPR REACTORS
729	15	K	FAC_NFC_REPR SPENT FUEL
730	1	K	FAC_NFC_REPR TH
731	6	K	FAC_NFC_REPR WEAPONS
732	71	K	FAC_NFC_STOR
733	50	K	FAC_NFC_STOR AFR
734	3	K	FAC_NFC_STOR ARS
735	18	K	FAC_NFC_STOR DRY
736	3	K	FAC_NFC_STOR FRESH FUEL
737	6	K	FAC_NFC_STOR MATERIAL
738	2	K	FAC_NFC_STOR MILITARY
739	1	K	FAC_NFC_STOR PLUTONIUM
740	1	K	FAC_NFC_STOR REPOSITORY
741	53	K	FAC_NFC_STOR SPENT FUEL
742	6	K	FAC_NFC_STOR U
743	5	K	FAC_NFC_STOR WASTE
744	1	K	FAC_NFC_WASTE
745	2	K	FAC_NFC_WASTE LLW
746	809	K	FAC_NUC_REL
747	25	K	FAC_NUC_REL ACCELERATORS
748	1	K	FAC_NUC_REL BE PRODUCTION
749	223	K	FAC_NUC_REL CHEMISTRY
750	1	K	FAC_NUC_REL COMPRESSORS
751	12	K	FAC_NUC_REL COMPUTERS
752	39	K	FAC_NUC_REL COMPUTING
753	11	K	FAC_NUC_REL CONSULTING
754	7	K	FAC_NUC_REL DEUTERIUM
755	18	K	FAC_NUC_REL D_USE
756	18	K	FAC_NUC_REL D_USE EQUIPMENT
757	24	K	FAC_NUC_REL D_USE MATERIAL
758	168	K	FAC_NUC_REL ELECTRONICS
759	395	K	FAC_NUC_REL ENERGY
760	132	K	FAC_NUC_REL ENGINEERING
761	46	K	FAC_NUC_REL FUSION
762	1	K	FAC_NUC_REL HAFNIUM
763	33	K	FAC_NUC_REL ISOTOPES
764	67	K	FAC_NUC_REL LASER
765	6	K	FAC_NUC_REL LITHIUM
766	109	K	FAC_NUC_REL MATERIAL
767	98	K	FAC_NUC_REL MEDICAL
768	19	K	FAC_NUC_REL METALLURGY
769	18	K	FAC_NUC_REL MILITARY
770	9	K	FAC_NUC_REL MINERALS
771	15	K	FAC_NUC_REL MINING
772	5	K	FAC_NUC_REL ORE
773	170	K	FAC_NUC_REL PHYSICS
774	63	K	FAC_NUC_REL PLASMA
775	753	K	FAC_NUC_REL R&D
776	689	K	FAC_NUC_REL R&D CENTRES
777	21	K	FAC_NUC_REL RADWASTE
778	743	K	FAC_NUC_REL RESEARCH
779	28	K	FAC_NUC_REL RESOURCES

780	29	K	FAC_NUC_REL SPACE
781	2	K	FAC_NUC_REL SPECIAL STEEL
782	12	K	FAC_NUC_REL TRAINING
783	11	K	FAC_NUC_REL TRITIUM
784	171	K	FAC_NUC_REL UNIVERSITIES
785	2	K	FAC_NUC_REL WASTE
786	1	K	FAC_NUC_REL WEAPONS
787	11	K	FAC_NUC_REL ZR PRODUCTION
788	16	K	FAC_NUC_REL ZR TUBING
789	98	K	FAC_R&D
790	99	K	FAC_R&D CENTRES
791	2	K	FAC_R&D CONVERSION
792	11	K	FAC_R&D ENRICHMENT
793	15	K	FAC_R&D FABRICATION
794	6	K	FAC_R&D MILITARY
795	47	K	FAC_R&D NFC
796	88	K	FAC_R&D NUCLEAR
797	19	K	FAC_R&D NUCLEAR TECHNOLOGY
798	1	K	FAC_R&D ORE PROCESSING
799	54	K	FAC_R&D REACTORS
800	9	K	FAC_R&D REPROCESSING
801	1	K	FAC_R&D STORAGES
802	10	K	FAC_R&D TECHNOLOGY
803	11	K	FAC_R&D WASTE
804	592	K	FAC_R_REACT
805	26	K	FAC_R_REACT ARGONAUT
806	54	K	FAC_R_REACT ASSEMBLIES
807	54	K	FAC_R_REACT CRITICAL
808	32	K	FAC_R_REACT FAST
809	5	K	FAC_R_REACT GAS
810	22	K	FAC_R_REACT GRAPHITE
811	41	K	FAC_R_REACT HEAVY WATER
812	66	K	FAC_R_REACT HOMOGENEOUS
813	11	K	FAC_R_REACT IRT
814	2	K	FAC_R_REACT ISOTOPE PRODUCTION
815	15	K	FAC_R_REACT LIGHT WATER
816	26	K	FAC_R_REACT MILITARY
817	140	K	FAC_R_REACT POOL
818	2	K	FAC_R_REACT PULSE
819	9	K	FAC_R_REACT SLOWPOKE
820	2	K	FAC_R_REACT SUPPLY
821	72	K	FAC_R_REACT TANK
822	29	K	FAC_R_REACT TEST
823	61	K	FAC_R_REACT TRIGA
824	2	K	FIRMS_D_USE TECHNOLOGY
825	70	K	FIRMS IRAQI SUPPLY
826	17	K	FIRMS NFC
827	1	K	FIRMS NFC CONV
828	2	K	FIRMS NFC CONV_PLANTS
829	2	K	FIRMS NFC ENR
830	1	K	FIRMS NFC ENR_CENTRIFUGES
831	1	K	FIRMS NFC ENR_LASER
832	3	K	FIRMS NFC ENR_PLANTS
833	5	K	FIRMS NFC EXPORT
834	3	K	FIRMS NFC FUEL FABRICATION
835	1	K	FIRMS NFC MATERIAL
836	2	K	FIRMS NFC MINES
837	1	K	FIRMS NFC ORE
838	6	K	FIRMS NFC POWER REACTORS
839	2	K	FIRMS NFC REACTOR EQUIPMENT
840	1	K	FIRMS NFC REACTOR INTERNALS
841	1	K	FIRMS NFC REACTOR TURBINES

842	4	K	FIRMS NFC SUPPLY
843	5	K	FIRMS NFC TECHNOLOGY
844	119	K	FIRMS NUC_REL
845	8	K	FIRMS NUC_REL CHEMISTRY
846	1	K	FIRMS NUC_REL COMPRESSORS
847	1	K	FIRMS NUC_REL COMPUTERS
848	1	K	FIRMS NUC_REL CONSTRUCTION
849	2	K	FIRMS NUC_REL CONSULTING
850	1	K	FIRMS NUC_REL CONTROL SYSTEMS
851	6	K	FIRMS NUC_REL ELECTRONICS
852	92	K	FIRMS NUC_REL ENERGY
853	8	K	FIRMS NUC_REL ENGINEERING
854	1	K	FIRMS NUC_REL EQUIPMENT
855	1	K	FIRMS NUC_REL ISOTOPES
856	6	K	FIRMS NUC_REL MATERIAL
857	5	K	FIRMS NUC_REL R&D
858	14	K	FIRMS NUC_REL RESEARCH
859	4	K	FIRMS NUC_REL RESOURCES
860	11	K	FIRMS NUC_REL SUPPLY
861	1	K	FIRMS NUC_REL WASTE HANDLING
862	12	K	FIRMS SUPPLY
863	12	K	FIRMS SUPPLY IRAQ
864	12	K	FIRMS TRADE
865	4	K	IMP. ALBANIA
866	17	K	IMP. ALGERIA
867	51	K	IMP. ARGENTINA
868	11	K	IMP. AUSTRALIA
869	4	K	IMP. AUSTRIA
870	2	K	IMP. BANGLADESH
871	49	K	IMP. BELGIUM
872	1	K	IMP. BOLIVIA
873	100	K	IMP. BRAZIL
874	6	K	IMP. BULGARIA
875	24	K	IMP. CANADA
876	1	K	IMP. CHILE
877	92	K	IMP. CHINA
878	1	K	IMP. CUBA
879	34	K	IMP. CZECHOSLOVAKIA
880	1	K	IMP. ECUADOR
881	12	K	IMP. EGYPT
882	1	K	IMP. EURATOM
883	1	K	IMP. EUROPE
884	36	K	IMP. FINLAND
885	121	K	IMP. FRANCE
886	12	K	IMP. GDR
887	187	K	IMP. GERMANY
888	4	K	IMP. HONG KONG
889	41	K	IMP. HUNGARY
890	43	K	IMP. INDIA
891	16	K	IMP. INDONESIA
892	74	K	IMP. IRAN
893	258	K	IMP. IRAQ
894	20	K	IMP. ISRAEL
895	21	K	IMP. ITALY
896	145	K	IMP. JAPAN
897	2	K	IMP. KAZAKHSTAN
898	17	K	IMP. KOREA/NORTH
899	135	K	IMP. KOREA/SOUTH
900	14	K	IMP. LIBYA
901	3	K	IMP. LIECHTENSTEIN
902	7	K	IMP. LITHUANIA
903	11	K	IMP. MEXICO

904	6	K	IMP. MOROCCO
905	1	K	IMP. NAMIBIA
906	14	K	IMP. NETHERLANDS
907	1	K	IMP. NIGERIA
908	1	K	IMP. NORWAY
909	75	K	IMP. PAKISTAN
910	10	K	IMP. PERU
911	12	K	IMP. PHILIPPINES
912	1	K	IMP. POLAND
913	16	K	IMP. ROMANIA
914	18	K	IMP. RUSSIA
915	4	K	IMP. SAUDI ARABIA
916	1	K	IMP. SEYCHELLES
917	1	K	IMP. SINGAPORE
918	31	K	IMP. SOUTH AFRICA
919	63	K	IMP. SPAIN
920	1	K	IMP. SUDAN
921	35	K	IMP. SWEDEN
922	54	K	IMP. SWITZERLAND
923	11	K	IMP. SYRIA
924	79	K	IMP. TAIWAN
925	3	K	IMP. THAILAND
926	19	K	IMP. TURKEY
927	91	K	IMP. UK
928	5	K	IMP. UKRAINE
929	1	K	IMP. UNITED ARAB EMIRATES
930	3	K	IMP. UNKNOWN STATE
931	1	K	IMP. URUGUAY
932	243	K	IMP. USA
933	73	K	IMP. USSR
934	13	K	IMP. YUGOSLAVIA
935	2	K	IMP. ZAIRE
936	3	K	LEGISLATION AUTHORITIES
937	17	K	LEGISLATION EXPORTS
938	1	K	LEGISLATION LAW
939	1	K	LEGISLATION LICENSING
940	1	K	LEGISLATION NUCLEAR
941	13	K	LEGISLATION NUCLEAR TRADE
942	3	K	LEGISLATION ORGANIZATION
943	1	K	LEGISLATION POLICIES
944	56	K	MATERIAL
945	10	K	MATERIAL BERYLLIUM
946	7	K	MATERIAL DEUTERIUM
947	306	K	MATERIAL GRAPHITE
948	163	K	MATERIAL HW
949	9	K	MATERIAL LEU
950	4	K	MATERIAL LITHIUM
951	113	K	MATERIAL PU
952	2	K	MATERIAL PU METAL
953	6	K	MATERIAL PU OXIDES
954	6	K	MATERIAL PU PUO2
955	7	K	MATERIAL PU WEAPONS
956	6	K	MATERIAL SPENT FUEL
957	10	K	MATERIAL TH
958	1	K	MATERIAL TH ORE
959	11	K	MATERIAL TRITIUM
960	1495	K	MATERIAL U
961	1	K	MATERIAL U ALLOYS
962	2	K	MATERIAL U DU
963	269	K	MATERIAL U HEU
964	818	K	MATERIAL U LEU
965	22	K	MATERIAL U METAL

966	45	K MATERIAL U MOX
967	236	K MATERIAL U NU
968	35	K MATERIAL U ORE
969	148	K MATERIAL U OXIDES
970	12	K MATERIAL U OXIDES MOX
971	1	K MATERIAL U OXIDES NU
972	13	K MATERIAL U U3O8
973	7	K MATERIAL U UCL4
974	3	K MATERIAL U UF4
975	20	K MATERIAL U UF6
976	80	K MATERIAL U UO2
977	3	K MATERIAL U UO3
978	2	K MATERIAL U UO4
979	2	K MATERIAL U WEAPONS
980	26	K MATERIAL ZIRCONIUM
981	476	K NON_PROL
982	1	K NON_PROL DISARMAMENT
983	64	K NON_PROL POLICIES
984	300	K NON_PROL SG
985	280	K NON_PROL SG AGR
986	224	K NON_PROL SG AGR_IAEA
987	129	K NON_PROL SG AGR_NPT
988	36	K NON_PROL SG AGR_PA
989	48	K NON_PROL SG AGR_STA
990	19	K NON_PROL SG AGR_TLC
991	35	K NON_PROL SG AGR_US
992	1	K NON_PROL SG CLAND.
993	1	K NON_PROL SG CLAND. ACTIVITIES
994	1	K NON_PROL SG CLAND. FACILITIES
995	1	K NON_PROL SG CLAND. MATERIAL
996	2	K NON_PROL SG DIVER.
997	2	K NON_PROL SG DIVER. EQUIPMENT
998	1	K NON_PROL SG DIVER. TECHNOLOGY
999	2	K NON_PROL SG IAEA
1000	1	K NON_PROL SG INCONSISTENCIES
1001	5	K NON_PROL SG NEGOTIATIONS
1002	1	K NON_PROL SG NON_COMPLIANCE
1003	48	K NON_PROL SG POLICIES
1004	1	K NON_PROL SG UNDEC.
1005	1	K NON_PROL SG UNDEC. ACTIVITIES
1006	1	K NON_PROL SG UNDEC. FACILITIES
1007	1	K NON_PROL SG UNDEC. MATERIAL
1008	10	K NON_PROL SG UNDERTAKINGS
1009	174	K NON_PROL TREATIES
1010	175	K NON_PROL TREATIES ARMS CONTROL
1011	117	K NON_PROL TREATIES BW CONVENTION
1012	175	K NON_PROL TREATIES DISARMAMENT
1013	55	K NON_PROL TREATIES ENMOD CONVION
1014	129	K NON_PROL TREATIES GENEVA PROTOCOL
1015	32	K NON_PROL TREATIES INHUMANE WEAPONS
1016	154	K NON_PROL TREATIES NPT
1017	93	K NON_PROL TREATIES OUTER SPACE
1018	175	K NON_PROL TREATIES PTBT
1019	187	K NON_PROL TREATIES RAROTONGA
1020	84	K NON_PROL TREATIES SEABED
1021	120	K NON_PROL TREATIES TEST BAN
1022	203	K NON_PROL TREATIES TLATELOLCO
1023	174	K NON_PROL TREATIES WEAPONS
1024	365	K ORGANIZ
1025	1	K ORGANIZATIONS NUCLEAR_RELATED
1026	95	K ORGANIZ_NUC
1027	10	K ORGANIZ_NUC CONSULTING

1028	52	K	ORGANIZ_NUC COORDINATION
1029	2	K	ORGANIZ_NUC ENGINEERING
1030	52	K	ORGANIZ_NUC GOVERNMENT
1031	1	K	ORGANIZ_NUC INTERNATIONAL
1032	70	K	ORGANIZ_NUC MANAGEMENT
1033	15	K	ORGANIZ_NUC RELATED
1034	54	K	ORGANIZ_NUC RESEARCH
1035	49	K	ORGANIZ_NUC TECHNOLOGY
1036	273	K	ORGANIZ_NUC_REL
1037	35	K	ORGANIZ_NUC_REL CONSULTING
1038	70	K	ORGANIZ_NUC_REL COORDINATION
1039	102	K	ORGANIZ_NUC_REL ENERGY
1040	10	K	ORGANIZ_NUC_REL ENGINEERING
1041	33	K	ORGANIZ_NUC_REL GOVERNMENT
1042	2	K	ORGANIZ_NUC_REL INTERNATIONAL
1043	70	K	ORGANIZ_NUC_REL MANAGEMENT
1044	1	K	ORGANIZ_NUC_REL MATERIAL
1045	1	K	ORGANIZ_NUC_REL MILITARY
1046	2	K	ORGANIZ_NUC_REL MINING
1047	2	K	ORGANIZ_NUC_REL PHYSICS
1048	194	K	ORGANIZ_NUC_REL RESEARCH
1049	16	K	ORGANIZ_NUC_REL RESOURCES
1050	5	K	ORGANIZ_NUC_REL TECHNOLOGY
1051	47	K	ORGANIZ_NUC_REL UNIVERSITIES
1052	297	K	PROGRAM_NFC_
1053	14	K	PROGRAM NFC CONVERSION
1054	28	K	PROGRAM NFC ENRICHMENT
1055	37	K	PROGRAM NFC FUEL FABRICATION
1056	9	K	PROGRAM NFC HEAVY WATER
1057	3	K	PROGRAM NFC LWR_MOX
1058	7	K	PROGRAM NFC MILITARY
1059	3	K	PROGRAM NFC ORE PROCESSING
1060	6	K	PROGRAM NFC POLICY
1061	153	K	PROGRAM NFC POWER REACTORS
1062	3	K	PROGRAM NFC REACTORS
1063	42	K	PROGRAM NFC REPROCESSING
1064	41	K	PROGRAM NFC RESEARCH REACTORS
1065	78	K	PROGRAM NFC WASTE PROCESSING
1066	5	K	PROGRAM NFC WEAPONS
1067	21	K	PROGRAM NUC_REL
1068	7	K	PROGRAM NUC_REL FUSION
1069	3	K	PROGRAM NUC_REL ISOTOPES
1070	3	K	PROGRAM NUC_REL MILITARY
1071	3	K	PROGRAM NUC_REL SUBMARINES
1072	9	K	PROGRAM NUC_REL WEAPONS
1073	64	K	PROGRAM R&D_
1074	1	K	PROGRAM R&D CONVERSION
1075	7	K	PROGRAM R&D ENRICHMENT
1076	2	K	PROGRAM R&D EQUIPMENT
1077	5	K	PROGRAM R&D FUEL FABRICATION
1078	1	K	PROGRAM R&D HEAVY WATER
1079	2	K	PROGRAM R&D LWR_MOX
1080	5	K	PROGRAM R&D MILITARY
1081	24	K	PROGRAM R&D NFC
1082	6	K	PROGRAM R&D NUCLEAR
1083	38	K	PROGRAM R&D REACTORS
1084	3	K	PROGRAM R&D REPROCESSING
1085	14	K	PROGRAM R&D TECHNOLOGY
1086	12	K	PROGRAM R&D WASTE
1087	2	K	PROGRAM R&D WEAPONS
1088	1	K	RESOURCES HEU WEAPONS
1089	48	K	RESOURCES PU

1090	25	K RESOURCES PU COMMERCIAL
1091	8	K RESOURCES PU LWR_MOX
1092	2	K RESOURCES PU SUMMARY
1093	27	K RESOURCES PU WEAPONS
1094	5	K RESOURCES TH
1095	71	K RESOURCES U
1096	1	K RESOURCES U COMMERCIAL
1097	21	K RESOURCES U HEU
1098	1	K RESOURCES U HEU COMMERCIAL
1099	2	K RESOURCES U HEU WEAPONS
1100	17	K RESOURCES U WEAPONS
1101	44	K TRAFF_EQUIP
1102	3	K TRAFF_EQUIP CONVERSION
1103	27	K TRAFF_EQUIP D_USE
1104	5	K TRAFF_EQUIP D_USE COMPUTERS
1105	4	K TRAFF_EQUIP D_USE ELECTRONIC
1106	2	K TRAFF_EQUIP D_USE EXPLOSIVES
1107	2	K TRAFF_EQUIP D_USE FURNACES
1108	15	K TRAFF_EQUIP D_USE KRYTRONS
1109	2	K TRAFF_EQUIP D_USE LASERS
1110	1	K TRAFF_EQUIP D_USE OSCILLOSCOPES
1111	1	K TRAFF_EQUIP D_USE SPECTROMETERS
1112	14	K TRAFF_EQUIP D_USE WEAPONS
1113	1	K TRAFF_EQUIP D_USE WEAPONS COMPONENTS
1114	12	K TRAFF_EQUIP ENRICHMENT
1115	1	K TRAFF_EQUIP TECHNOLOGY
1116	78	K TRAFF_MATER
1117	51	K TRAFF_MATER D_USE
1118	6	K TRAFF_MATER D_USE BERYLLIUM
1119	4	K TRAFF_MATER D_USE CESIUM
1120	1	K TRAFF_MATER D_USE COBALT
1121	1	K TRAFF_MATER D_USE DEUTERIUM
1122	5	K TRAFF_MATER D_USE HARD ALLOYS
1123	7	K TRAFF_MATER D_USE HW
1124	2	K TRAFF_MATER D_USE ISOTOPES
1125	6	K TRAFF_MATER D_USE MARAGING STEEL
1126	3	K TRAFF_MATER D_USE OSMIUM
1127	24	K TRAFF_MATER D_USE RADIOISOTOPES
1128	3	K TRAFF_MATER D_USE RADIOSOURCES
1129	6	K TRAFF_MATER D_USE RED MERCURY
1130	1	K TRAFF_MATER D_USE STRONTIUM
1131	2	K TRAFF_MATER D_USE TRITIUM
1132	4	K TRAFF_MATER D_USE ZR
1133	74	K TRAFF_MATER_NUC
1134	25	K TRAFF_MATER_NUC PU
1135	2	K TRAFF_MATER_NUC PU WEAPONS
1136	60	K TRAFF_MATER_NUC U
1137	2	K TRAFF_MATER_NUC U DU
1138	9	K TRAFF_MATER_NUC U HEU
1139	18	K TRAFF_MATER_NUC U LEU
1140	5	K TRAFF_MATER_NUC U NU
1141	2	K TRAFF_MATER_NUC U U3O8
1142	5	K TRAFF_MATER_NUC U WEAPONS
1143	5	K TRAFF_MATER_NUC WEAPONS
1144	1	K WEAPONIZATION NUCLEAR
1145	3	K WEAPONS
1146	1	K WEAPONS CONVENTIONAL
1147	1	K WEAPONS COOPERATION
1148	3	K WEAPONS MISSILES
1149	24	K WEAPONS NUCLEAR
1150	9	K WEAPONS NUCLEAR ACQUISITION
1151	24	K WEAPONS NUCLEAR CAPACITY

1152	2	K	WEAPONS NUCLEAR DEVELOPMENT
1153	14	K	WEAPONS NUCLEAR PROGRAM
1154	1	K	WEAPONS NUCLEAR TECHNOLOGY
1155	4	K	WEAPONS NUCLEAR TESTS
1156	32	K	WEAPONS NUC_MATER
1157	17	K	WEAPONS NUC_MATER PU
1158	15	K	WEAPONS NUC_MATER U

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Annex 6

Consultants Group Meeting on Environmental Monitoring and Special Analysis Methods for Safeguards

CONSULTANTS GROUP MEETING ON ENVIRONMENTAL MONITORING AND SPECIAL ANALYSIS METHODS FOR SAFEGUARDS

FINAL REPORT

IAEA

VIENNA, 30 MARCH - 2 APRIL, 1993

Table of Contents

1. Introduction

The IAEA is examining technical methods to support a possible broadened safeguards regime. In particular, there is recent emphasis on enhancing the Agency's ability to detect undeclared nuclear activities which should have been declared under the terms of a comprehensive safeguards agreement. Approaches are considered which involve assurance that there are no undeclared spent fuel reprocessing and/or enrichment activities in a State covered by a comprehensive safeguards agreement.

The IAEA convened a Consultants Group meeting, held between 30 March and 2 April, 1993. The Agency was interested in collecting information relevant to the following topics:

(a) the most sensitive and selective analytical methods for measuring the chemical, elemental or isotopic signatures associated with the undeclared production of high-enriched uranium (HEU) or plutonium;

(b) the appropriate sampling methods and quality assurance requirements for a programme of environmental monitoring aimed at the detection and characterisation of the above signatures, including the effect of concealment methods;

(c) the most appropriate methods which are available for handling and evaluating data resulting from such measurements; and

(d) the availability of expertise in the IAEA's Member States which could be utilised in the areas of training, provision of analytical services or the development of enhanced analytical capabilities within the IAEA itself.

A total of 28 outside participants/observers attended the Consultants' Meeting; approximately the same number of secretariat staff participated in the working groups and/or the plenary meetings. The participants are listed in Annex 6.1. The Scientific Secretary of the Meeting was Mr. R. Hooper; the Chairman was Mr. G. Andrew from the UK.

In the course of the Consultants' Meeting 24 documents, as listed in Annex 6.2, were distributed (prepared papers or copies of transparencies). These were the basis for the technical presentations.

Following the general presentations, working groups were formed and asked to concentrate on the three topics:

- detection of undeclared Pu production;
- detection of undeclared HEU production; and
- development of IAEA in-house capabilities.

Participants in the three working groups are listed in Annex 6.3. The following *"Terms of Reference"* were provided by the secretariat:

(a) What are the environmental signatures associated with the detectable steps in the

- production of Pu;
- production of HEU?

(b) What sampling and corresponding analytical methods are available for detecting and characterising (quantifying) these signatures?

(c) What are the limitations of these sampling and analytical techniques, including the effect of concealment measures? What are the training and equipment requirements?

(d) What are the data handling and evaluation techniques available?

(e) How can the IAEA make best use of the capabilities in the Member States and within the IAEA to improve its environmental sampling and analytical capabilities?

2. Overall Conclusions

2.1 For both reprocessing and uranium enrichment a range of signatures exist that in principle would allow the detection of undeclared activity. For uranium enrichment, the primary signature would be the detection of disturbed isotopic ratios. For the detection of reprocessing and nuclear facilities a wide range of signatures have been identified.

2.2 It is unlikely that detection of such signatures will always provide unambiguous identification of undeclared activity. It would, however, focus the attention of the IAEA on particular sites or countries and trigger further investigations.

2.3 In the context of the IAEA programme and likely resources, the most cost effective, wide area monitoring approach would be based on the collection of water samples and their analysis in the laboratory.

2.4 For a sampling programme close to, or within a facility, there is a very high probability of being able to confirm the existence of undeclared nuclear activity. The probability of detection may be at least an order of magnitude lower for a longer range environmental sampling programme.

2.5 The probability of success of a long-range monitoring programme would be improved if supplementary information (e.g. supplied by Member States) is taken into account.

2.6 It is realised that significant environmental monitoring experience, available in Member States, remains unpublished. If access to this information is given to the IAEA it would help the IAEA in selecting and demonstrating (testing) the most suitable techniques.

2.7 Quality assurance will be an essential component of an environmental monitoring programme. This will include: training, selected laboratories, standardised and documented sampling, analysis, data management, model verification and assessment procedures.

2.8 The use of a structured environmental sampling programme as part of routine safeguards inspection activities has the potential to provide a cost effective and valuable source of information on the activities being undertaken, declared or otherwise, at nuclear facilities.

2.9 Although the IAEA's analytical facilities in Austria and at Monaco provide a valuable existing resource, they do not include the extensive capabilities that would be needed for the type of environmental analysis required for safeguards applications.

3. Overall Recommendations

3.1 A range of detailed recommendations for developing the IAEA's environmental monitoring capabilities have been identified. Specific areas where further work is recommended include:

- a critical review of methods for sampling and analysis;
- a review of currently available, relevant environmental data;
- development of a database including relevant environmental background data and isotopic compositions indicative of uranium and plutonium production;
- development of recommendations concerning the implementation of short-and long-range environmental sampling techniques;
- the definition of training and QA programmes;
- a review of the availability of suitable reference material and where necessary to develop new ones; and
- the definition of protocols for data management, mathematical modelling and statistical analysis of environmental measurement data.

3.2 The IAEA should supplement their own analytical resources with certain specialised equipment and facilities. These include:

- an inductively coupled plasma mass spectrometer;
- a clean-room facility; and
- screening instrumentation for the selection of sampling and analysis sites.

Use should be made of the comprehensive range of analytical capabilities available in Member States.

3.3 The IAEA should institutionalise the use of environmental monitoring as part of special inspections and consider its application in routine safeguards activities, as outlined below.

3.4 Consideration should be given to the implementation of a multi-national trial for short- and long-range monitoring on (a voluntary basis) as part of Member States' support programme, to gain experience and build confidence in the use of such techniques.

4. Suggested Next Steps

In considering how best to further integrate environmental monitoring techniques into routine safeguards activities and special inspections, the IAEA should consider five *"reference cases"*.

4.1 Case One: Special Inspections: Ad Hoc Monitoring.

In this case, it is assumed that the IAEA has some reason to suspect possible undeclared nuclear activities at a particular site (which could be co-located with a declared site). The IAEA has recently gained extensive experience with this type of inspection scenario in Iraq and other countries. Therefore, next steps should focus on operational details needed to institutionalise that experience, including protocols for sampling and analysis, training and equipment requirements, development of quality assurance/quality control programs and data handling and evaluation procedures. The IAEA should draw on cost-free experts and Member State support programs, as needed, to provide assistance in these areas.

4.2 Case Two: Undeclared Activities at Declared Sites: Routine Monitoring.

This case addresses the situation in which a declared facility is contained within a larger site that is not subject to routine inspection. It is assumed that the IAEA has no reason to suspect undeclared activities within that larger site. As part of its initiative to strengthen/streamline safeguards, the IAEA may wish to use environmental monitoring/sampling close to or within sites to obtain added assurance of the absence of undeclared activities. The IAEA's experience in dealing with this type of scenario is rather limited. Therefore, further conceptual studies are needed to:

1. analyse the cost/benefit trade-offs involved in trying to implement monitoring sampling techniques as an additional safeguards measure; and
2. determine how such a monitoring/sampling program might be implemented in practice.

4.3 Case Three: Water Sampling as a Wide Area Routine Monitoring Technique.

The IAEA has gained some experience with this type of technique in Iraq. In the context of ongoing SAGSI efforts to strengthen/streamline safeguards by gaining increased confidence in the absence of undeclared reprocessing activities, the IAEA should assess the costs and benefits of implementing a water sampling program as a wide area monitoring technique in other states. It is suggested that the IAEA should also consider implementing a trial program in one state, where commercial nuclear fuel facilities exist, possibly as part of its R&D Support Programme.

4.4 Case Four: Air Sampling as a Wide Area Routine Monitoring Technique

The IAEA has essentially no experience with this type of sampling program. Moreover, the costs associated with this type of program are likely to be fairly high, in comparison to water sampling, and there are a host of complex issues to be addressed. The IAEA should investigate suitable opportunities, including existing national systems, for wide area sampling on a limited basis. For the longer term, more extensive applications of air sampling as an area monitor could be evaluated when experience from such a trial is available. Air sampling may be especially important for wide range sampling of arid environments.

4.5 Case Five: Water, Soil, Biota, Vegetation and Air Sampling/Monitoring Anywhere in a State as a Wide Area Routine Monitoring Technique.

Such a sampling/monitoring regime would allow a full range of environmental samples (water, soil air, etc.) to be taken 'anywhere' in a state, possibly as part of a strengthened inspection programme. The resource requirements for widespread application of this type of comprehensive monitoring regime would be very substantial. Experience of the other, more modest, approaches would be necessary before considering further. A cost/benefit analysis would need to be undertaken and legal questions, for example over the removal of samples from commercial premises, would also need to be resolved.

5. WORKING GROUP REPORTS

5.1 WORKING GROUP 1 - DETECTION OF UNDECLARED HEU PRODUCTION

HEU processes can be identified through the use of routine environmental monitoring. Regardless of the chemical form in the environment, the detection of altered isotopic ratios in uranium is an unambiguous indicator that enrichment activities have occurred. A comprehensive sampling plan is essential to the success of environmental monitoring as applied to safeguards activities.

5.1.1 INTRODUCTION

Three cases were defined which require different approaches to detection through environmental monitoring. These are for undeclared enrichment activities in:

- a declared facility,
- an undeclared facility at a known site, and
- an undeclared facility at an unknown site.

Several technologies have been used for production of highly enriched uranium. A first safeguards priority should be detection of HEU production by the technologies with proven capability of producing HEU in quantities sufficient for the assembly of nuclear weapons. These technologies are:

- gaseous diffusion;
- gas centrifuge;
- vortex tube and,
- electromagnetic isotope separation

Uranium mining operations could be carried out for production of power reactor fuel and declarations of uranium mining activities are not required for full scope safeguards states. Therefore detection of mining operations by environmental monitoring is not a safeguards objective. Detection of conversion of uranium oxide to UF_6 is of interest as it indicates preparation for uranium enrichment activities. Other separation technologies may use different feed materials and different signatures must be identified for each separation technology to be identified.

The group decided to identify the process steps involved in uranium enrichment, then list the possible signatures from each step. The group did not spend time on uranium mining or milling operations.

5.1.2 REFERENCE FACILITY

The IAEA considers high enriched uranium as direct-use nuclear material. 20% enrichment is taken as the threshold value. The amount of such material needed to produce a nuclear explosive is assumed to be 25 kg - this amount is defined as a significant quantity.

For the purpose of the discussions by the consultants, it is assumed, that a reference uranium enrichment facility destined to produce high enriched uranium, be a facility large enough to just produce 25 kg of 90% enriched uranium per year.

Two situations are to be distinguished:

1. a facility using natural uranium as a feed, and

2. a facility using recycled uranium as a feed.

The table below shows the relative material flows associated with such a model facility, operating at a capacity of 6000 SWU/y with a tails enrichment of 0.25%. The calculation is based on ideal cascade behaviour and can thus only yield estimates.

TABLE 5.1.1
Reference Facility throughput for natural and recycled uranium feed

Mg/h	Case 1	Case 2
Feed	5615.1	4223.3
Product	28.8	35.3
Tails	5586.2	4188.0

This facility is relatively small in terms of throughput and any material, once in place, could be easily stored on site. When following enrichment routes based on UF_6, commercially used feed and tails cylinders contain around 12 t of UF_6. Product cylinders would, in the case of 90% enrichment, have to be specially designed to guard against the risk of criticality.

Because of the high enrichment to be achieved, gaseous diffusion plants may not easily lend themselves to the scenario considered here, as substantial accumulations of 90% enriched uranium could cause criticality problems.

Due to the small amounts of material to be handled at the reference facility, containment of material during normal operation may be possible. HEPA-type filters with high DFs and precautions regarding the facility location (such as locating the facility underground) may impede the detection of such facilities even if measurements were made at close range.

5.1.3 KEY SIGNATURES

Uranium with isotopic abundances different from that of natural uranium is the primary signature for HEU production activities. In any separation technology some enriched uranium will be inevitably be released to the environment. Environmental samples taken at or near an enrichment facility can contain some of the enriched material altering the uranium isotopic abundance. Analysis of samples of vegetation, water and soil for uranium isotopic content using a sensitive analytical technique, such as thermal ionisation mass spectrometry is recommended as the primary technique for the detection of HEU production.

The sampling techniques and equipment are relatively simple and require minimum resources from the IAEA. Analysis of the samples requires sophisticated analytical equipment, clean laboratories, skilled technicians and development of standard sampling and quality control programs, and is therefore relatively expensive to implement on a large scale. The IAEA could possibly use member state resources to supplement the IAEA resources for sample analysis to reduce the cost of these functions to the Agency. Greater detail on sampling techniques is included later in this report.

5.1.4 SECONDARY SIGNATURES

Table 5.1.2 lists the secondary signatures for processes using UF_6 gas.

In the conversion step, one could look for uranyl fluoride, but the isotopic ratio would not change from uranium ore (i.e., no fractionation). However, an analytical method that yielded oxidation states of atomic uranium and fluoride, such as ESCA (electron spectrometry for chemical analysis), could be used to identify the uranyl compound. It is suggested that the environmental monitoring approaches used in the Kerr-Magee accident in Oklahoma. U.S.A. be reviewed.

Isotopic analysis of uranium is the best chance of detecting uranium enrichment. The sensitivity of the method is sufficient to detect the operation if samples can be taken in close proximity to the facility.

The group identified a need to test the U isotopic sampling and analysis techniques at a pilot facility. In particular, it would be helpful to know how far away the signature can be identified.

A unique secondary signature for gas centrifuge plants could be the electromagnetic noise frequency generated when the centrifuges are operating. This signature can should be explored as a possible on site technique for detection of undeclared activities at declared sites.

Other processes that do not use UF_6 gas may emit other unique signatures. These processes include atomic vapour laser isotope separation or other laser isotopic processes, and electromagnetic isotope separation.

TABLE 5.1.2
SIGNATURES FROM ENRICHMENT PROCESSES USING UF_6 GAS

Process	Signature	Sample Matrix	Measurement Technique
Conversion	UO_2F_2	Air, vegetation, soil	ESCA
	HF	Air, capture gas in impinger	IC, SIE
	F^-	Biota, water	IC, SIE
	Uranium Conc.	Vegetation, water	TIMS
Enrichment	Uranium Isotope Ratios	Vegetation, water, soil, sediments, swipes	TIMS
	UO_2F_2	Swipes, vegetation	ESCA

ESCA - Electron Spectrometry for Chemical Analysis
IC - Ion Chromatography
SIE - Selective Ion Electrode
TIMS - Thermal Ionisation Mass Spectrometry

5.1.5 ENVIRONMENTAL SAMPLING PLAN

Prior to the dispatch of inspectors to the site of a suspected uranium enrichment facility, a comprehensive environmental sampling plan should be developed on the basis of a careful analysis of the expected types of facility operations, the key environmental signatures, and the expected effects of the local environmental characteristics on the dispersion and deposition of discharges. This plan should not only address the expected signatures, but also the types and locations of samples to be collected, and the most appropriate sample collection techniques.

A careful analysis of the local environmental characteristics such as the climatology, topography, surface water drainage areas, and extent of vegetation coverage is required to develop an effective sampling location plan that will have the highest chance for detecting the build up of emissions within particular geographical areas. This process will involve the collection of existing WMO climatological data over the surrounding region, the acquisition of topographic maps, descriptions of the geology and the extent and types of vegetation coverage. Analysis of the climatological data in conjunction with the topographic maps will help to derive the major wind flow patterns over the area that will determine the most likely locations for collecting emissions in soil and vegetation samples. Inspection of the terrain maps will reveal the pertinent surface water drainage areas for defining the most suitable water and sediment sampling locations.

5.1.6 TYPES OF SAMPLES

The major transport mechanisms for uranium, on site and in the immediate proximity, will be:

- air transport and deposition of particulate matter, and
- surface water transport.

Deposition surfaces that should be considered for sampling of air-transported particles, and corresponding sampling techniques, are given in table 5.1.3:

TABLE 5.1.3

Deposition Surface	Sample Type/Method
Interior surfaces where particles accumulate	Wipe sample
Pine needles, grasses, hairy leaves	Vegetation or faecal matter, grab sample
Ground surface	Surface soil or road surface sample.

Soluble and suspended uranium may be transported off site by process waste water streams, natural surface drainage, and surface streams. Sample types that should be collected include:

- bottom sediment;
- suspended sediment, and
- water.

5.1.7 COLLECTION TECHNIQUES

Surface water samples: Uranium transported by waste water and runoff can be present as dissolved ion, colloidal, suspended silt, or bottom sediment. Stream and surface water sampling for uranium and its various isotopes should consider all of these phases.

Dissolved uranium can be collected as a grab sample from a surface water body. A pre-cleaned, and acid treated, linear poly-ethylene bottle should be used to collect and store the sample. The water should be filtered before collection to remove suspended sediment, as it may act as a sink for the dissolved uranium. Conversely, the sediment can be left in and digested in the laboratory with the rest of the water sample. Depending on the sensitivity of the analytical technique, it may be necessary to concentrate the dissolved uranium from a large volume of water. This may be accomplished by pumping or transferring the water through a resin bed or exchange column containing a selective adsorbent for uranium. Pilot studies will need to be performed before going to the field to determine the type of sorbent and volume throughput.

Suspended silts and clays may contain absorbed and precipitated uranium. These suspended particles can be collected in sediment traps, which may be left unattended in the stream for periods of days. Also, large volumes of water (the volume will depend on the sediment loading) can be pumped through filters to collect suspended water in a shorter time frame. Silt size particles can be effectively collected on paper or glass fibre filters. However, a higher relative concentration of uranium will likely be found on clay and colloidal sized particles. A micrometer or sub-micrometer filter, either glass fibre or membrane, can be used to collect finer sediments. Clays are nominally 2 μm or less, and colloids will require filter pore sizes down to 0.02 μm.

Bottom sediments and oxide coatings on stream rocks and gravels serve as sinks for uranium and other heavy metals. These can be collected using a drag sampler or clam-shell samplers. The bulk of the uranium will be present on the finer sediments, so rocks and large objects can be discarded. If no fine sediments are available, then the oxide coatings on rocks may be sampled.

5.1.8 WIPES AND VEGETATION SAMPLES

Wipe media, which should be certified free of nuclear material, are best employed within the confines of facility buildings. Wipes of work areas, process withdrawal points, ledges, or any location where an accumulation of dust is likely or evident have the best chance of containing effluent characteristic of facility operations. Wipes of outside surfaces are far less likely to be of use. Many other media are preferable in that they are better "concentrators" of facility discharges.

Vegetation collected in the immediate environs of a suspect facility can yield useful information. Appropriate types of vegetation would include pine needles, grasses, and leaves, particularly hairy leaves, taking care to avoid the inclusion of any soil with the vegetation sample. Individual vegetation samples, as with any samples, should be isolated immediately and collected by double bagging.

It is of utmost importance to maintain sample integrity in the collection of samples. Great care must be taken to insure that samples are not contaminated by the collector, the sample media, the sample container (and shipping process), the initial processing laboratory, or at any point along the sample custody chain from collection until the sample is protected within a clean analytical process stream.

Some measures that will greatly reduce the likelihood of contamination include:

1. avoidance of the use of collectors who work in or have recently visited other nuclear facilities;

2. acquisition and use of a single source of certified nuclear free wipe sampling media;

3. immediate double-bagging of collected samples (as each is collected);

4. proper documentation of sample collection locations;

5. packaging and shipment procedures that avoid initial, intermediate, or final destinations at nuclear related facilities;

6. initial processing (splitting) of samples (one at a time) at a certified clean room (class 100 or better) using proper clean room techniques, and

7. implementation of standard reference procedures for the collection and handling of samples.

5.1.9 FAECAL MATERIAL

Herbivores, which graze, are natural accumulators of grass and surface soils. Since the gut uptake of uranium is not high, most material is likely to be excreted. Such faeces could contain material that had been previously aerially deposited over a wide area and the collection of these might give some indications of an enrichment facility.

The collection of faeces should be directly into clean plastic bags. No elaborate storage protocol is necessary, other than ensuring that the plastic bag remains sealed. Material that is deposited onto non-vegetated land surfaces may be collected for analysis. A major area of such land surfaces consists of exposed soil, which will have a natural uranium content. Deposited material is likely to migrate into the soil (in the absence of anthropogenic activities) at relatively slow rates and it is expedient to maximise the area from which a sample is collected, whilst minimising he depth to which the sample is taken, within the limits of practicality. Since deposited material will accumulate on the surface, the sampling of sub-surface soil for background uranium is possible but care must be taken to avoid cross-contamination with the surface soil. Soil can be collected using traditional soil coring tubes.

5.1.10 SOIL SAMPLING

The natural uranium that is found in soils is likely to be associated with a range of particle sizes. The possibility of soil sieving should be considered, since deposited material is likely to be associated with small and intermediately sized particles (less than 50 micrometers, or silt- and clay-sized particles). Such sieving could result in a significant reduction in sample volume, whilst maintaining the amount of sampled deposition.

Road dust has been found to contain quite high levels of various radionuclides that have been deposited from the atmosphere. Part of the reason for this is that road dust includes a significant fraction that is soil from the very uppermost surface layer. Such dust can also include material originating from passing vehicles and there is the possibility of a spread of contamination from an enrichment facility (although the probability of this is unlikely to be great and will diminish significantly with increasing distance from a site). The collection of road dust is a relatively straightforward task and this can be achieved for quite large areas, without difficulty, by brushing into a sample container. The possibility remains for sample concentration by sieving, as in the case of soil sampling.

In the case of both soil and road dust sampling, no elaborate storage protocol is necessary and samples can stored in plastic bags. However, plastic gloves should be worn and soil samples, from depths between about 5 and 15 cm should be taken before surface samples. Plastic gloves should be changed at every sampling location.

5.1.11 ANALYTICAL TECHNIQUES

Accurate measurements of the isotopic abundances of ^{234}U, ^{235}U, and ^{238}U are necessary. These measurements are typically performed using thermal ionisation mass spectrometry with pulse-counting capabilities that permit analysis of nanogram-size samples. Any change in ^{234}U or ^{235}U abundance is unequivocal evidence that man-altered uranium is present. The ratio of ^{234}U to ^{235}U can provide some information about the type of enrichment technology used. The presence of ^{236}U would indicate the presence of uranium that had been exposed to a neutron flux. Separation of uranium from other elements before analysis is necessary for high sensitivity and precision. Other analytical techniques will be required for analysis of secondary signatures such as UO_2F_2. Descriptions and applications of these analytical techniques are included in the laboratory working group report.

5.1.12 **CONCLUSIONS**

1. Isotopically altered uranium is the primary signature for the detection of a highly enriched uranium production facility. Uranium concentration, uranium compounds, and other compounds and materials associated with the specific technology or associated processes used are important secondary signatures.

2. A comprehensive environmental sampling plan, taking into account existing geographical, meteorological, and hydrological data, should be developed. The plan should include at a minimum standard sampling procedures, analytical procedures, training procedures, and a quality assurance plan.

3. Environmental samples collected in the immediate vicinity of the facility have a high probability of detecting HEU production activities and related activities. The highest probability of detection will be samples within the facility; with a high chance of success using samples of vegetation, soils, and water and sediments, within close proximity; and lower success rates in water and sediment samples collected at distance.

4. Implementing sample collection techniques will require only a minimum of Agency resources, once a plan is in place. However, sample processing and analysis will require greater effort and considerable resources for success.

5.1.13 **RECOMMENDATIONS**

1. The Agency should consider collection of environmental samples within and around appropriate facilities during routine inspections to enhance safeguards capability for detection of HEU production.

2. A working group composed of Member States should be convened by the Agency to evaluate the capabilities of environmental sampling and analysis as a safeguards tool for detection of undeclared HEU production activities. The working group could:

- review the data currently available from member state enriched uranium processing facilities;
- determine needs for additional data;
- help co-ordinate taking and analysing samples for additional signatures and data if required; and
- provide the IAEA with recommendations for actions concerning implementation of environmental sampling techniques for detection of undeclared enriched uranium processing activities.

5.2 WORKING GROUP 2 - DETECTION OF UNDECLARED PLUTONIUM PRODUCTION

The Plutonium Working Group considered the type of signature, the collection of samples, the analytical technology and the necessary quality assurance needed for the detection of undeclared Pu production through environmental monitoring. The group initiated its deliberations by defining a starting point as the "reactor", continuing on to reprocessing, after various fuel cooling times, and finally to an end Pu product created through conversion of the dissolved Pu to a material ready for weapon manufacture.

5.2.1 UNDECLARED REACTOR OPERATIONS

Detection of an undeclared reactor by environmental sampling is possible by sampling short-lived atmospheric radioactive gases and transported radionuclides in surface water (streams, rivers, lakes, oceans). Effectiveness of detection techniques decrease with distance from the reactor. On-site and short-range sampling of short-lived fission gases is key to the detection of an undeclared reactor, however, the reactor must be operating. Aqueous effluents containing trace activation and fission products are also excellent sources for effective on-site and short-range detection. Aqueous effluents also have the advantage of long range detection because of their traceable and columnated transport. Furthermore the reactor does not have to be operating and many effluent signatures will remain in the stream sediments for several years gradually migrating downstream where they concentrate in deposited sediments and aquatic biota.

Tables 5.2.1 to 5.2.3 outline a variety of signatures and the associated sampling and detection technologies, their degree of effectiveness and cost.

Reactor fuel for the production of plutonium and target manufacture for the production of tritium involves the use of material and machinery common to other manufacturing industries with the exception of uranium and possibly enriched lithium. Aqueous waste from such operations which may find its way to surface water systems and is the primary source for short and long range detection.

The costs involved with aqueous sampling are most reasonable and primarily involve laboratory-based analysis. The extent of the analyses desired determine the individual sample costs ($100 - $500 US per analysis). However, capital equipment can be relatively expensive depending upon the degree of sensitivity and selectivity required ($100,000 - $300,000 US). One very useful on-site tool which combines a number of methods of analysis is the mobile laboratory which has been demonstrated by Member States to be very effective (cost $750,000 - $1,500,000 US).

Table 5.2.1
Detection of an Undeclared Reactor.

	Signatures	Sampling techniques	Analytical techniques	Effect-iveness	Cost
No Counter Measures					
On Site	short-lived fission gases[1] ^3H, ^{14}C volatile isotopes AQ short-lived ACT, FP long-lived ACT, FP AQ U, Pu isotopics Thermal sig.	mobile lab • γ-spec • ^3H liq. scint • noble gas γ-det sample screen sample coll.: • wipes • effluents • protect clothes	radiometry γ-spec chem., GC, lab. anal.	high mod high	high mod mod
10 km	short-lived fission gases[1] ^3H, ^{14}C volatile isotopes AQ short-lived ACT, FP AQ long-lived ACT, FP AQ U, Pu isotopics Thermal sig.	mobile lab • γ-spec • ^3H liq. scint • noble gas γ-det sample coll. • stream water • air filters	radiometry lab. anal.	high high	mod mod
Long Range	^3H AQ short-lived ACT, FP AQ long-lived ACT, FP AQ U, Pu isotopics Thermal sig.	sample coll. • water	lab anal.	high	mod
Counter Measures					
On Site	short-lived fission gases[1] ^3H, ^{14}C AQ long-lived ACT, FP AQ U, Pu isotopics Thermal sig.	mobile lab • γ-spec • ^3H liq. scint • noble gas γ-det sample screen sample coll., wipes effluents protect clothes	radiometry	mod	high
10 km	^3H, ^{14}C AQ long-lived ACT, FP AQ U, Pu isotopics Thermal.	^3H sampler sample coll: • water • air filters	lab. anal.	mod	mod
Long Range	AQ long-lived ACT, FP AQ U, Pu isotopics Thermal	sample coll: • water	lab anal.	mod.	mod.

[1] - Reactor operating

Table 5.2.2
Reactor signatures

Reactor Type	G (LWC)	Magnox	HW (LWC)	BWR	PWR	CANDU
Releases to air during normal reactor operation.						
^{41}Ar	x	X	x	x	x	x
^{88}Kr	x	x	x	x	x	x
^{85m}Kr	x	x	x	x	x	x
^{87}Kr	x	x	x	x	x	x
^{133}Xe	x	x	x	x	x	x
^{135}Xe	x	x	x	x	x	x
^{14}C	X	X	x	x	x	x
^{3}H (HTO)	x	x	X	X	x	X
Releases to air due to fuel failure						
^{132}I	X	X	X	x	x	x
^{133}I	X	X	X	x	x	x
^{131}I	X	X	X	x	x	x
^{129}I	x	x	x	x	x	x
^{85}Kr	x	x	x	x	x	x
^{103}Ru	x	x	x	x	x	x
^{106}Ru	x	x	x	x	x	x

Table 5.2.2 Continued

Reactor type	G (LWC)	Magnox	HW (LWC)	BWR	PWR	CANDU
Releases to water						
^{3}H	x	x	X	x	x	X
Short-lived (<30 days) activation products						
^{24}Na	x					
^{56}Mn	x					
^{64}Cu	x					
^{76}As	x					
^{51}Cr	x		x	x	x	
^{72}Ge	x					
^{56}Fe	x					
^{32}P	x					
^{239}Np	x		x			
Long-lived Activation Products (>30 days)						
^{60}Co	x		x	x	x	x
^{58}Co			x	x	x	x
^{57}Co			x			
^{65}Zn	x		x			
^{54}Mn			x	x	x	x
^{46}Sc	x					
^{63}Ni			x			
^{55}Fe			x			
^{56}Fe			x			

Table 5.2.2 Continued

Reactor type	G (LWC)	Magnox	HW (LWC)	BWR	PWR	CANDU
Fuel Rod Storage/Failure						
^{134}Cs	x	x	x	x	x	x
^{135}Cs	x	x	x	x	x	x
^{137}Cs	x	x	x	x	x	x
^{132}I	x	x	x	x	x	x
^{133}I	x	x	x	x	x	x
^{131}I	x	x	x	x	x	x
^{129}I	x	x	x	x	x	x
^{103}Ru	x	x	x	x	x	x
^{106}Ru	x	x	x	x	x	x
^{95}Zr	x	x	x	x	x	x
^{95}Nb	x	x	x	x	x	x
^{141}Ce	x	x	x	x	x	x
^{144}Ce	x	x	x	x	x	x
^{140}Ba	x	x	x	x	x	x
^{140}La	x	x	x	x	x	x
^{230}Np	x	x	x	x	x	x
^{238}U	x	x	x	x	x	x
^{234}U	x	x	x	x	x	x
^{235}U	x	x	x	x	x	x
^{236}U	x	x	x	x	x	x
^{239}Pu	x	x	x	x	x	x
^{240}Pu	x	x	x	x	x	x
^{241}Pu	x	x	x	x	x	x
^{242}Pu	x	x	x	x	x	x
^{238}Pu	x	x	x	x	x	x
^{4}He			X			
CO_2	X	X	x			
D_2O			X			X
Thermal	x	x	x	x	x	x

Table 5.2.3
Sampling Techniques

On-site	Mobile Lab. High Vol. Air: • Filter; • Charcoal (Iodine isotopes); • ^{3}H Liq. Scint.; • Noble gases - compression/counting. Sample screening: • α-counting; • γ-spectrometry; • Portable GC. Sample Collection: • wipes; • effluents; - filters; - waters (with preconcentration); • protective clothing.
Short Range (10 km)	Mobile Lab. High Vol. Air: • Filter; • Charcoal (Iodine isotopes); • ^{3}H Liq. Scint.; • Noble gases - compression/counting. Sample Collection: • High Vol. Air: - Filter; - Charcoal (Iodine isotopes); - Vegetation; - Soil; - Stream water: Above site Below site - Tritium, grab samples Meteorology
Long Range	Sample Collection: • stream water Meteorology

5.2.2 **UNDECLARED REPROCESSING OF IRRADIATED FUEL**

Recovery of Pu from irradiated fuel will, potentially, give rise to environmental signatures, from both the radioactive and non-radioactive operations. It is assumed at this stage that environmental signatures will primarily arise from gaseous discharges, rather than from a aqueous discharges. It is thought that for small scale weapons manufacture liquid wastes will be stored and not discharged. However, if liquid wastes are discharged, the fission and activation products, as well as the actinides may find their way into the aqueous discharges.

Recovery of Pu from irradiated fuel involves three main stages:

- fuel dismantling and dissolution;
- separation and purification, and
- conversion (from nitrate to metal).

Fuel dismantling and aqueous dissolution is likely to result in the release of ^{133}Xe and ^{85}Kr (unless cryogenic methods are employed), volatile radionuclides such as $^{129/131}$I, ^{14}C, ^{3}H and $^{103/106}$Ru and possibly particulates derived from fuel solutions.

Dissolution of metal fuels will result in releases over a period of a few hours. With simple off-gas systems (condenser and scrubber only) the total inventory of $^{129/131}$I, ^{14}C, ^{133}Xe and ^{85}Kr will be released, along with a small fraction ($<10^{-4}$) of the ^{3}H and $^{103/106}$Ru (see Table 5.2.4). The ^{3}H release faction is uncertain at present. Storage of fuel for 1-2 years prior to reprocessing would effectively remove ^{131}I and ^{133}Xe.

More elaborate off-gas systems, employing nitric acid recombination, caustic scrubbing and HEPA filtration will further reduce the release of volatile radionuclides by 2-3 orders of magnitude. Modest scale dissolutions (50 kg) using an elaborate off-gas treatment system, may result in detectable releases of $^{129/131}$I, ^{14}C, ^{133}Xe, ^{85}Kr, ^{3}H and $^{103/106}$Ru (see Table 5.2.4).

The release of non-volatile fission products and actinides, in the form of aerosols, may occur to a very much smaller extent. For a simple off-gas treatment system releases are likely to be in the region of 10^{-8}-10^{-10}. More elaborate off-gas treatment systems will reduce the release of aerosols to effectively zero. Important non-volatile radionuclides include ^{95}Zr, ^{95}Nb, ^{144}Ce, $^{134/137}$Cs and $^{239/240/241}$Pu (see Table 5.2.5). Storage of fuel for 2 years prior to reprocessing would reduce potential release fractions for ^{93}Nb, ^{93}Zr by a factor of approximately 190.

Table 5.2.4
Estimated Release Fractions from the Dissolution of Irradiated Fuel

Radio-nuclide	Release fraction from a simple off-gas system	Estimated release from a 50 kg dissolution of 1000MWd/t fuel using a condenser/scrubber off-gas system. (Bq)	Estimated release from a 50 kg dissolution of 1000MWd/t fuel using a more elaborate off-gas system. (Bq)
^{129}I	1	1.35×10^6	1.35×10^3
^{131}I	1	4.45×10^{13}	4.45×10^{10}
^{14}C	1	7.20×10^6	7.20×10^3
^{85}Kr	1	6.00×10^{11}	6.00×10^{11}
^{133}Xe	1	1.05×10^{14}	1.05×10^{14}
^3H	10^{-5}	2.55×10^5	2.55×10^2
$^{103/106}Ru$	10^{-4}	1.55×10^9	1.55×10^6

Table 5.2.5
Estimated Release of Non-Volatile Radionuclides as Fuel Solution Droplets

Nuclide	Estimated release (Bq) of non-volatile radionuclides from a 50 kg dissolution of 1000MWd/t fuel assuming a release fraction of 10^{-10}
^{95}Zr	9500
^{95}Nb	9500
^{99}Tc	0.085 (1.3 x 10^{-10}g)
^{134}Cs	60
^{135}Cs	0.006
$^{137}Cs/Ba$	600
$^{144}Ce/Pr$	6000
^{238}Pu	0.04
^{239}Pu	9.0
^{240}Pu	2.9
^{241}Pu	104
^{242}Pu	1.51 x 10^{-4}
^{241}Am	0.12
^{110m}Ag	0.72

5.2.3 SEPARATION AND PURIFICATION OF PU

Pyrochemical processes are likely to generate considerable quantities of particulate material which would require removal by HEPA filtration, etc. Releases of $^{103/106}Ru$ and $^{129/131}I$ are likely to be very much lower than for aqueous dissolution systems. Significant quantities of ^{14}C and ^{3}H may be released. There are good prospects for the application of cryogenic trapping of the active noble gases. Small quantities of irradiated fuel will, potentially, be released as fine aerosols. Precipitation processes are unlikely to result in clear environmental signatures as the feed materials consist mainly of commonly occurring inorganic materials.

With solvent extraction, although there is the potential for the release of radionuclides, the main releases are likely to arise from the handling and preparation of inactive feed materials. Important classes of extractants include: secondary and tertiary amines with carbon chains of length C_8-C_{12}, organo-phosphorus compounds, specifically phosphates and phosphonates with carbon chains typically of length C_4-C_6, ketones (hexone etc.) and some ethers (Butex and Trigly). Important diluents include: aromatic hydrocarbons such as di-ethylbenzene (lower flash point aromatic hydrocarbons might be tolerated), chlorinated and brominated hydrocarbons and long chain alkanes (dodecane, odourless kerosene etc.).

5.2.4 CONVERSION OF PLUTONIUM NITRATE TO METAL

Conversion processes involving a precipitation step may utilise H_2O_2, HI, $H_2C_2O_4$. These processes require dynamic, dehydration and calcination prior to high temperature fluorination with HF. These processes will inevitably give rise to signatures from particulate releases. Direct fluorination with HF will also result in environmental signatures from the high temperature dehydration operation prior to calcium reduction. The calcium hexaplutonate (IV) process does not require high temperature calcination or dehydration, and may therefore result in a considerably reduced environmental signature. Calcium reduction of PuF_3 or PuF_4 to Pu metal will be carried out in a closed bomb and will provide minimal releases of Pu to the environment.

5.2.5 SIGNATURES ARISING FROM REPROCESSING

Reprocessing operations are likely to give clear environmental signatures which should, in principle, be easily distinguishable from reactor operation and Pu recovery for fuel purposes. The release of $^{85}Kr/^{133}Xe$ and $^{129}I/^{131}I$ during reactor operation will be distinctly different from that occurring during reprocessing. The $\beta\gamma/\alpha$ ratio will also be very different. Operations to produce Pu for nuclear fuel and Pu for weapons purposes will give markedly different Pu isotopic signatures (from the conversion process).

The reprocessing term is process-dependent and will therefore encompass a wide range of active and inactive components. The environmental signatures will depend on the release fraction, plume transport and dispersion and, in the case of organic materials, their reactivity in the environment.

Environmental signatures may consist of the radioactive and non-radioactive species listed below:

Radioactive:

- gaseous and volatile products: ^{85}Kr, ^{133}Xe, ^{3}H, ^{14}C, $^{103/106}Ru$;
- fuel derived particulates: ^{95}Zr, ^{95}Nb, $^{134/133/137}Cs$, ^{144}Ce, ^{99}Tc;
- 2 years cooling will effectively remove ^{133}Xe and ^{131}I by decay, and
- conversion derived particulates: characteristic Pu isotopic, ^{241}Am and ^{99}Tc.

Non-Radioactive:

- NO_x from aqueous dissolution;
- secondary/tertiary amines with C chains C_8 - C_{12};
- organo-phosphorus compounds (phosphates, phosphonates) with C chains C4 - C_6;
- diluents, such as C_{12} alkanes, aromatic hydrocarbons, brominated/chlorinated hydrocarbons;
- reducing agents such as sulphonate, hydroxylamine, and
- HF, H_2O_2, $(C_2O_4)^{2-}$, I_2 from conversion.

5.2.6 ATMOSPHERIC TRANSPORT

The fate of atmospheric effluent emissions from a facility is governed by a combination of physical and chemical properties associated with the current atmospheric conditions as well as with the emitted material. The controlling atmospheric properties are associated with:

1. the advective processes which determine the rate of downwind transport from the emission point, and

2. the diffusive processes due to atmospheric turbulence, which governs the rate of dilution during the downwind transport process.

The controlling physical and chemical properties of the emitted particle or gaseous material that govern their eventual distribution in the environment include the particle size distribution and the chemical stability in the atmosphere. These properties determine the rate of removal of the material from the atmosphere due to gravitational settling of particles, dry and wet deposition, photo-dissociation due to exposure to sunlight, hydrolysis, or chemical reactions with other atmospheric constituents. In order to predict the relative importance of these processes in defining the spatial and temporal evolution of the emitted material in the environment for a given situation, it is necessary to resort to the use of atmospheric dispersion modelling in conjunction with environmental measurements.

5.2.7 SAMPLE COLLECTION

The transfer of radionuclides through environmental pathways is strongly dependent on the nature of the radionuclide and the type of discharge (atmospheric or aquatic) and will determine the strategy adopted for sampling and analysis. Atmospheric discharges can be categorised as either particulate or gaseous, whilst aquatic discharges can broadly be considered either soluble or insoluble.

5.2.8 WATER SAMPLING

A number of parameters will influence the properties of the sample and will influence the sampling and analysis methods used, these should, if possible, be recorded:

- temperature;
- pH;
- salinity;
- dissolved oxygen concentration;
- suspended particle concentration and particle size distribution;
- local tidal/hydrological conditions and
- humic acid concentration.

If the sampling is performed in river estuaries, sharp changes in the above parameters can occur and precipitation of colloidal material can take place.
Sampling surface waters should involve collection of the water, particulate materials as well as biota.

Water samples, for the determination of metallic radionuclides, should be filtered through 0.45 μm filters (the nature of the filter material depending on the analyte), acidified with HCl or HNO_3 0.2M and stored at ca. 4°C but not frozen. Water samples can be preconcentrated before analysis using cation-exchange resins. The sample should be irradiated with UV light in the presence of an oxidising agent such as H_2O_2 in order to destroy organo-metallic complexes which may be present in solution. PTFE (teflon) containers should be used after an appropriate cleaning procedure.

For volatile analytes such as tritium, iodine and organics, glass or metal containers should be used. Water samples collected for tritium determination, should be stored in well sealed containers since exchange with atmospheric tritiated water vapour can readily occur. Again, glass or metal containers should be used.

Caesium species can be extracted directly from sea water, using organic adsorbents. For fresh waters, fibrous sorbents have been used in order to concentrate radiocaesium from large volumes of water.

Biota should also be sampled since they are bioaccumulating species for radioisotopes, as shown in Table 5.2.6, where the concentration factors for different elements in three different organisms are reported. For example, Sr is more concentrated in fresh water organisms than sea water, a different trend is shown for Cs and I. Suitable bioaccumulators include: seaweed (for ^{129}I), filter feeders (for actinides) and algae and molluscs (for $^{90}Sr/^{40}Ca$).

Table 5.2.6
Concentration factors for selected elements in three types of aquatic organisms.

	Sea water			Freshwater		
Element	Seaweed	Invertebrates	Fish	Seaweed	Invertebrates	Fish
Na	0.95	0.19	0.067	100	17	20
Mg	0.77	0.77	0.77	100	100	50
P	2.9×10^3	2.9×10^4	2.9×10^4	10^4	10^5	10^5
S	0.44	0.44	1.7	100	100	750
K	26.	6.6	11	670	830	10^3
Ca	5.	13	0.5	130	330	40
Cr	2×10^3	2×10^3	400	40	20	40
Mn	2×10^4	10^4	600	10^4	4×10^4	100
Fe	5×10^4	2×10^4	3×10^3	10^3	3.2×10^3	100
Co	10^3	10^3	100	200	200	20
Ni	250	250	100	50	100	100
Cu	10^3	1.7×10^3	670	10^3	10^3	200
Zn	10^3	10^5	2×10^3	10^3	10^4	10^3
As	1.7×10^3	330	330	1.7×10^3	330	330
Sr	13	6.2	0.5	500	100	5
Y	5×10^3	10^3	25	5×10^3	10^3	25
Zr	2×10^3	20	200	10^3	6.7	3.3
Nb	10^3	100	3×10^4	800	100	3×10^4

Table 5.2.6 Continued

	Sea water			Freshwater		
Element	Seaweed	Invertebrates	Fish	Seaweed	Invertebrates	Fish
Mo	10	10	10	10^3	10	10
Ru	2×10^3	2×10^3	10	200	300	10
Ag	200.	3.3×10^3	3.3×10^3	200	770	2.3
Cd	10^3	2.5×10^5	3×10^3	10^3	2×10^3	200
Sn	100.	10^3	3×10^3	10^2	100	300
I	4×10^3	50	10	40	5	15
Cs	20	20	30	80	100	400
Ba	500	100	10	500	200	4
La	5×10^3	10^3	25	5×10^3	10^3	25
Ce	5×10^3	10^3	25	5×10^3	10^3	25
Ta	10.	1.7×10^4	3×10^4	800	670	3×10^4
W	30	30	30	1.2×10^3	10	1.2×10^3
Au	33	33	33	33	50	33
Hg	10^3	3.3×10^4	1.7×10^3	10^3	10^5	10^3
Pb	10^3	10^3	300	200	100	300
Po	2×10^3	2×10^4	2×10^3	2×10^3	2×10^4	50
Ra	10	100	5×10^3	2.5×10^3	250	50
Th		2×10^3	10^4	1.5×10^3	500	30
U	67	10	10	10^3	100	10
Pu	350	100	3.5	350	100	3.5

5.2.9 **ATMOSPHERIC SAMPLING.**

Noble gases such ^{85}Kr and ^{133}Xe are unreactive and most sampling procedures are based on the collection of air-samples in the field using compressors or adsorption on activated charcoal or molecular sieves.

Radio-iodine may be present in the air both in the vapour phase as well as in particulate form. Air-borne particulates may be collected using static wet or dry deposition collectors or high-volume air-filters employing glass fibre or polystyrene filters or cellulose ester membranes. Similar techniques can be used for the collection of the semi-volatile fission products Cs and Ru. Radio-iodine vapour is usually trapped on activated charcoal or molecular sieves.

Tritiated water vapour and hydrogen gas are the most common forms of tritium in the air, other forms of tritium which are naturally occurring being tritiated methane and ethane. Collection of tritiated water vapour from the air is commonly performed in the vicinity of nuclear reactors and nuclear fuel reprocessing plants. Collection from air can be by: dilution, desiccation, condensation or freezing.

5.2.10 **ANALYTICAL TECHNIQUES**

The analytical methods will divide into those applicable to the measurement of the radionuclides, inorganic substances and organic signatures. For the shorter lived nuclides counting methods will be most appropriate α- and γ-spectrometries, β-scintillation and proportional counting. The radiochemical separation required and spectral resolution will depend on the individual isotope and method details cannot be presented in this overview. As half-life increases (approximately above 100 years) techniques such as mass spectrometry or neutron activation analysis begin to have better limits of detection than the radiometric methods. This greater sensitivity may not be of use if high background levels are present and mass spectrometry may complement radiometric methods for isotope ratio measurements. For example, the $^{239}Pu/^{240}Pu$ ratio is best determined by mass spectrometry whereas the $^{238}Pu/^{239+240}Pu$ ratio is best determined by a α-spectrometry. Thermal ionisation mass spectrometry can be used for actinide isotope ratio measurements and quantitation by isotope dilution. Care must be taken to avoid isobaric interference and reference should be made to the literature for individual methods (see especially the resin based technique for U and Pu).

ICPMS can provide a more rapid quantitative determination than TIMS but does not provide the same precision for isotope ratio measurements (although multiple collector sector instruments are now becoming commercially available). The technique is applicable to a number of long-lived radionuclides, e.g. ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu, ^{237}Np, ^{99}Tc (high levels of ^{129}I).

Accelerator Mass Spectrometry is available in a number of laboratories world-wide and is used routinely (and at relatively low cost) for $^{14}C/^{12}C$ and $^{129}I/^{127}I$ isotope ratio measurements and is probably the most suitable method for these two measurements, due to the high sensitivity of the technique (limit of detection ~ 10^6 atoms) and the freedom of the method from isobaric interferences. Resonance ionisation mass spectrometry provides freedom for isobaric interferences but is not recommended at this stage as the technique is not fully mature and in widespread routine use.

Neutron activation analysis is of use in a number of important determinations, particularly ^{129}I and ^{99}Tc.

The use of more than one technique for an analysis, such as NAA and AMS for ^{129}I or α-spectrometry and TIMS for Pu isotope ratio measurements, will also be of value in confirming the accuracy of a measurement.

Fluorine has been identified as a signature from a number of processes, particularly enrichment and can be measured by NAA or perhaps ion chromatography.

Organic signatures can be identified and measured by a variety of chromatography based methods. Probably of greatest value will be GCMS. Using a mass spectrometer as the GC detector allows, selectivity with great flexibility and high sensitivity. Other detectors can be both specific and more sensitive than mass spectrometry but are more limited in their application. Derivitisation may be required to render certain compounds less polar for gas chromatography, e.g., dibutyl phosphoric acid, alternatively liquid chromatography or supercritical fluid chromatography could be considered.

A variety of devices are useful for detecting organic, in the field. Volatiles can be determined by "sniffer" device, based on photo-ionisation detectors, electron capture detectors of flame ionisation detectors. these devices are inexpensive but relatively non-selective. Greater selectivity is offered by the ion mobility spectrometer which will be particularly useful for the detection of TBP. GCMS provides excellent selectivity and sensitivity in the field and can be used with a thermal desorption probe to measure low volatility organic signatures in soil or sediment samples.

The techniques divide into those which can be used in the field and those which should be laboratory-based. The methods have been categorised in this way in Table 5.2.7. Recommended methods have been underlined.

Table 5.2.7
Recommended Field- and Laboratory-Based Analytical Techniques

	Field-based methods	Laboratory-based Methods
Radionuclides: • "Short" $t_{1/2}$ (< 100 yrs) • "Long" $t_{1/2}$ (>100 yrs)	 Portable NaI, Ge detectors (also vehicle-based systems)	 Radiochemistry with: • α/γ-spectrometry • scintillation, proportional and GM-counting TIMS, AMS, ICPMS, NAA
Inorganic materials	Portable XRF	XRF Ion Chromatography
Organics	Ion Mobility Spectrometer GCMS: •Purge and trap •Thermal desorption Atmospheric pressure ionisation mass spectrometry Long-path-length ir spectroscopy	High Resolution GC-MS Infrared Spectroscopy GC with: • ECD • NPD • FPD LC-MS

It is recommended that use be made of facilities in Member States for measurement involving major pieces of equipment, e.g., AMS, TIMS: low background γ-spectrometry, NAA, ICPMS. In this way the Agency can access the experience of (accredited) member state laboratories and sample can be sent to more than one facility for cross-checking/QA purposes.

There are clear cost-benefit advantages from the use of field-based instruments in order to select samples for subsequent laboratory based measurement. For certain measurement, e.g., direct γ-spectrometry; sample bulking can be of value. That is, a set of samples is bulked together and monitored and only if positive signal is detected are the samples individually analysed.

It is recommended that in short term, the Agency acquire the less sophisticated instrument for use in the field (if not already used) especially hand-held and vehicle-based γ-spectrometry system, sniffer devices (IMS for volatile organic thermal desorption-GCMS for less volatile substances). The Agency should complement its own laboratory-based facilities by using member state laboratories for α, β, γ-spectrometry, TIMS, AMS, ICPMS, NAA and high resolution GC-MS. A laboratory accreditation scheme should be developed to ensure quality.

Methods for long-range monitoring are based on river water sampling for various radionuclides and air monitoring for ^{85}Kr, ^{129}I and particulates. River water sampling is likely to be the simpler, less expensive option and should be considered before developing arrays of air sampling stations which will require a world-wide network and, if it is to be used, should be a longer-term goal.

The methods discussed above do not fully address the problem of very short lived signatures ($t_{1/2}$ less than a few days). These signatures will best be determined in the field very close to the site. Hand-held γ-spectrometer will be of value but it may also be useful to have mobile laboratory for radio-chemical separations and high resolution γ-spectrometer or β-counting methods. It is thought that transient signatures from dissolution such as ^{133}Xe and ^{85}Kr are unlikely to be useful at close range as operations are likely to have ceased before an inspection can take place.

5.2.11 QUALITY ASSURANCE AND TRAINING

It is essential to develop a quality assurance (QA) programme that covers sample collection, sample handling, methods for on-site and laboratory analysis, data handling and record keeping. The QA programme should address the variety of different scenarios likely to be encountered. Appropriate calibration and analytical standards and a variety of reference materials will be needed. To keep costs down, one should carefully design a QA programme that recognises that for some signatures high precision data are not required. If, for example, one analyses for a typical short-lived radionuclide which does not exist in nature, background measurements are unnecessary, however low the reported concentration. In other cases where one looks for faint anomalies in certain isotope ratios, the QA programme should demand a knowledge of background values and their variability; this would be much more expensive.

The protocols should include "blank" samples as well as "background" samples. In the case that an attempt is made to find an undeclared facility adjacent to a declared one, the analyst should try to take "background" samples from a plant somewhere else, which is similar to that part of the installation which is being examined. When attempting to find an undeclared nuclear facility at a declared site, the optimum background samples would be from similar facilities which are a part of the declared installation.

Laboratory analyses should be verified using "round robin" sample analysis and exchanges of data between laboratories. The IAEA, with the support of Member States should compile a database of environmental background measurements for the range of signatures of interest. Maintenance of this data

will probably require at least one person/year but it would be a considerably greater effort to initially build this data base from historical data.
One further factor which should be addressed by a QA programme is staff motivation. This can be maintained by encouraging peer knowledge and interest and ensuring that the personnel associated with the sampling programme are allowed some research efforts of their own, utilising the data collected. The costs for such a QA programme cannot be estimated until the scale of the environmental monitoring programme is defined.

5.2.12 CONCLUSIONS

1. Environmental monitoring is viable for the detection of undeclared nuclear facilities.

2. At long distances from the source, river water sampling and analysis for soluble, particulate and colloidal materials is likely to be the most cost-effective monitoring method. There is a good chance that a reprocessing facility would be detected. An undeclared reactor will be detected only in the (quite likely) event of an accidental leakage to the environment.

3. Reactors, reprocessing and enrichment plants have quite different signatures.

4. Certain signatures from facilities which form part of a covert nuclear weapons programme will differ from the signatures from commercial nuclear activities.

5. The chances of finding an undeclared nuclear facility is high if supplementary information is provided by Member States.

6. IAEA needs access to a broad range of analytical techniques for the detection of radionuclides, isotopes, inorganic and organic signatures.

7. IAEA should develop an applied research programme in support of its environmental monitoring activities.

8. It would be worthwhile to collect environmental samples during routine safeguards site visits.

9. The reprocessing source term is process-dependent and will therefore encompass a wide range of active and inactive components. The environmental signatures will depend on release fraction, plume transport and dispersion, and in the case of organic materials their reactivity in the environment.

10. The fuel dismantling and dissolution stage will be primarily detectable by continuous sampling methods or by utilising environmental accumulation mechanisms.

11. Long-range and medium range analytical techniques should concentrate on ^{85}Kr, ^{133}Xe, $^{129/131}I$, ^{14}C, ^{3}H and radioactive particle deposition.

12. The analytical techniques used at short range should look for the above nuclides with the exception of ^{85}Kr, ^{133}Xe and should also look for non-radioactive materials.

5.2.13 RECOMMENDATIONS

1. The IAEA should gain field experience in river water monitoring for the detection of small nuclear facilities at long distances and should include in this programme the collection of some air samples for method evaluation purposes.

2. A forensic approach to sampling and analysis should be employed at near field locations, using portable equipment and/or a mobile laboratory.

3. The IAEA should assemble and maintain data base of environmental background measurements.

4. Use should be made of Member States' existing analytical capabilities. The limited IAEA funds should primarily be used to purchase mobile/portable equipment.

5. IAEA should define a Research and Development programme on applications of environmental monitoring for safeguards.

6. The IAEA should conduct a second workshop to allow greater consideration of the implementation of environmental monitoring programmes for specific scenarios.

7. A working group of scientists, from Member States, should be established to advise the IAEA on the "direction" of the evolving environmental programme. It will be important to keep abreast of developments in the nuclear field likely to influence environmental signatures as well as developments in techniques for environmental monitoring.

5.3 WORKING GROUP 3 - ANALYTICAL METHODS

5.3.1 INTRODUCTION

Discussions within this working group focused on four main areas:

1. sampling strategies and sample types (0-10 km for on-site collections, 10-1000 km for country wide collections);

2. analytical methods for radiochemical, inorganic, and organic signature compounds;

3. quality assurance and training; and

4. data evaluation (including statistical and graphical methods).

This group took a broad approach to the issue of environmental sampling and analysis which may need to be further focused with inputs from additional working groups. This group discussed both the areas of detection of undeclared enrichment and reprocessing facilities. Key environmental sample types have been identified as well as signature specific analytical techniques that would allow for maximum information gain. Techniques available within the present IAEA facilities have been identified as well as those areas where expertise, available within Member States, would be necessary.

5.3.2 RECOMMENDATIONS

1. The IAEA should continue to apply environmental or non-routine sampling methods for ad hoc (or special) inspections.

2. The IAEA should propose environmental sampling methods as a part of routine safeguard inspections. As an initial step, the voluntary acceptance of these methods by the State authorities would be seen as a "confidence building" measure.

3. The IAEA should try to ensure that environmental sampling and analysis be based on multiple methods and signatures to increase confidence. The use of multiple signatures and methods would reduce false-positives or interferences from counter measures.

4. The IAEA should establish and co-ordinate a quality assurance program for laboratories involved in environmental analyses for safeguards.

5. To ensure efficiency of operation, reduce sample handling and potential contamination, screen collected samples, maintain sample integrity, and establish a quality assurance program, the IAEA should consider having a centralised location for certain analyses. This could be accomplished by

upgrading existing capabilities and obtaining new equipment at the Agency's laboratories at Seibersdorf concomitant with necessary and available resources. The following are in order of priority:

- a new clean room facility;
- a new inductively coupled plasma mass spectrometer;
- an upgrade of low-level counting facilities;
- a thermal ionisation mass spectrometer, and
- a scanning electron microscope with energy dispersive spectroscopy.

(Note: In addition, other IAEA laboratories may need to be upgraded to support this increased environmental sampling and analysis program.)

5.3.3 SAMPLING STRATEGIES AND SAMPLE TYPES

1. An environmental sampling program on a wide-area (the order of 10-100 km) basis should include the following sample types:

- water and sediment sampling from natural water bodies, for example: water samples from rivers using high volume samplers, possibly with resin bed trapping of actinides (as used in the Iraqi programme); sediment core samples would provide historical information;
- air particulate sampling, perhaps using moving filter belts or activated charcoal media for trapping ^{129}I;
- biological accumulators such as herbivore thyroids (^{129}I), aquatic mussels, lichen, and tree cores (^{3}H, ^{14}C), and
- noble gases (Kr, Xe), molecular hydrogen, and gaseous carbon compounds.

2. The IAEA should consider collection of the following sample types, on-site:

- smear samples;
- surface or process waters;
- vegetation;
- soil sample over large surface area, to a depth of approximately 1 cm, as close to suspected source as possible;
- air particulate samples, including continuous collection methods in declared facilities.

3. In any environmental sampling regime, it is considered essential to establish baseline or background levels against which any change can be detected. This involves, but is not limited to, taking up-stream or up-wind samples or samples of soil, sediment, etc. at depths corresponding to time periods before significant nuclear activities took place.

4. The IAEA should consider on-site screening methods, such as portable gamma-spectrometry, XRF, photo-ionisation detectors, GCFID, sensitive films, or ion-selective electrodes primarily as a means of selecting sampling points.

5. The IAEA should contact Member State Support Programs for assistance in the development, testing, and evaluation of on-site screening techniques. Emphasis should be on commercially available equipment.

6. The IAEA should convene meetings of experts on environmental sampling methods to draft sampling protocols and detailed procedures for use by safeguards inspectors.

7. The IAEA should keep abreast of the "Open Skies Convention" to investigate a possible use of airborne effluent detection methods, including gaseous and aerosol (including particulates) sample collections as well as gamma spectrometry surveys.

5.3.4 ANALYTICAL METHODS

Suggested analytical methods related to sample type, sampling area, and target effluent(s) are listed in Table 5.3.1 together with the current availability of the technique in an IAEA laboratory. The effluents chosen represent a first attempt at establishing key species to be analysed. They are not an exhaustive list, and additional measurement techniques may have to be included as well as updating existing facilities. Sample types are essentially generic, and details will be subject to country area and local conditions.

Table 5.3.1
Suggested Analytical Methods.

Sample Type	Wide area on-site	Measurement Method	Target Effluent	Current Laboratory Capabilities
Noble Gases	Wide area + on-site	Cryogenic Chromatrog. + Gas Prop. Counting (GPC)	^{85}Kr ^{133}Xe	MSL IAEA-HYD
HT, HTO in air	Wide area + on-site	^{3}He + MS	^{3}H	MSL
		Electrol. concen + GPC	^{3}H	IAEA-HYD
^{14}C in air	Wide are + on-site	Accelerator Mass Spec. (MS) small samp.	^{14}C	MSL
		GPC large samp.	^{14}C	IAEA-HYD
^{129}I in air	Wide area + on-site	AMS	^{129}I	MSL
		Neutron Activation Analysis (NAA)	^{129}I	IAEA-PCI
Particulates in air	Wide area + on-site	Alpha, Beta Gamma	Actinides FP's other radio-nuclides.	IAEA-SAL* IAEA-PCI* IAEA-MEL*
		Fission Tracks	Fissile Isotopes of U, Pu	(IAEA-PCI)

SAL = Safeguards Analytical Laboratory
PCI = Physics, Chemistry, Instrumentation Laboratory
MEL = Marine Environmental Laboratory (Monaco)
HYD = Hydrology Laboratory
AGR = Agrochemicals Laboratory
MSL = Member State Laboratory only
( ) = Not routinely applied
* = Upgrading needed to reach optimum detection limits.

Table 5.3.1 Continued

Sample Type	Wide area On-site	Measurement Method	Target Effluent	Current Laboratory Capabilities
Particulates in air	Wide area + on-site	Thermal Ionisation Mass Spec. (TIMS)	U, Pu Isotopes	IAEA-SAL*
		El. Spectr. for Chem. Analysis (ESCA)	UO_2F_2	MSL
		Scan. El. Microscopy with X-Ray Fluoresc. (SEM-XRF)	Actinides Other Elements Morphol.	MSL
		Ion Microprobe Mass Spec.	Actinides Other El's	MSL
Water (grab)	Wide area = on-site	Inductively Coupled Plasma - Mass Spec. (ICPMS)	Actinides Other El's	MSL
		^3He + MS	^3H	MSL
		Electrol. Concentr. + GPC	^3H	IAEA-HYD
		TIMS	U, Pu Isotopics	IAEA-SAL*
		AMS	^{14}C ^{129}I	MSL
Water (Ion Exchange Filter)	Wide area + on-site	Alpha, Beta Gamma	Actinides FP's	IAEA-SAL* IAEA-PCI* IAEA-MEL
		TIMS	U, Pu Isotopics	IAEA-SAL*
		ICPMS	U, Pu Isotopics Other Elements	IAEA-MEL

* = Upgrading needed to reach optimum detection limits.

Table 5.3.1 Continued

Sample Type	Wide area On-site	Measurement	Target Effluent	Current Laboratory Capabilities
Sediments	On-site	Alpha, Beta Gamma	Actinides FP's	IAEA-SAL* IAEA-PCI* IAEA-MEL*
		AMS	^{14}C ^{129}I	MSL
		TIMS	U, Pu Isotopics	IAEA-SAL*
		ICPMS	Actinides Other Elements	IAEA-MEL
Biological Accumu-lators/ Collectors	Wide area +	^{3}He + MS	^{3}H	MSL
		AMS	^{14}C ^{129}I	MSL
		TIMS	U, Pu Isotopes	IAEA-SAL*
		Alpha, Beta Gamma	Actinides FP's	IAEA-SAL* IAEA-PCI* IAEA-MEL*
Smear Samples	On-site	same as particulates in air		
		NAA	U + Cl, F	IAEA-PCI
		XPS (ESCA)	U, Cl, F Compounds	MSL
		Ion Microprobe	U, Pu Isotopics Other El's	MSL
		GCMS	Organics	MSL IAEA-AGR

* = Upgrading needed to reach optimum detection limits.

The main conclusions from the discussions are presented below:

Tritium measurement by mass spectrometry is a key analytical technique required for small sample sizes (e.g., vegetation, water grab samples). This capability will need to be supplied by Member States.

Accelerator mass spectrometry has been identified as an important high sensitivity technique for ^{129}I and ^{14}C, key indicators of reprocessing. IAEA laboratories can process the samples, and Member States can supply the analytical capability. NAA may be helpful in certain circumstances (e.g. ^{129}I).

Upgrades of equipment for low-level counting (alpha, beta, gamma) will be required for participating IAEA laboratories.

Inductively-coupled plasma mass spectrometry will be an important analytical technique, particularly in water sampling programs, since it provides a rapid method for analysis of a wide range of nuclides at high sensitivity. This method can be automated to provide a more cost-effective approach for high volume screening of liquid samples than the current IAEA TIMS capability which is best applied for the measurement of uranium and plutonium isotope ratios.

For analysis of specific compounds, (i.e., UO_2F_2) techniques such as ESCA (XPS) and/or ion microprobe will need to be employed. These capabilities exist in Member State laboratories and we would not recommend that IAEA try to acquire these techniques. SEM with energy dispersive X-ray detection would be the suggested method to screen particulates collected on air filters, water filters, and/or smear samples.

For potential signature organics, (TBP, etc.), other methods available in IAEA laboratories can be utilised. These would include GC-MS, for organics. Additionally, for major anions, (fluoride, chloride, nitrite, nitrate) ion chromatography is suggested.

5.3.5 QUALITY ASSURANCE

The IAEA should establish and co-ordinate a quality assurance program for laboratories involved in environmental analyses for safeguards. The goal of the quality assurance programme should be to attain reliable accuracy and precision in chemical analyses at trace and ultra-trace levels by designing and controlling the total analytical measurement process. Quality assurance has to be considered at all levels in the measurement process.

Planning:

The IAEA should develop a list of inspectors who have been trained in the following areas:

- nuclear activities and practices (expertise presently exists at IAEA);
- environmental analysis (sampling, analysis, etc.);
- sampling, including sampling techniques and choice of sampling location;
- the use of field screening equipment to select optimum sample collection sites;
- detailed record keeping;
- design of sampling strategy, and
- design of analytical procedures.

The IAEA has expertise in sampling and analysing waters, sediments, and sea biota. Member States will need to provide expertise in high-volume water sampling, atmospheric sampling, sampling for noble gases, soil sampling, smear sampling, etc. It is important that inspectors be trained in the selection of sampling sites, as samples may be collected at the discretion of the inspector. Sampling strategy must be worked out depending on the environmental parameters. The strategy will be different for site specific vs. wide area sampling and must be optimised according to specific parameters such as geography, target effluents, and the potential undeclared activity. A knowledge of analytical techniques should allow the inspector to select non-destructive and destructive analytical methods, where appropriate. Where possible, replicate analyses should be performed, preferably using multiple methods as agreement between two different methods increases the confidence in the result.

Reference Materials/Standards (gases, alloys, nuclides, organics, etc.). The IAEA, working with Member States where needed, should obtain or procure existing reference materials for pertinent analyses, and develop special reference materials and control samples as appropriate (e.g., biological materials).

The IAEA should consider the long-term storage of archive samples, including biota, for future measurements to build up a record and as a quality assurance measure. Proper storage and treatment of samples will need to be considered.

A list of laboratories should be compiled from the IAEA and Member States capable of performing analyses on selected samples and perform round-robin measurement exercises establish precision and accuracy of participating laboratories

Sampling

The integrity of samples must be ensured from collection to analysis. Standardised containers, specific to sample type (e.g., precleaned containers and sampling kits) should be used together with standardised preservation techniques for sample transport. The sampling position should be recorded using a global positioning satellite system and informative sample descriptions and other relevant information should be recorded and made available to the analytical chemist. Chain of custody and tamper-evident seals should be utilised to ensure sample authenticity. Samples could also be bar-coded for entry into automated laboratory data management system for sample tracking and accountability. In some instances it may be necessary to collect and analyse duplicate samples. Also, representative samples should be taken for the measurement of baseline/background levels.

The IAEA should design and build a clean room to ensure integrity of sample splitting, storage, handling and analysis. Sub-portions of samples should be archived and/or specimen banked.

Analysis

The IAEA should recommend standard operating procedures (SOP's) for each analytical method to be utilised. Participating laboratories should operate under Good Laboratory Practice (GLP) and have a documented quality assurance programme. Quality control should involve internal instrument calibrations and the assessment of methods using blanks, reference materials and replicate analyses. The use of multiple methods for identification and quantification is recommended as it will increase confidence in analytical results.

5.3.6 DATA EVALUATION

1. Measurement laboratories should provide analytical results with associated confidence limits and detection limits.

2. Well-characterised control standards should be used to evaluate the performance of the different laboratories and techniques.

3. The IAEA should apply modern computerised relational data base tools (such as Paradox, Ingress) for the evaluation of large, multi-dimensional data sets.

4. Accepted parametric and non-parametric statistical tests should be applied to the data. Other useful tools such as pattern recognition (cluster analysis, principal component analysis, discriminant analysis) and expert systems should be evaluated.

5. The IAEA should study the methodology for producing country-wide environmental sampling plans based on geographical, meteorological, or hydrological information.

6. The IAEA should consider the application of mapping techniques based on mathematical models for planning the sampling strategies and for the evaluation of environmental measurement data.

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6. Annexes

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	Participant	Observer
European Community	Mr. K. Mayer	Mr. P. De Bievre Mr. L. Koch Ms. M. Betti
France	Mr. D. Calmet	Mr. P. Blaize Mr. Lecomte
Germany	Mr. W. D. Lauppe	-
Japan	Mr. H. Katagiri	-
Russian Federation	Mr. G. Kaurov	Mr. N. Titkov
United Kingdom	Mr. A. W. McMahon	Mr. G. Andrew Mr. K. W, Nicholson Mr. P. T. Roberts Mr. R. Horscroft
United States of America	Mr. D. Sloss	Mr. W. Belew Mr. A. L. Boni Mr. B. Fuhr Mr. I. Goldman Mr. P. Gudihsen Ms. E. Raber Mr. R. Velapoldi Mr. N. Wogman Mr. L. Holcombe
Australia	-	Mr. P. Duerden
Sweden	-	Mr. L. E. DeGeer

IAEA	Mr. R. Hooper	Scientific Secretary
	Mr. J. Jennekens	DDG-SG
	Mr. E. Kuhn	SGCP
	Mr. V. Pouchkarjev	SGCP
	Mr. W. Wagner	SGCP
	Mr. N. Tuley	SGCP
	Mr. L. Ong	SGCP
	Mr. N. Harms	SGOB
	Mr. M. Saied	SGOB
	Mr. T. Biro	SGOB
	Mr. D. Rundquist	SGDE
	Ms. K. Sirisena	SGDE
	Mr. J. Fager	SGDE
	Mr. H. Saukkonen	SGOA
	Mr. I. El Osery	SGOA
	Ms. S. Johnson	SGOA
	Mr. P. Danesi	DIR-RIAL
	Mr. S. Deron	SH-SAL
	Mr. G. Bagliano	SAL
	Mr. D. Donohoue	SAL
	Mr. R. Fiedler	SAL
	Mr. W. Stichler	PCI
	Mr. A. Markovicz	PCI
	Mr. V. Valkovic	SH-PCI
	Mr. R. Zeisler	PCI
	Mr. P. Povinec	MEL-Monaco

6.2 LIST OF DOCUMENTS

1. *Probability of Detection of In-Country Fuel Reprocessing with Atmospheric Transport of Kr-85*, W. W. Bowman, A. L. Boni, SRTC

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8. *High Sensitivity Methods of Environmental Monitoring Developed at IAEA-MEL*, P. P. Povinec et. al., (copies of transparencies).

9. *Analytical Capabilities, Instrumentation Unit*, RIAL-PCI, A. Markovicz (copies of transparencies).

10. *IAEA Isotope Hydrology Laboratory*, W. Stichler (copies of transparencies).

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24. *On the Environmental Monitoring Capability for Non-Proliferation of Nuclear Materials*, G. A. Kaurov.

6.3 **PARTICIPANTS IN THE THREE WORKING GROUPS**

Pu Production	HEU Production	Development of IAEA In-House Capabilities
Wogman*	**Belew***	**Mayer***
Betti	Kaurov	Horscroft
Lauppe	Titkov	Golman
Katagiri	Nicholson	Raber
Blaize	Holcombe	Velapoldi
Roberts	Dugihsen	Lecompte
Fuhr	Calmet	
Boni		
De Geer		
McMahon		
IAEA:	IAEA:	IAEA:
Hooper	Kuhn	Donohue
Tuley	Rundquist	Sinsena
Fattah	Wagner	Povinec
Johnson	Susan Mei (Chinese mission)	Fielder
Deron		Velkovic

* - Chairman of Working Group.

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P.O. Box 62
Oak Ridge, TN 37831

6 ISPO/POTAS
U.S. Program for Technical Assistance to Safeguards
International Safeguards Project Office
Brookhaven National Laboratory
Bldg. 475B
Upton, Long Island, NY 11973
ATTN: A. Reisman, ISPO/POTAS (for SSTA)

3 LLNL
Special Security Office/Z Division
Lawrence Livermore National Laboratory
Livermore, CA 94550
ATTN: G. Anzelon

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ATTN: S. Deland

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P.O. Box 100
A-1400 Vienna, Austria
EUROPE
ATTN: B. Pellaud, IAEA/DDG-SG (1)
M. Zifferero, IAEA/Action Team (5)
R. Hooper, IAEA/9+2 Team (8)

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