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RECOMMENDATIONS FOR STRENGTHENING IAEA SAFEGUARDS:

CURRENT INITIATIVES

Brookhaven National Laboratory

Technical Support Organization

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Prepared for the

Office of Research
U.S. Nuclear Regulatory Commission
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I. INTRODUCTION

It is desired to evaluate the capabilities of the IAEA and its ability to successfully carry out its mission in international safeguards. The eventual objective is to provide a set of recommendations for offering additional aid to the IAEA if, and how, it is needed. The process of accomplishing this objective consists of these essential steps. First, to determine the current status of the IAEA. Second, to enumerate and evaluate the current initiatives which are already underway and will tend to improve IAEA safeguards. And finally, by taking into account what the desired characteristics of the IAEA should be, to determine what measures are required to strengthen the IAEA so as to achieve an acceptable level of safeguards.

This work is concerned with the second step. As expressed in the initial "Statement of Work",(1) the task is to "conduct a survey to identify current initiatives for strengthening safeguards being undertaken in the U.S. and abroad....". Additionally, a "comprehensive description of current initiatives... will be prepared and the anticipated resulting improvements will be evaluated".(2)

The identification of current initiatives presented herein is fairly complete and it is believed that any omissions, whether inadvertent or not, are of relatively little impact. However, the evaluation of the ultimate effects of the R and D and other initiatives that is taking place, or that has been completed recently but not yet implemented, is sometimes quite speculative since these effects depend to a large extent on the efficiency of performance by IAEA, State, and facility personnel. Also, a proper judgement of the effectiveness of a given study should take into account the difficulty of discerning biases in the reporting by the State of the importance of that State's contribution.

This report has been prepared in a manner that will presumably clarify for the reader what tends to be a confused, multi-faceted, often redundant, compendia of tasks, projects, and programs. The format in which it is presented begins with the presentation of a "Framework for IAEA Safeguards". There are five main divisions in this framework. For each of these, the significant efforts (if any) that are taking place to improve the performance of the safeguards mission of the IAEA are discussed with some examples given. The selected examples of current efforts that are described were judged to be among the most important. There are, however, some differences in the amount of detail discussed in each section in order to balance the overall discussion. For example, in the section on Resources, instrumentation is discussed comparatively briefly. To do otherwise would represent an overwhelming task because of the preponderance of safeguards R and D activity in this field.

For completeness, references are made to the appropriate portions of the Appendices following this report. These Appendices provide a breakdown of the world-wide efforts in support of IAEA support, by State and/or organization and are provided with keyed references to the framework.

A final section, Summary and Conclusions, completes the work.

II. FRAMEWORK FOR IAEA SAFEGUARDS

A framework for IAEA Safeguards has been provided by the NRC and is given in Appendix K. The framework serves as a means of organizing information, including R and D programs and other initiatives that are ongoing throughout the world, directly or indirectly, in support of IAEA safeguards.

An alternate framework, similar to the original in many respects (The differences are outlined in Appendix K.) is used througnout this paper in discussions and referrals (Table 1). Section III of this report includes specific discussions of each major division of the framework. Pertinent R and D programs are listed in some detail in Appendices A through J and include those dealing with peripheral and complementary issues as well as formal support programs. The discussions of section III as well as the listings in the Appendices are keyed to the framework.

Table 1.

An Alternate Framework for IAEA Safeguards

A. Information and Communication

1. Timely and accurate information from States to the IAEA.

2. Effective communications within the IAEA (including an efficient data processing system).

3. Effective feedback from the IAEA to States inspected.

4. Effective reporting by IAEA to the BOG and, thence, to the international community.

5. Information propagation without transgression of State-imposed confidentiality.

B. Safeguards System Design

1. Achievable short-term and long-term technical objectives and inspection goals.

2. Standardized evaluations of IAEA safeguards approaches for all types of facilities and fuel cycles.

3. Standardized evaluation of inspection activities and verification procedures with respect to effectiveness of diversion deterrence (i.e., quality assurance program).

4. Cost-effective design of new nuclear facilities to include safeguards features.

C. State Systems of Accounting and Control (SSACs)

1. Adequate safeguards agreements, subsidiary arrangements, and interpretations.

2. Internationally standardized SSACs and guidelines for national authorities and operators.

3. Well-developed SSACs that promote cooperation by minimizing cost and interference for facility operators and/or States.

4. State compliance with IAEA standards and guidelines including adequate access to facilities where inspections are carried out.

Table 1 (cont'd.)

D. Resources

1. Adequate quality and number of trained safeguards inspectors.

2. Adequate management of safeguards programs to promote effective and efficient utilization of inspectors in the field and at Headquarters.

3. Adequate management of safeguards program for other functions (communications, decision-making, personnel matters, organization, planning, human factors).

4. Adequate funds to carry out safeguards inspection program.

5. Adequately available safeguards equipment and procedures for inspectors' and headquarters' use.

6. Effective and efficient utilization of safeguards equipment including personnel training, manuals, and conduct of workshops.

7. Adequate data reduction methodology including reasonable error propagation models and statistical treatment.

8. International standards and reference materials.

E. Complementary Issues

1. Adherence to NPT (re: safeguards).

2. Fullscope safeguards in non-NPT States (NNWS) and relation to NPT States.

3. Nuclear Supplier Guidelines (re: safeguards).

4. Support and advice given by supplier States for improved physical protection in other States outside of IAEA responsibilities.

5. Institutional arrangements (e.g. IPS, CAS).

6. Conversion of non-NPT States to NPT States.

7. Bi- and multi-lateral programs outside of IAEA aegis.

8. Public relations and public opinion.

9. Possible international sanctions through UN or other, non-IAEA, route.

III. CURRENT INITIATIVES

A. Information and Communication (Framework: Area A)

This section summarizes and evaluates current activities in support of the IAEA's information processing and communications responsibilities (framework area A). These activities include not only support for the IAEA's computerized nuclear materials information system (the International Safeguards Information System, ISIS), but also support for such activities as inspection data collection and processing and communication of information between the IAEA and its member states.

Most of the activities in this area have been carried out under the auspices of the U.S. Program of Technical Assistance to IAEA Safeguards (POTAS), mostly in the form of providing cost-free experts to the IAEA, with a substantial fraction of the remainder having been in the form of various types of computer equipment, provided either as gifts-in-kind or as financial support for leasing or purchasing specific necessary pieces of equipment. Current activities in this area are fairly limited. In the following, all current activities are listed and their anticipated effects described. The discussion is nominally organized by topics given in the framework. In some cases, an initiative is related to more than one of the topics, however. Parenthetically, the specific areas of the framework are indicated.

It is notable that almost all of the R&D effort in this section deals with the flow of data from States to the IAEA and the Board of Governors and the assimilation and processing of that data. Some systems will also tend to improve the protection of data confidentiality. There does not appear to be any specific effort to improve feedback to the States or beyond the BOG. Presumably, however, improvements in data flow and data analysis will indirectly improve the outward flow of information to the States and to the world community.

1. Information from States to IAEA - Framework Area A-1

a. IAEA Activities

(1) INFCIRC/207 Import/Export Reporting

Under the provisions of the voluntary offer known as INFCIRC/207, the US, UK, and USSR provide the IAEA with data on imports and exports of nuclear material. In November 1980, the IAEA issued a letter[3] requesting changes in the procedures for submitting these data. The changes requested would improve the IAEA's ability to track material across international boundaries.

In December 1981, a meeting was held at IAEA headquarters at which representatives of states affected by the proposed changes developed procedures for implementing the change. Implementation of these procedures is being carried out, and, if successful, they will significantly improve the ability of the IAEA to track international shipments of nuclear material.

b. U.S. POTAS Activities

As mentioned above, the bulk of US support to the IAEA in the area of information and communication has been provided in the forms of cost-free experts or data processing equipment (or funds for lease or purchase of equipment). Most of the POTAS tasks in this area are complete. Five tasks remain active POTAS tasks in support of information and communication. Some of these appear below under paragraph 2.

(1) Tasks E.55 and SP.4: Remote Continuous Verification (RECOVER) System

The Remote Continuous Verification (RECOVER) System is a system of computers and interfaces by means of which the IAEA can use existing international telephone lines to monitor the status of containment and surveillance (C/S) equipment at facilities anywhere in the world. The development of this system, its implementation, and further testing has been accomplished through funding by

ACDA (Appendix AIII). The system has recently been upgraded to allow direct transmission of inspection data from the facility to IAEA headquarters in Vienna. Tasks E.55 and SP.4 support evaluations of the operating characteristics of the system.

In addition, a task funded by the DOE (requested by ACDA and the IAEA) involves an analysis of the capabilities and possible applications of RECOVER, particularly with respect to its cost-effectiveness. The analysis includes an examination of a recently-completed test implementation of a limited version of the system.

Under the DOE task, a preliminary report was prepared and provided to the IAEA for comment in late 1981. The primary conclusions of the report were that RECOVER could be cost-effective at large fast critical assemblies and at CANDU reactors, but that it would not be cost-effective (given the assumptions made in the analysis) for other types of facilities such as LWRs, fuel-fabrication facilities, or reprocessing plants. At IAEA request, these conclusions and the assumptions upon which they are based are being re-examined, particularly with respect to LWRs. Regardless of the results of this re-examination, this task will provide the IAEA with a firm technical basis for any decision to implement the system.

(2) Task SP.19: LWR Evaluation Procedures (Also applies to A-2 and A-4)

As mentioned above, the Safeguards Evaluation Section (SES) of the IAEA must analyze and summarize a large amount of data in the process of preparing the annual Safeguards Implementation Report (SIR). Many of these data concern inspections at LWRs. Task SP.19 will provide the IAEA with a set of standardized procedures for collection and analysis of LWR inspection data for preparation of the SIR.

Draft procedures were provided to the IAEA in early 1982 for trial use and comment. Based on this trial, modifications are being made in the procedures. It is anticipated that the procedures will be used at least partly for preparation of the 1982 SIR. Use of these procedures will help to ensure that the conclusions in the SIR are based on uniform, documented analytical procedures and thus help to support the general conclusions reached. The procedures will also significantly reduce the time and effort required to produce the SIR.

c. Euratom Activities

(1) Task MT-14: Automatic Data Evaluation of Reprocessing Safeguards Analysis (sic) (Also applies to A-2 and A-5)

A system has been developed for collecting, reducing, and evaluating measurement data in a reprocessing plant by computer. The data collected include alpha-spectrometry, mass-spectrometry, and isotope dilution weight data. The system will be extended under this task to include paired comparisons of operator and inspection data, and to include isotope correlation techniques as an automatic check for consistency and a basis for interlaboratory and inter-batch comparisons.

The system could provide significant benefits in the areas of better data confidentiality, faster data reduction, increase in tamper resistance, and a reduced error rate.

(2) Task NMA-2: ISADAM Transfer and Adaptation (Also applies to A-2)

The International Safeguards Data Management (ISADAM) system was developed under Euratom auspices to store and process Euratom safeguards data. Under this task, the ISADAM system will be implemented on the main IAEA computer system in Vienna, tested using Euratom safeguards data, and modified as necessary for compatability with the IAEA safeguards accountancy system.

This task will familiarize Euratom and IAEA personnel with the details of each other's data management procedures, and could result in improvements in safeguards data processing and increased compatability between the Euratom and IAEA systems.

d. Federal Republic of Germany Activities

(1) Task A.4: Nuclear Research Centers (Also applies to A-2)

The objective of this task is development and testing of safeguards systems for two special research centers in accordance with the requirements of the international supervisory authorities and the operator.

The task is composed of four substasks:

(a) development and testing of a computerized data acquisiton and processing system for nuclear materials control in the Karlsruhe Nuclear Research Center (KfK), beginning with the Fast Zero Power Reactor (SNEAK);

(b) development and testing of a computerized data acquisition and processing system for nuclear materials control in the Juelich Nuclear Research center (KFA), beginning with the Hot Cell Facility (HC);

(c) improvement and testing of appropriate measurement systems for data verification; and,

(d) integration of the measurement system into the Nuclear Material Accountancy and Control System (NACS) in the KFA.

This task should result in improved data collection and evaluation at the facilities involved, and will provide experience in the design, implementation, and maintenance of sophisticated computer-based facility accounting systems such as are coming into increasingly wide use throughout the world.

(2) Task B.4: Information System for Nuclear Facilities (Also applies to A-2)

The purpose of this task is to define the specifications for data evaluation software for supporting and increasing the effectiveness of nuclear facility inspections. Four subtasks are included:

(a) compile the requirements of different nuclear facilities;

(b) compare and unify the requirements of different types of nuclear facilities;

(c) implement software modules which meet these requirements for the information system of KFA Julich; and,

(d) same as (c) for the information system of KfK Karlsruhe.

This task should result in software to speed up and improve inspection data collection and evaluation, and will provide experience in analysis of computerized nuclear facility inspection data evaluation.

e. United Kingdom Activities

(1) Task G.6: Application of Advanced Statistical Techniques to Plants (Also applies to A-2)

The objective of this task is to improve the sensitivity in detection of prolonged and abrupt diversion of SNM by application of advanced statistical techniques. In particular, the task will involve application of Kalman filtering techniques to the problem of improving the sensitivity of detection of losses in fuel reprocessing. The techniques will be applied to measurements from United Kingdom Atomic Energy Authority fuel fabrication lines, with particular attention to the line at Winfrith which includes some recycling.

This task will provide experience in the use of advanced statistical techniques in the analyses of actual facility data, and could result in improved sensitivity to loss.

2. Communication within IAEA - Framework Area A-2. (Also see 1.b.(2), 1.c.(1), 1.c.(2), 1.d.(1), 1.d.(2), and 1.e.(1))

a. IAEA Activities

(1) Many data are collected by IAEA inspectors during the course of an inspection. These data are used not only by inspectors but also by several other groups at IAEA headquarters. For several years, work has been going on to develop procedures for more efficient and standardized collection and dissemination of inspection data. Much of the earlier work was done under the auspices of the U.S. POTAS, which provided several cost-free experts to the IAEA (Appendix AI, tasks D.6, D.14, D.30, D.31, D.38, F.6, F.11, and F.12). This effort has continued within the IAEA under the Task Force on Inspection Reports (TFIR), which is composed of members of the IAEA staff from several divisions within the Department of Safeguards.

TFIR has thus far produced a set of draft forms and instructions for reporting inspection data, and procedures and computer programs for processing these data are under development. Although the new forms and procedures are not yet used by all IAEA inspectors, they are being implemented by at least one regional section. Successful completion of this effort will significantly improve the IAEA's ability to use efficiently the mass of inspection data collected and will help to ensure uniformity in the application of safeguards and in the conclusions drawn on the basis of inspection data.

b. U.S. POTAS Activities

(1) Task D.40: Cost-Free Expert Analyst/Programmer (Also applies to A-4)

Under this task, a cost-free expert was sent to the IAEA to assist the Safeguards Evaluation Section (SES) in computerized analysis and evaluation of safeguards data, particularly for the preparation and presentation of the annual

Safeguards Implementation Report (SIR). He reported to the IAEA in August 1981 and will remain at least through August 1983.

Preparation of the SIR is a very labor-intensive task, since it requires detailed analysis of data on several hundred inspections at several hundred facilities. The expert's efforts have already improved SES's ability to deal efficiently with this large amount of data, and should result in still further improvements.

(2) Task D.42 Cost-Free Expert-Documentation and Training Officer

Under this task, a cost-free expert is being provided to assist the IAEA with documentation and training in the use of the International Safeguards Information System (ISIS), the IAEA's main computerized nuclear materials and facilities data processing system.

In recent years, the ISIS has grown significantly, and an increasing number of different groups with the Department of Safeguards are developing their own specialized software and procedures. This task will assist the IAEA in ensuring that the ISIS is used most efficiently, by standardizing documentation and by providing users with training in the use of the system.

(3) Task SP.20: Assistance to IAEA by U.S. Experts

The IAEA is sometimes faced with the problem of rapidly analyzing a new or unusual problem with safeguards data. Often these analyses must be carried out as quickly as possible, and IAEA personnel may not be available. Special expertise may also be required in some cases. This task will provide the IAEA with the services of appropriate U.S. experts when assistance is required in these situations. This will improve the IAEA's ability to respond quickly when faced with a new or unusual problem in safeguards data analysis.

c. Euratom Activities

(1) Task MT-1: NDA Measurement Data Transfer

IAEA inspectors often make NDA measurements in the field. The results of these measurements may be most efficiently analyzed at IAEA headquarters. At this time, the instruments used by the IAEA record data on machine-readable magnetic media in a variety of physical forms (e.g., cassette tape, tape cartridge, floppy disk) and in a variety of logical data formats, making centralized processing of the data very difficult.

The purpose of this task is to define a common physical and logical data format for NDA information exchange through magnetic media, and to supply samples of hardware and software to implement the format. This effort could significantly improve the IAEA's capabilities for efficient collection and rapid, easy analysis of NDA measurements made by inspectors at facilities.

(2) Task NMA-1: NUMSAS Transfer

The Nuclear Material Statistical Accountancy System (NUMSAS) is a computer software system developed under Euratom auspices for general-purpose nuclear mataerials accountancy and data analysis. Under this task, a version of the NUMSAS will be implemented on the main IAEA computer system in Vienna, and modified for compatibility with the IAEA safeguards accountability system.

This task will give the IAEA familiarity with a sophisticated computerized nuclear materials accountancy system, and could result in improvements both in the present NUMSAS and potentially in the IAEA's ISIS.

3. Feedback to States from IAEA - Framework Area A-3

There are apparently no significant initiatives in this area at present.

4. IAEA Reports to BOG and International Community - Framework Area A-4

See 2.b.(1) and 1.b.(2).

5. Confidentiality - Framework Area A-5

See 1.c.(1).

6. Miscellaneous, Non-classifiable, Activities

A Japanese support program task is involved with information and communication. At the first meeting of the Japan/IAEA JASPAS Review Committee (Tokyo, July 1-2, 1982), this new task, JB.1, "Quick Evaluation and Development of New Software", was proposed by the Japanese authorities. However, no further details on this task are available.

B. Safeguards System Design (Framework: Area B)

In recent years, it has become recognized that, in order to make the most of the safeguards-related resources available to the IAEA, the design and implementation of safeguards approaches would require a "systems" approach. At the present time, there are several such systems studies underway which correspond to the various types of facilities that require safeguards.

The application of safeguards is a complicated endeavor. States, facility operators, inspectors, and the IAEA are all involved. Sometimes their efforts are applied in the same direction, sometimes they are not in unison. In spite of all the complications of an operating facility, the inspector must somehow reach his objective, e.g., prepare a report, containing all the appropriate information on verification, etc., and forward it to headquarters. At headquarters, the goal must be that the IAEA can make a determination of whether or not a diversion has taken place.

What the systems study must accomplish is to unify all of these operations, and more, in a way that eases the path of all those concerned. For the State and facility operator, the desire is to make the inspection and verification procedure as unobtrusive as possible. For the inspector, the object is to minimize his effort but still to accomplish all that is necessary to make the inspection meaningful. For the IAEA, the desire is to obtain the assurance that no diversion has taken place and to do so with a minimum effort and a maximum certainty. The systems studies described below hold the promise of accomplishing these ends or of evaluating trade-offs among the various procedures and goals. They also have the potential of directing what aids are needed such as new instruments or improvements in old instrumentation and techniques.

The following first describes some recent efforts toward defining technical goals and objectives. Then the current efforts of a number of systems studies are described, arranged by facility type, tha involve safeguards approaches. The subject of safeguards evaluation is discussed next, followed by reference to studies involving facility design for ease of safeguards.

1. Technical Goals and Objectives (B-1)

A number of years ago the IAEA secretariat, together with SAGSI, developed a set of quantitative guidelines or "technical criteria" for the application of safeguards which have come to be referred to as "goal quantities" and "timeliness criteria". These were described by G. Hough, et al. at the 1978 IAEA safeguards symposium(4), among other places. These technical criteria have been controversial and are not universally supported among the member states. The status of these criteria within the IAEA, as guidelines for the design of safeguards systems rather than requirements defining safeguards adequacy, was summarized in a paper given by Safeguards Deputy Director General Grümm at the 1980 INMM conference.(5) Since this time, the status of the technical criteria within the IAEA has not changed.

The U.S. Nuclear Regulatory Commission commissioned a study of the effort and resources that would be required to fulfill a set of similar criteria supported by the U.S. The resulting report(6) suggested that the fulfillment of such criteria would require, at a minimum, considerable increases in the resources available to the IAEA. The NRC has asked the contractor to review some of the assumptions that lead to these estimates.

2. The Development of Safeguards Approaches (B-2)

a. Light Water Reactors (LWRs)

The IAEA has had more experience with LWR safeguards than with any other facility type. The basic safeguards approach, developed as a result of this experience, was described in STR-80, written in 1978-1979. A number of issues are either omitted or dealt with very briefly in this document, in part because it was one of the first STRs to document a safeguards approach and in part because of the variability of LWR safeguards problems in the field. Some of these issues are:

• The use of LWR's for the undeclared production of plutonium. Quantitative estimates of the rate of Pu production and the manner in which production might be carried out in PWRs were investigated under POTAS task C.24.(7) The report implied that such production was more difficult in BWRs.

• The problems of mixed-oxide fresh fuel, reactors where the containment is inaccessible during power operation, and the safeguarding of boiling water reactors, where fuel elements are easily disassembled. These issues are the topics of POTAS task C.22, phase II.

• The use of Cerenkov glow observation using night vision devices. Because this technique had not been developed when STR-80 was being written, its impact on LWR safeguards was not taken into account.

• The possibility of tampering with surveillance devices. These were analyzed under POTAS task E.7.(8)

• The consequences of the failure of surveillance devices and the related question of appropriate follow-up actions in such cases.

• Diversion possibilities inherent in the shipment of spent fuel to reprocessing plants or away-from-reactor storage. This has become a much more prevalent practice in recent years.

Many of these considerations have been taken into account in work by the IAEA Systems Studies Section since STR-80 was published, especially in work that has gone on in the development of the "Safeguards Effectiveness Assessment Methodology" (SEAM). During 1979-1980, a "Model Inspection Activities List" (MIAL) was developed for LWR's, and based on that list, an updated description of LWR safeguards and an analysis of their effectiveness is currently in preparation in the Systems Studies Section.

b. CANDU Reactors and Heavy Water Production Facilities

The safeguarding of CANDU reactors is the main thrust of the Canadian support program. The basic approach was formulated by the Canadians in the late 1970's. This approach, in a number of variants corresponding to the various CANDU-type reactors, was documented between 1978 and 1981, largely by D. Jung, a Canadian cost-free expert supplied by Canada to the IAEA. This documentation consists of IAEA STR's 72, 83, 91, 95, and 99.[9] Considerable detail regarding the hardware involved is given. The definition of basic safeguards approach is therefore considered to be complete. The variants of the system involve combinations of the following hardware: (1) fresh fuel bundle counters, (2) spent fuel bundle counters, (3) a CCTV system for surveillance of the fuelling machines, (4) film cameras for surveillance of the spent fuel pool and fresh fuel loading area, (5) a spent fuel verifier, (6) a sealing system for spent fuel in the spent fuel pool.

One issue which is still the subject of research is that of core verification in case of a surveillance failure; suggestions in this area include (1) random refuelling of the core, (2) the observation of coolant temperature differentials across the core, (3) the application of RECOVER.

While it is probable that these systems will be applied to Canadian CANDUs, it is unclear to what extent other nations possessing CANDU reactors will accept the safeguards system developed by the Canadians.

Heavy water safeguards are of course not mandated by the NPT, but a bilateral agreement does exist between Argentina and the IAEA that a Swiss-supplied heavy water production plant will be safeguarded. It is not clear what constitutes safeguards for heavy water; and the IAEA has not as yet formulated a position. The United States Arms Control and Disarmament Agency has funded (partly through ISPO) three tasks in this area; POTAS task C.8, a task with the Lummus Company, and a more recent task to define a comprehensive safeguards approach to heavy water facilities. The approach being taken in these studies[10] is that of material accountancy through the use of unattended automatic instrumentation, whose output would be used by both the plant operator and the IAEA. The latter will probably convene an advisory group meeting on safeguards for heavy water in September 1983.

c. Enrichment Facilities

Gaseous diffusion enrichment facilities are all located in weapons states and not subject to IAEA safeguards (although it is possible that the Eurodif facility may come under a voluntary offer by France). The technology for which the safeguards needs are now most pressing is the gas centrifuge. Such facilities exist or are under construction in the United Kingdom, the Federal Republic of Germany and the Netherlands (the three URENCO partners), as well as in Japan and the U.S. The U.S. facility will come under the U.S. voluntary offer when completed.

The most recent IAEA document on enrichment plant safeguards is AG-100[11], but all previous work is likely to be superceded by the outcome of the

Hexapartite Safeguards Project (involving the U.S., Australia, the IAEA, EURATOM, Japan, and the URENCO partners) whose task it is to agree upon an acceptable safeguards approach for centrifuge enrichment plants. The Hexapartite Safeguards Project is scheduled to complete its work in November of 1982, but there is a possibility that it may be extended. A fundamental issue is the necessity of inspector access to the cascade building for the purpose of detecting the production of highly enriched uranium (all centrifuge facilities are declared for the production of low-enriched uranium only).

In support of both the Hexapartite Safeguards Project and the U.S. voluntary offer, the U.S. Department of Energy is coordinating a study on safeguards for the U.S. centrifuge facility (the Portsmouth Gas Centrifuge Enrichment Facility). This study is evaluating enrichment plant safeguards alternatives with regard to (1) the cost to the U.S., (2) the cost to the IAEA, (3) the possible risk of the dissemination of sensitive technology and (4) the effectiveness of the safeguards approach. This study will be completed in the very near future. Results relating to material accountancy verification[12] have appeared.

An enrichment facility based on the nozzle process of German design is under construction in Brazil. Material accountability schemes for this plant have been considered[13]; it is expected that inspectors would be allowed into the process area so that the question of detecting high enriched uranium production is not controversial.

There are enrichment facilities in operation and under construction in South Africa; they are not under safeguards.

d. Reprocessing Facilities

In June of 1978, an IAEA Advisory Group on reprocessing plant safeguards recommended that the Agency undertake a broad study of safeguards systems and techniques for reprocessing plants. This was undertaken during 1979-1980 by the 11-member International Working Group on Reprocessing Plant Safeguards (IWG-RPS). This group issued a final report in September 1981.(14) It reviewed a broad range of issues relating to reprocessing plant safeguards, including conventional material accountancy and containment and surveillance, advanced (near real-time) material accountancy, and extended containment and surveillance. It pointed out that some advanced techniques would be necessary if the IAEA were to meet its technical criteria, even in facilities of modest size, but it did not recommend any particular combination of techniques as optimal, nor did it evaluate any particular safeguards system. Several suggestions for further study and research were outlined and discussed.

Tasks on systems studies for reprocessing plants have also been undertaken individually by the support programs of the U.S. and the Federal Republic of Germany. The German task (Task A.1) involves an extended study of advanced techniques that could be used to safeguard an entire "nuclear fuel cycle center" including reprocessing, conversion, and mixed-oxide fabrication facilities. The U.S. support program includes POTAS task C.47 which involves the development of a specific safeguards approach for a medium-sized reprocessing facility, and the evaluation of that approach using the IAEA's safeguards effectiveness assessment methodology. Japan is also said to be undertaking an independent study on reprocessing plant safeguards. None of these studies have produced final reports. However, see also information on "TASTEX", p. 37.

e. Low-Enriched Fuel Fabrication Facilities

The general safeguards approach for low-enriched fuel fabrication (and conversion) facilities has been in existence for some time; these facilities where in-process material is generally accessible and timeliness criteria can be satisfied with one or two physical inventory takings per year, are amenable to conventional material accountancy verification procedures. This approach is described in STR-96.[15] In addition both the U.S. support program (POTAS tasks C.3 and C.5[16]) and the EURATOM cooperative program (tasks NMA 1,2, and 4) have supplied or are supplying software to the IAEA to assist it in the problems of data handling, error propagation, and sample size calculation at these facilities. However, some practical problems remain to be solved: (1) unless the Agency was to undertake continuous inspection at many fabrication facilities, flow verification is difficult to implement properly because of the necessity to sample the large throughput of the facilities, (2) either a sealing system or a more accurate means of non-destructive assay is needed for finished assemblies.

f. Mixed-Oxide Fuel Fabrication Facilities

As with the low-enriched fuel fabrication facilities, the basic safeguards approach to mixed oxide facilities involves conventional material accountancy. However, the timeliness criterion for PuO_2 is taken to be 1-3 weeks; this necessitates a series of interim inspections (in addition to the physical inventory verification) at a frequency of approximately one every two weeks for the purpose of timely detection of abrupt diversion. This approach was described in STR-89[17], and reviewed by an IAEA Advisory Group[18]. Principle areas of concern are: (1) the frequency of inspection which puts a considerable burden on the safeguarded facility; it does however, alleviate the problems of flow verification present in LEU fabrication facilities, (2) problems with availability of in-process inventory at interim inspections, (3) the question of assembly verification, either by seal or measurement.

A study of mixed-oxide fabrication plant safeguards is part of the proposed Belgian support program.

g. Large Critical Facilities

There are only a few of these facilities, but they absorb a disproportionate fraction of IAEA resources because of the large amounts of material of high strategic value that they contain. An STR[19] was written on safeguards approaches for large critical facilities, but it is regarded as preliminary. At present, at least in Japan, the Agency relies on very frequent inspections in which item counting, identification, and NDA are performed on the nuclear material plates or elements in inventory. This is very burdensome to the facility, and Japan has initiated a program to devise a containment/surveillance envelope around the facility using CCTV, portal monitors, and seals. The possibilities of interfacing this whole system with RECOVER are being investigated in Japan's assistance program under task JA.1.

h. Research Reactors

These facilities are of concern when their inventories contain significant quantities of material or their power is high enough to produce significant quantities of plutonium. The problem of plutonium production in research reactors is currently the topic of a study funded by the U.S. Arms Control and Disarmament Agency. The study, due to be finished in the very near future, estimates the plutonium production capability of a wide variety of research reactors.

3. Safeguards Evaluation (B-3)

During the period from 1979-1981, an eight-member consultant's group met on the subject of the development of a methodology for evaluating safeguards effectiveness. With the help of U.S. consultants provided under POTAS funding, the group drafted and approved two documents: a methodology overview and a case study application of the methodology to a PWR. The methodology was discussed in-house at the IAEA and received enough support so that IAEA staff could deliver a paper[20] at the 1981 INMM meeting stating the methodology overview as revised by the secretariat[21]. It found that the basic principles of the methodology were sound, and recommended further applications as well as the testing of the methodology on actual inspection reports.

This latter task is currently being undertaken by the Safeguards Evaluation Section at the IAEA. In support of that effort, is a POTAS task (C.46) whose object is to deliver to the IAEA software to help automate some of the calculations.

In addition, three POTAS tasks currently under way (C.22, C.47, and C.48) all will utilize the methodology in analyzing safeguards approaches to various facility types (LWRs, reprocessing facilities, and mixed-oxide fabrication facilities, respectively). The methodology is also being used in the Portsmouth GCEP project in the U.S. (see the section on safeguards approaches for enrichment facilities) to evaluate alternative safeguards approaches.

The methodology has three phases, or modes of application: a design mode, used for safeguards system design; an implementation mode, for analysis of safeguards at a specific facility; and a performance mode, in which actual inspection data are evaluated. The methodology basically involves (1) a description of the safeguards approach for a facility, (2) the generation of a set of diversion paths or possibilities, (3) the estimation of a detection probability for each path, (4) the ranking of paths and detection probabilities by "technical compexity level," indicating the credibility of the diversion scenario. Widespread use of the methodology within the Agency, especially in the performance mode, will probably involve considerable effort (1) because a large number of diversion path analyses will have to be done to address the variety of conditions in the field, (2) because methods will have to be developed to make valid estimates of detection probabilities based on data available from inspection reports.

4. Design Features to Facilitate Safeguards (B-4)

One of the important conclusions of the International Nuclear Fuel Cycle Evaluation (INFCE) was that, "Safeguards requirements must be included in the initial design", (of large reprocessing facilities).(22) Since then, the IAEA has recognized the importance of this concept for all types of facilities; for example, in the 1980 SIR.

The POTAS has supported some work on reactor design features (task C.25)(23). In this study a set of guidelines was proposed which were to: reduce consumption of IAEA resources, reduce inspection frequency, improve inspection conditions, improve safeguards data quality, and improve the ability to obtain data. Eleven such guidelines were proposed which covered LWRs and BWRs and which, if implemented, would aid in a variety of safeguards applications including containment and surveillance and material accounting.

The Action Plan Working Group (APWG) also considers this an important area and, in response, the NRC has funded, since FY 1980, a contract to study design features at various types of facilities. Thus far such studies identify and develop safeguards design features to facilitate the application of IAEA safeguards at reprocessing plants(24) and light water reactors. A study covering Mixed-Oxide Fuel Fabrication Plants begun in FY 1981 is also nearly complete(25). The effort is to be extended to cover low enriched uranium fabrication as well. The IAEA periodically convenes an International Consultants Group on Design Features. This group is currently preparing a set of design guidelines for all types of facilities. The NRC-sponsored programs are also in support of this effort.

In the studies already undertaken,(23-25) a baseline safeguards system is defined and evaluated, problem areas are identified as are design features to alleviate them, and the most promising are analyzed and evaluated in detail including cost-effectiveness. A set of conclusive recommendations can usually be reached by this method. Often the recommendations include not only design features to be included in new plants, but some that might represent practical upgrades for existing facilities. As might be expected, the evaluation process to determine the improvements in effectiveness for a given design change can be quite similar to that discussed above under "Safeguards Evaluation".

C. State Systems of Accounting and Control (SSACs) (Framework: Area C)

In the past, poorly conceived and/or implemented SSACs have been noted as a serious impediment to the successful application of the IAEA safeguards system in certain countries. In an effort to rectify this situation, a number of States have contributed, and continue to contribute, to the improvement of SSACs. Most of these contributions involve the training of SSAC administrators. Importantly, there are also two tasks which, when complete, will assist facility operators with designs of proper SSACs by making available a series of guides to this end. Ultimately there should be an impact for all items of area C of the framework although only items C-2 (and possibly C-3) will be directly affected. The following is a description of contributions to the development and implementation of SSACs.

1. Guidelines and Training (C-2)

a. U.S. POTAS Program

Over the past few years, the U.S. POTAS program has funded several projects contributing to improved States' Systems of Accounting for and Control of nuclear material. Some of these projects have been completed, some are still underway, and some have continued under other funding or have led to additional projects as offshoots.

Most of these projects have related directly to training of personnel who administer SSAC's within a country or of facility operators who have to set up the systems required by the SSAC at the facility level. These are described briefly in the following, and are identified by the POTAS task number.

(1) Task B.2

Cost-free lecturers were provided for IAEA-sponsored training courses on SSAC's in FY 1978, 79, and 80, including one given in the USSR in 1978.

(2) Task B.5

Funding was provided for the travel and per diem expenses of SSAC personnel from various countries who wished to attend IAEA-sponsored training courses on SSAC's in FY 1977, 1978, and 1979.

(3) Task B.6

Two U.S. contractors were funded to assist the IAEA in planning and conducting a course on the application of an SSAC to a bulk fuel processing facility. The course was given in two parts, one at the Los Alamos National Laboratory and the other at the fuel-fabrication plant of the Exxon Nuclear Co., in Richland, Washington, during the period April 27 - May 12, 1981. An important feature of the course was that it included applications and "hands-on" demonstrations at an operating fabrication plant.

The 16-day course included 42 sessions with a large lecture staff from several U.S. organizations. The following quotation is from the Foreword of the Proceedings(26):

"This Advanced International Training Course on State Systems of Accounting for and Control of Nuclear Materials was developed "to provide practical training in the implementation and operation of a national system of accounting for and control of nuclear materials that satisfies both national and IAEA international safeguards objectives." The course was conducted by the University of California's Los Alamos National Laboratory, the Battelle Pacific Northwest Laboratory, and the Exxon Nuclear Company, Inc. The course is part of the ongoing series of safeguards training courses sponsored by the U.S. Department of Energy in cooperation with the International Atomic Energy Agency.

"A total of some 70 participants (including course attendees, lecturers, and equipment demonstrators) took part in the 16-day course. Nations represented included Belgium, Brazil, Canada, Egypt, France, India, Iraq, Israel, Italy, Japan, Korea, Luxembourg, Malaysia, Mexico, Pakistan, Poland, Sweden, Switzerland, Taiwan, Turkey, and Yugoslavia. Participants also came from the cosponsoring organization--the IAEA in Vienna, Austria--and from the Euratom Organization of the Commission of the European Communities in Luxembourg.

"Major emphasis in the course was placed on the principles and practical methods used in establishing and operating nuclear material accounting and control systems at bulk-handling facilities -- particularly low-enriched uranium (LEU) conversion and fuel-fabrication plants. Emphasis was also placed on the interaction between (1) facility safeguards, (2) national system (SSAC) safeguards, and (3) international (IAEA) safeguards.

"Course attendees hold positions of major responsibility in technical research, operations, and technical management in nuclear materials accounting and control organizations at both the facility and national levels in their respective countries. Many attendees had attended one or more of the basic SSAC courses previously offered by the International Atomic Energy Agency in 1976 and 1977 in Vienna, in 1978 in the USSR, and in 1980 in Santa Fe, New Mexico.

"The course lecture staff included safeguards experts from the IAEA, U.S. Department of Energy, U.S. Nuclear Regulatory Commission, U.S. Department of State, Los Alamos National Laboratory, Battelle Pacific Northwest Laboratory, Exxon Nuclear Company, Inc., and Allied General Nuclear Services.

"In addition to the formal lecture presentations, panel discussions, and the safeguards design workshop, the course featured a tour and demonstration of state-of-the-art nondestructive assay instruments and methods at the Los Alamos National Laboratory and extensive tours and demonstrations of safeguards equipment, methods, and plant accounting systems at the Exxon Nuclear Fuel-Fabrication Plant at Richland, Washington.

"The course culminated in a two-day workshop on safeguards system design for a fuel-fabrication plant. Based on data provided for a model LEU fuel-conversion/fabrication plant, students in the workshop developed a FNMC plan for the model plant and made recommendations for establishing and implementing an appropriate measurement and accountability system. The resulting system designs were then reviewed and evaluated in an informal panel discussion involving participation of both attendees and course instructors.

"In addition to the formal material presented, participants were able to exchange information and ideas with each other concerning the actual practice of safeguards in the different countries and organizations represented. These informal exchanges and contacts among responsible safeguards personnel from differing professional and cultural backgrounds provided significant additional benefit to both lecturers and participants. These interactions should prove of considerable value to participants in their task of implementing effective safeguards in their own individual countries."

(4) Task SP.6

This task paid the travel expenses of an IAEA data specialist who conducted an SSAC training course in South Korea in 1979.

(5) Task SP.7

Three U.S. sponsored training courses on SSAC's were given during

1980-1981.

(6) Task SP.12

The U.S. funded the travel expenses of IAEA staff conducting SSAC training courses in Taiwan in 1980.

A current project sponsored by POTAS is in direct support of the establishishment and strengthening of SSAC's. This project is being performed under two POTAS tasks, C.31 and C.49.

(7) Task C.31

The purpose of this task is to assist the IAEA to prepare a series of guides that will describe in detail the design and functioning of an SSAC at the facility level. These guides are intended primarily as a training tool for facility operators to improve their understanding of how to design and operate a nuclear-material control and accounting system at the facility to best meet the requirements of an SSAC. It is expected that these guides will also have some impact on Framework area C-3 by promoting efficiency.

Ultimately a series of guides is envisioned for all major types of fuel-cycle facilities. Initially, however, guides will be prepared for a mixed (uranium and plutonium) oxide fuel-fabrication plant, a particularly sensitive type of facility. The topics covered by the guides will include general features of an SSAC at the facility level, record and report systems, measurement systems, physical inventory taking, measurement control programs, closing the material balance, and the treatment of measurement uncertainties. The writing of these guides is expected to take approximately one year.

Some earlier work on this project has resulted in a draft guide for the record system of a light-water power reactor.

(8) Task C.49

This task provides for the coordination of the writing of the guides under C.31 with the IAEA, through the services of a cost-free expert stationed at the Agency headquarters. This expert will discuss drafts of the guides with the appropriate Agency personnel, to assure that the content and presentation meet Agency needs. He will also participate in the writing of some of the guides. It is expected that this will help promote cooperation among all parties (facility, state, and IAEA) and, thus, effects Framework Area C-3 as well.

b. Other U.S. Efforts

In compliance with the Nuclear Nonproliferation Act of 1977, the Department of Energy has sponsored a continuing series of courses in SSAC's given at Los Alamos National Laboratory with the cooperation of other institutions and companies, such as Pacific Northwest Laboratory and the Exxon Nuclear Company. More recently, the emphasis has been on advanced courses, designed as a follow-on to a more basic or elementary course sponsored by the U.S.S.R.

c. U.S.S.R.

The U.S.S.R. has sponsored two basic IAEA training courses in SSAC's held in the Soviet Union, one in 1978 and one in 1981. These courses may be regarded as complementary to the advanced courses now being offered by Los Alamos.

A more formal support program has recently been established by the U.S.S.R. It includes training courses for personnel from other countries responsible for the design and implementation of SSAC's.

d. Efforts by the IAEA

The IAEA assists in the establishment of SSAC's by providing consultation to countries requesting assistance. It has also published a document in its information series, entitled "Guidelines for States' Systems of Accounting for and Control of Nuclear Materials" (IAEA/SG/INF/2), which sets forth general guidelines for SSAC's.

As stated in the Foreword of the Guidelines, the "document presents guidelines for the organization and functions of the SSAC with respect to obligations arising from Safeguards Agreements concluded by a State with the IAEA, including the elements of the System and the performance required from it at the State and facility levels." The guidelines are intended for use by States having agreements based on either INFCIRC/66/Rev.2 or INFCIRC/153.

2. SSAC Development (C-3) (See also 1a (7) and (8), above)

a. Federal Republic of Germany

Although the Federal Republic of Germany sponsors a large program in support of the IAEA, only one task may be interpreted as being in support of SSAC's. This is Task B.6, "Setting up a Material Book-keeping for Dry-stored Fuel Elements". This task would be applicable to any scheme for the dry storage of spent reactor fuel elements, such as certain kinds of away-from reactor storage that have been proposed. Since this project was listed in an October 1981 program description, it is assumed to be still current.

b. The U.K.

One task in the U.K. support program may be regarded as in support of SSAC's; this is Project F.2, which includes the development of a system based on the automatic reading of optical characters, for the rapid taking of inventories. This would be useful to both the SSAC authorities and to the IAEA.

D. Resources (Framework: Area D)

"Adequate" as applied to resources presumes a goal to which performance can be compared. It should be emphasized that the ultimate performance goal is related to the IAEA quantity and timeliness goals which are only tentative. However, by any reasonable standards, IAEA resources are currently inadequate for what most knowledgeable member States expect of it.

The items listed, 1 through 8, are interrelated and also related to items under other main headings. Adequate funds are necessary to pay inspectors; training is necessary to improve the quality of inspectors, etc.

The U.S. Nuclear Nonproliferation Act of 1978 requires that the U.S. provide MC&A and physical protection training for safeguards personnel of other, especially developing, nations. Such courses are conducted annually under the auspices of Los Alamos (MC&A), and Sandia (physical protection). (See Section C on SSACs, especially pages 26-29.)

In the following, reference to the framework is given parenthetically following each heading.

1. Quality and Number of Trained Inspectors (D-1)

The number of inspectors is a function of budgets, of recruiting and of length-of-stay at IAEA. The Board of Governors determines budgets. Because it is an international agency, the IAEA must recruit from developing as well as developed countries. In any event, it takes time to educate and train and provide experience for an inspector. If an inspector retires after two years, the Agency will have made use of him for only about one year. Another problem is that processing applicants and getting them moved to Vienna takes time that is hard to estimate. At the end of each calendar year, unspent funds are cut off. The BOG keeps asking why the Agency needs more money when it fails to spend what it had. It can't commit a recruit until it has funds. The U.S. should urge the BOG to permit carry-over of committed but unspent funds for personnel and for instruments.

The only significant effort to improve the quality of inspectors, whether from the U.S. or elsewhere, is through training rather than through selection. The U.S., at least, should have a more effective program to seek quality volunteers (and to give them some education concerning the IAEA beforehand).

The Agency has developed and continues to improve an extensive program for training inspectors. Cost-free experts supplied by the U.S., the U.K., the Federal Republic of Germany, and others assist in the development of curricula, video tapes, and text books and sometimes participate as lecturers.

There are a variety of training programs provided by supportive countries:

a. For many years the U.S. has funded Los Alamos National Laboratory to give lecture and laboratory courses to familiarize U.S. and IAEA inspectors with non-destructive assay (NDA) instruments and applications. (Appendix A, Table A-2.)

b. Canada provides on-site instruction to IAEA inspectors for the C/S equipment it has developed for use at CANDU reactors and storage pools. (Appendix C, Table C-1.)

c. The U.K. gives a 2-week course at Winfrith to train inspectors on instruments and applications at fuel cycle facilities. It also provides individual training for the use of NDA instruments. (Appendix E, Table E-1.)

d. The F.R.G. provides training for analytical chemists, of direct help to the Siebersdorf safeguards analytical laboratory, and potentially for inspectors who may make such analyses at future reprocessing facilities.

e. According to IAEA sources two European non-nuclear-weapon states have offered to educate recruits from developing nations on nuclear fuel cycles, facilities and operations.

2. Utilization of Inspectors in the Field and at Headquarters (D-2)

This is a field where friendly nations may provide assistance, but the Agency must play a major role. Efficient and effective operations are recognized by the Agency to be of great importance. It has invited member states to send experts to discuss these issues with the staff and to make recommendations. A U.S. cost-free expert has assisted the Agency in developing and implementing a computer based file of all the major nuclear facilities under safeguards, and of inspector man-days actual and proposed.[27] This should enable the Agency to review its current assignments and to assess the advantages or disadvantages of modifying these assignments. The U.S. and other nations have supplied consultants or cost-free experts to work with the IAEA staff in designing a logical method to assess effectiveness of safeguards as applied, or as they might be applied to certain classes of nuclear facility. (See section B, Systems.) This is an ongoing effort.

3. Other Management Functions (D-3)

Non-technical management problems were reviewed by Coopers and Lybrand (POTAS Task B.23) for which a report was issued in August 1981. Many suggestions were made which are just beginning to be carried out. A cost-free expert (under POTAS Task B.26) has been provided to help with non-technical management training at the Agency. Another POTAS task, A.106 has recently been initiated which will provide guidance in technical management, particularly with instrumentation priorities, requirements, specifications, and utilization. Also, as communications, data handling, and information impinges on the management functions, Section A of this work (Information and Communication) might apply and should be consulted.

4. Funds to Carry Out Safeguards Program (D-4)

The IAEA budget must be approved by the General Conference. Many of the States are more interested in the Agency's assistance program than in safeguards. The Agency has to present very convincing arguments in order to have more money approved. The U.S. supplied a cost-free expert to study IAEA instrumentation needs for the 5 years 1981-85.[28] As a result of this study, it appears that the Conference will approve a substantial increase in funds for instrumentation this year.

As was noted above, the requirement that all funds be spent and services delivered by 12/31 each year causes the Agency to lose money and to spend some with inadequate planning. The funds approved could be more effectively used if the BOG would approve a reasonable carry-over policy.

5. Available Safeguards Equipment and Utilization (D-5,D-6)

To facilitate the transfer of information on the status of safeguards information, the U.S. DOE, following the suggestion of the Action Plan Working Group, has supported the compilation of a Safeguards Instrumentation Catalog.[29] This is supported by a computer data base and the intention is to maintain its currency. The effect should be to make state-of-the-art information available to State and facility personnel and to IAEA personnel world-wide.

The following is a brief, incomplete description of the "state-of-the-art" in safeguards instrumentation. Details and specific references are omitted for the sake of brevity. Further information may be found in the Appendices, in the references accompanying the Appendices, in the Catalog (mentioned above), and in the references included in the latter.

a. NDA Equipment

Until fairly recently, useful NDA equipment had not been developed for all of the identified IAEA applications. The U.S. POTAS program has developed suitable instruments: A portable weighing device for UF_6 cylinders (2.5 to 15 tonnes), hand-held gamma-ray assay instruments, sophisticated high-resolution gamma-ray spectrometry instruments, a wide variety of passive and active neutron assay instruments, gamma-ray absorption instruments for U and Pu concentration in liquid samples, calorimeters, etc. A potentially useful device is an image intensifier system to confirm that spent fuel assemblies in reactor storage pools are radioactive. (See Appendix A.)

In many cases Agency inspectors are using these instruments. In other cases the instruments are being evaluated by them. In still other cases, field testing has not begun. The question is not availability, but rather suitability: are they suitably designed, reliable, and easy to calibrate and use, or do the instruments or the procedures require modification? Because of the many types and forms of materials which the Agency encounters, there will be a continuing need to refine instruments and techniques. Also, with microcomputers, it is possible to make operations more automatic, to reduce field data to the quantities of interest (grams of plutonium or enrichment of UF_6, e.g.), etc.

The U.K., Euratom (ISPRA), and F.R.G. have extensive supporting programs in this area. Japan and several other member states have projects. (See Appendices B through I.)

b. Containment and Surveillance equipment

At present the Agency uses seals and optical surveillance instruments, both of which are in a state of rapid change.

Until now the Agency has used the type-E cap seal, modified and marked in Vienna, and paper-adhesive seals. Acoustic seals (while not entirely satisfactory) have now been demonstrated for sealing the cages in which CANDU spent fuel bundles are stored, BWR fuel assemblies and other objects. These were developed at ISPRA and Sandia. An eddy-current technique has been developed to identify PWR fuel assemblies. A shrink-tubing seal has been developed for UF_6 cylinders (BNL/Sandia); and several types of fiber-optic seals have been developed which are readable (nondestructively) in the field and possibly remotely (Exxon, F.R.G., and Sandia). Plenty of ideas exist and many are at the field-test stage. Further support will be needed to learn which will be efficient and effective for various applications, to determine the dollar costs, the impacts on inspector effort, and to develop operating procedures, along with suitable modifications in the designs and operating manuals.

The principal optical surveillance device is a pair of 8 mm single-frame film cameras (modified movie cameras) in a tamper-indicating enclosure. This has a number of limitations. The development of small, efficient, TV cameras offers a number of advantages. Since TV camera systems are still being developed, a considerable amount of effort will be required to obtain the special, reliable, tamper indicating, instruments the Agency will need, designed for its specific applications. Euratom, Japan, and Sandia have been involved in this development and probably will continue to do so. The F.R.G. has recently developed a much improved film camera which may also be used. (See Appendix D.)

The Canadians have developed "extensive C/S" instruments to use at CANDU reactors. These include radiation monitors to detect fuel where it should not be, fresh and spent fuel bundle counters, optical surveillance, spent fuel NDA and seals (as mentioned above). (See Appendix C.)

The International Working Group on Reprocessing Plant Safeguards (U.S., U.K., France, Japan and F.R.G.) proposed extensive use of radiation and other types of monitors to be used at all known penetrations in the containment of a reprocessing plant. The Japanese have proposed portal and containment monitors for use at a fast critical facility. (See Appendix F.)

The Agency has had very little experience with the use of C/S devices other than seals and optical systems, and how, effectively, to combine them with material accounting. The U.S., at Sandia, supports continuing work on these techniques. More actual experiments and demonstrations will be needed to determine which of these may be useful and how to use them.

In 1978, an unusually productive program was initiated to test advanced safeguards technology at the reprocessing plant at Tokai, Japan. Participants in this exercise, called Tokai Advanced Safeguards Technology Exercise (TASTEX), were the U.S., Japan, France, and the IAEA. There were thirteen separate elements in the exercise which are listed in Table A-1 (POTAS Tasks) on page App-14. The principal stated objective of the plan was "to facilitate IAEA Safeguards through the evaluation of specific advanced Safeguards technology".(30) The techniques explored involve both MCA and C/S devices.

Techniques developed under TASTEX Tasks E (Electromanometer), G (K-edge Densitometer), H (High-Resolution, Gamma-Ray Spectrometry), and part of A (Spent Fuel Surveillance Devices) are expected to be implemented very soon by the IAEA. Further effort is planned under the Japanese Support Program and by the IAEA as well. For other tasks, either feasibility remains to be shown (C, J, and parts of A), more development work is needed (F and I), there is some limited use indicated (K and L), or the usefulness, at least at Tokai, has been shown to be of doubtful value (B, D, and M). For those tasks that are to be implemented, the IAEA inspectorate will benefit directly through increased accuracies and sensitivities in verification measurements, increased efficiencies in verification procedures, and reduced effort (especially in report writing and computation.

6. Standards and Reference Materials (D-8)

a. Analytical Standards

The National Bureau of Standards has had "standard reference materials" prepared and characterized by other laboratories (LANL, NBL, etc.) for chemical and isotopic analyses. Other major nuclear nations have similar programs, but NBS materials are the most widely used throughout the world. The need for more different items, for more accurately defined items and for international cooperation is recognized. However, development of new items is expensive and time consuming.

The most extensive program for exchange of samples and analytical results is the SALE program of NBL. In 1979, the following other nations participated (parentheses indicate number of labs in each): Italy (2), FRG, (6), U.K. (3), Belgium (2), France (2), Japan (2), Argentina (1), Austria (1), Netherlands (1), Taiwan (1), Czechslovakia (1), Finland (1). Euratom also conducts similar exchanges among its members and sometimes with other countries.

There is an International Plutonium Standards Steering Committee, with representatives of the U.S., Euratom, and Japan, which identifies needs and coordinates the development of plutonium elemental and isotopic standard reference materials and of U and Pu isotopic spikes for isotope dilution mass spectrometry. The U.S. is the main producer of all of these.

The CBMN (Geel) collaborates closely with the U.S. institutions in developing and characterizing Pu reference materials (also in improving analytical techniques).

b. NDA Standards

A large number of well characterized items have been manufactured by nuclear laboratories and facility operators for their own use. Only in a few cases have these been independently assayed at other facilities and are they available to the IAEA. Although there have been a few cases when well characterized items have been fabricated for round-robins, there is no organized program for the fabrication, qualification, and supply of NDA standards.

Items which are available include:

IAEA gamma-ray sources, for energy calibration of gamma-ray spectrometer systems.

Plutonium heat sources prepared by Mound for calorimeters for NBL and NBS.

Cf-252 neutron sources to check sensitivity of passive neutron instruments (LANL).

U_3O_8 standards for NDA, Euratom and U.S.

Scrap containers with some plutonium (measured in known matrix and container) (NBL).

The need-for and nature of desirable NDA standards depends on the technique. Some major techniques are reviewed:

(1) Enrichment: A uranium sample is needed to check instrument operation, but it need not be calibrated. For UF_6 or UO_2 or other major applications, the instrument is calibrated by using it to measure items which can also be analyzed destructively for enrichment. Standards are not generally needed.

(2) Plutonium isotopics: Livermore and others have carefully measured the gamma-ray emission rates for the Pu-isotopes. Standards are not needed.

(3) Gamma-ray assay of U and/or Pu in scrap and waste containers. Self-attenuation affects may be very severe. Reference items should be prepared at each facility for each class of materials. The IAEA will need help here.

(4) LEU and MOX fuel rods. Qualified reference rods are very expensive to make. The IAEA may be able to qualify MOX pellets for Pu using high-resolution gamma-ray spectrometry, neutron coincidence, and calorimetry. Even so, gamma-ray assay is seldom the best method to assay for Pu. Rod scanners usually use neutron interrogation.

(5) Calorimeters can compare sample heat to watts, for which good electrical standards exist. As noted above, some Pu "standards" are available.

(6) Passive neutron instruments: Many things affect the response - isotopic composition, other matrix materials, size, shape, etc. Self-multiplication is very large for samples of 1/2 kg or more. A very large vari-

ety of reference items would be desirable, but that is not practical. Los Alamos has a small program to calculate and experimentally confirm means to extrapolate between a few samples in order to assay many, somewhat different items. It applies to both passive and active assays. Much more remains to be done on this.

(7) Active neutron interrogation: Calculations and calibrations for this are more complicated than for passive. The more important applications are for HEU fuels and scrap, and for LEU fuel assemblies. A great deal remains to be done on calibrations and standard reference materials (or alternatives for the latter).

In sum, now that the Agency is obtaining and using NDA instrumentation, a considerable amount of assistance will be needed for calibration. A well thought out international cooperative program is needed. So far the U.S., U.K., FRG and Japan have shown some interest. (See Appendices A, D, E, and F.)

E. Complementary Issues (Framework: Area E)

In this general area, there is virtually no ongoing Research and Development because nearly all of the issues are political, not technical, in nature. Actions which may lead to progress take place largely through international discussions and subsequent publicity in an attempt to mobilize world opinion. One exception occurs with regard to improving physical protection (see 4. below). Technical advice to bear on these issues, which conceivably may improve with time, and the ability of the IAEA to perform within its chartered area, can be improved by technical developments of all kinds. In a sense, then, all of the other sections of this work (A through D) affect progress being made on the issues discussed in this section. Also, some of the subjects covered here are aided through existing support programs by providing cost-free experts, as well as travel funds and/or accomodations for participants, for pertinent discussions.

1. Adherence to NPT (E-1)

117 countries have now signed the Nuclear Non-Proliferation Treaty. This number includes three of the five Nuclear Weapons States, the exceptions being France and China. France, though not a signatory, is in principle subject to some IAEA safeguards in accordance with the Euratom agreement, and has in fact offered to subject its non-military facilities to IAEA inspection on the same basis as the U.S. and the U.K.

The number of Non-Nuclear Weapons States that are parties to the NPT has been slowly increasing. Two of the 114 current Non-Weapons signatories became adherents to the Treaty in the past six months (Antigua-Barbadoes, Papua New Guinea). Also during this period, two additional signatories (Venezuela, Guatemala) concluded Safeguards Agreements with the IAEA, raising the number of NPT adherents with Agreements to 75. These additions, while in the direction of rounding out the extent of adherence to the treaty, are not of great practical significance. The important questions still concern eight nations that have not signed the NPT, though all their nuclear activities are at present subject to IAEA inspection, and the four countries that have not signed and which conduct some substantial nuclear activities not subject to IAEA safeguards. Inducement to any or all of these to adhere to the NPT would be a major step forward.

2. Fullscope Safeguards in Non-NPT States (E-2)

The IAEA recognizes the de facto existence of full-scope safeguards in eight countries. These are Argentina, Brazil, Chile, Colombia, Cuba, North Korea, Spain, and Viet Nam.[31] The Spanish program is extensive, with many nuclear power plants operating or under construction, a new large fabrication facility for low enriched uranium, and a number of small activities in reprocessing, fabrication of research reactor fuel, etc. But the Spanish program does not comprise a full fuel cycle activity, and therefore ranks lower as a conceptual proliferation threat.

The Brazilian program contemplates construction of a number of power reactors, a chemical reprocessing plant, and a uranium enrichment facility. This program, which is being developed with assistance from the Federal Republic of Germany, is subject to IAEA safeguards in accordance with the German agreement. The program is not advancing at the rate initially contemplated by Brazil, and economic considerations have led to some doubts that commercial-sized fuel reprocessing and uranium enrichment plants will be built.

The Argentine program is very different. Argentina's plan for a long time has been to become completely self-sufficient in the nuclear field, relying on technologies using only natural uranium. To this end, they contracted some years ago with the FRG for a heavy water, natural uranium reactor (now operating) and with Canada for CANDU reactors (under construction). They have also been developing indigenous fuel fabrication, fuel reprocessing, and heavy water production capability (from Switzerland). The instability resulting from the recent Falklands controversy and from an astonishingly high rate of inflation will probably slow down the movement toward a domestic nuclear power program that could be used as a springboard for nuclear weapons capability.

The other five countries accepting de-facto full-scope safeguards despite their not having joined the NPT do not have extensive nuclear capability.

The situation vis-a-vis non-NPT states accepting full-scope safeguards is at present acceptable, but it will have to be watched.

3. Nuclear Supplier Guidelines (E-3)

The Guidelines in effect were adopted in 1978. They have been adhered to by all the manufacturing countries. There has been no formal change in content since their issuance, but there has been a strengthening of their application. This has been principally through actions to apply suasion to Switzerland and Italy concerning parts being supplied to Pakistan in connection with a uranium enrichment plant being built there. In the Swiss case, the material being shipped to Pakistan seems to have been stainless steel valves and similar components, which strictly speaking might not be covered by the Guidelines since they are not specifically on the trigger list. In practice, it seems that the list has been extended to include not only components "especially designed or prepared for the separation of isotopes of uranium" (the words of the trigger list), but more commonplace material or equipment which is being acquired for incorporation into a plant of this kind.

Some countries have adopted policies and practices more severe than called for by the Guidelines. The NNPA requires that the U.S. not ship fissionable material to any country that does not accept full-scope safeguards. Canada and Australia have adopted similar policies. The German policy toward assistance to Brazil has approached this, since the agreement with Brazil calls for IAEA safeguards to be applied to all facilities supplied in connection with the agreement, and this covers essentially all the Brazilian fuel cycle. The U.S. has supported some studies under the ACDA, to clarify the extent to which the export of certain materials (graphite and heavy water) can be controlled. (See Appendix A-III.) It remains to be seen whether the outcome of this work will affect the Guidelines and their adherents.

The intent motivating the Guidelines seem to be well satisfied by current practice. Diligence will be needed to ensure that slips do not occur.

4. Support and Advice Given by Supplier States for Improved Physical Protection in Other States Outside of IAEA Responsibilities (E-4)

The Supplier Guidelines call for an agreement between the supplier and the receiver, stating the level of physical protection that will be applied to the material or facility involved. They also call on supplier countries to promote the transfer of information on physical security, protection of fissile material in transit, and recovering of stolen nuclear materials and equipment. The IAEA requires that the State's system of accounting and control include physical protection measures, and to this end has issued an excellent guide on physical protection measures (INFCIRC/225).

In general, physical protection measures used in safeguards are identical to the methods of force and protection used by all governments for more general purposes, such as police protection of the civil populace. These methods quickly and naturally diffuse throughout the world. Specific measures generated through safeguards programs are in most cases varieties of surveillance, such as seals, cameras, and unattended TV viewers and recorders. These are developed particularly for IAEA programs.

One effort that is specifically designed to aid in world-wide improvement of physical protection is that of the U.S. Department of Energy (See Appendix A-II) and other U.S. agencies. The DOE supports ongoing R and D in physical protection technology, training programs, and bi-lateral programs which are often relevant to C/S and physical protection concerns. In addition, DOE, ACDA, NRC, and the Department of State as a group conduct a "Physical Security Review Program" which has the responsibility of assuring that States destined to receive nuclear fuel of U.S. origin have adequate physical protection systems in place. This often includes the establishment of a bilateral technical exchange program with the State involved.

5. Institutional Arrangements (E-5)

The institutional arrangements that have been discussed most frequently have been regional fuel cycle facilities, and international plutonium storage.

Regional fuel cycle facilities are facilities where large scale processes in the nuclear fuel cycle of value to a number of geographically related countries are conducted jointly by these countries. The intermingling of staff members from different countries is intended to provide automatic surveillance that assures that no single member of the group can use the facility for proscribed purposes. The closest so far that any facility has come to this concept has been the Tripartite centrifuge facility, at Almelo. Even at Almelo, however, the German and Dutch participants maintained physically separate parts of the plant, each staffed entirely by the country concerned. The British facility was even more separate, being located at Capenhurst, in England.

There has been discussion from time to time of other regional possibilities, such as a Japanese-Australian uranium enrichment combine on Australian soil. This particular possibility becomes more remote as time passes and the Japanese program leading to a national isotope separation facility advances. It is unlikely that regional fuel cycle facilities will emerge, at least in the forseeable future.

There is more possibility for International Plutonium Storage Facilities. For a period under the Carter administration, there was reluctance to press this concept, particularly in some White House circles, because this would appear to "legitimize" the chemical processing which produced the plutonium. There is now renewed interest in international plutonium storage, and the negotiations directed at establishing a plan should soon accelerate. The interest in other countries has waned, however. It may be possible to get an agreement, but this agreement may not be as good now as it might have been two or three years ago. A repetition of American indecisiveness is likely to lead to another case where the gain might have been greater if opportunity had been seized when conditions were optimal.

6. Conversion of Non-NPT States to NPT States (E-6)

As has been pointed out a number of times, the principal concerns are found with respect to four countries that have not signed the NPT and that have some fuel cycle facilities outside safeguards. These are Israel, Pakistan, India, and South Africa. In each case, there is cause to believe that the reason for not signing NPT and not accepting full-scope safeguards is the existence of nuclear weapons aspirations. The same ambitions may be strong and even dominant among some States that have accepted full-scope safeguards, but perhaps only for the present.

Signing the NPT is not an act empty of meaning. While States sometimes do break commitments and treaties when it is in their interest to do so, the threshold is higher than when no such impediment is present. This is surely the reason why all of the States suspected of having nuclear weapons aspirations have not adhered to NPT.

The principal motivation for a State's desiring nuclear weapons is probably the urge to improve national security against some perceived foreign threat. These are clearly the principal reasons why any of the four countries above might seek nuclear weapons capability. During the negotiations of NPT, in the late 1960's, this problem was recognized. At one point near the end of the negotiations the three large nuclear weapons states were pressured into making a statement that they hoped would satisfy the stated need for a nuclear umbrella over non-nuclear weapons states threatened with nuclear attack from any source. In fact, the declaration fell far short of the assurance the non-weapons states required. It was at this point that adherence of India to the Treaty may have been lost.

A second problem that keeps some States (or so it is claimed) from signing is continued vertical proliferation. The steady increase of nuclear arsenals by nuclear weapons states is itself a violation of the Treaty.

Full and effective adherence to the NPT will probably not occur unless and until these two problems are solved:

1) Assurance of adequate protection of the nations concerned against threats they perceive about them, especially from nuclear weapons States (or potential nuclear weapons), and

2) Progress toward reduction of size of nuclear arsenals in nuclear weapons States.

7. Bi- and Multi-Lateral Programs Outside IAEA Aegis (E-7)

The largest multilateral program outside the IAEA structure is that of Euratom. Euratom has maintained a safeguards system for nearly two decades. The IAEA-Euratom agreement to an extent accepts Euratom safeguards as substitute for IAEA safeguards, an arrangement IAEA finds embarassing and not wholely legal or logical. Yet the Euratom system despite many evident weaknesses has the multinational character that also would make regional fuel cycle facilties attractive. The U.S. has in the past reviewed the question of whether steps should be taken to weaken Euratom so as to strengthen IAEA safeguards, and has decided that this should not be done.

The Comecon system of Eastern Europe has no counterpart to Euratom, because the Soviet Union maintains tight control of all aspects of the nuclear fuel cycle in Comecon countries that could contribute to nuclear weapons capability.

The bilateral programs that were initiated by the U.S. some years ago under the Atoms for Peace program have all evolved into trilateral agreements, with the IAEA as the third party discharging the safeguards responsibility. These are still safeguarded under INFCIRC/66. The number of these cases is diminishing as more countries sign safeguards agreements under INFCIRC/153. The number now may have been reduced to a point beyond which further change is unlikely in the near future, as the only countries under trilateral agreements are now those unlikely to join the NPT and accept full-scope safeguards.

The Treaty of Tlatelolco, naming South America as a nuclear free zone, was concluded in 1967. Eighteen of the twenty-two South American States have signed and ratified this Treaty, which is thus not yet in full effect.

8. Public Relations and Public Opinion (E-8)

The principal difficulty faced in public relations is to educate the public and even the body politic in the true nature of the IAEA and the NPT. Beyond this, it becomes even more difficult to spread understanding of the nature of IAEA safguards. The education process is proceeding, but the results often seem much smaller than the effort that has been necessary. It is still common even in Congressional circles to find those who think that an international body such as IAEA can have police powers over its member states, and can demand rights even from non-members. Others are found who have learned of IAEA's limitations, and therefore decide it is ineffective. The education process has been stepped up, and will have to be augmented even more.

9. Possible International Sanctions Through UN or Other Non-IAEA Source (E-9)

The IAEA cannot be a vehicle for sanctions (in the strictest sense), because its charter does not provide for this.* IAEA is a specialized Agency of the United Nations, to which it reports. As the Non-Proliferation Treaty provides, the Director-General of IAEA can inform the United Nations of any violation of NPT. The UN can then consider any appropriate measures, including

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* The IAEA can terminate all assistance programs and withdraw IAEA-supplied material and equipment. This, and also expulsion, could be considered forms of sanctions, albeit not very potent ones. As sanctions these are not effective since a State that produced a weapon would presumably no longer require either assistance or the application of safeguards.

sanctions. This is the only formal means of concluding agreements for international sanctions.

Sanctions have not been very effective in the past. They did not impede the Italian invasion of Ethiopia fifty years ago. They did not have any appreciable effect on Rhodesia a decade ago; the subsequent agreements by the white minority to share power with the native populace were altogether the result of local pressures.

The more successful line of action is likely to be pressure applied by one of the more powerful countries on a State with respect to which it has particular influence because of trade, alliances, or geography. This is the method which has been tried with varying success in recent years, and it is the one most likely to be used in the future.

IV. SUMMARY AND CONCLUSIONS

A cursory examination of the first 9 appendices of this work (A through I) is enough to suggest that there is a great deal of R&D going on in international safeguards. Only a slightly more detailed look is needed to make one realize that an overwhelming preponderance of the effort is supported by the U.S.

In quality and versatility, as well as quantity, U.S. support is far and away the most impressive. Other states often slant their contribution toward their particular interest (the Canadian program almost entirely deals with CANDU-related problems, for example). This is not without some merit since it would have to be done in any case. Euratom also has a relatively diverse program and the additional contributions of certain Euratom nations, notably FRG and the UK represent important programs. On the other hand, there are some States that do not contribute shares of the burden proportionate to their size and wealth (See Appendix I).

Of greater interest perhaps, is the distribution of the R&D with respect to the five major divisions, and the sub-divisions of the framework. By far the largest number of tasks, approximately 60% deals with Resources (D). Of this, approximately half involves the utilization of instrumentation (D-6) and a quarter, the provision of equipment (D-5). Of the remaining 40% of the tasks, System Design (B), Information and Communication (A), Program Management (D-2), and the training of inspectors (D-1) are the most significant; each is covered by from 5 to 15% of the total. The areas of SSACs (C) and Complementary Issues (E) receive relatively little support (the latter is not unexpected because of the difficult, non-technical nature of the subject); only a few percent each.

In the area of Information and Communications (A), the preponderance of effort is in the sub-areas of transfer of information from the States to the IAEA (A-1) and the processing of received data by the IAEA (A-2). In these sub-areas, recent efforts have resulted in certain improvements. One relatively highly visible effort related to information transfer is the current attempts to implement RECOVER and TRANSEAVER. In the other sub-areas (A-3,A-4,A-5), while little is being done directly, improvements in the first two areas are expected to help enormously as the entire information system will improve. (See pp. 6-15)

The area of System Design (B) is currently undergoing an extremely important transition. At the conclusion of the ongoing efforts in Safeguards Evaluation Assessment Methodology, the entire field of system design will be much closer to providing a much needed basis for unifying the IAEA safeguards system and making it more efficient. Efforts in objectively stating technical objectives and criteria (B-1) and providing balanced approaches (B-2) and inspection procedures (B-3) should have a solid foundation. The systems approach can be expected to maximize the utilization of the available inspection force and provide guidance for the development and acquisition of new instrumentation and other aids. The design of new facilities that incorporate safeguards-related features (B-4) may be an elusive goal despite the ideas that are now fruitfully being explored. It is likely that many States will continue to resist safeguards improvements that are viewed as expensive impediments to productivity. (See pp. 15-26)

The implementation of State Systems of Accounting and Control (C), has been a weak spot in many States. There have been and continue to be relatively small but effective efforts in providing guidelines and training which ultimately will improve the development and implementation of SSACs (C-2,C-3). Yet the provision of agreements and subsidiary arrangements (C-1) and the extent of compliance by individual States (C-4) is politically dependent and often presents problems not readily solvable by technological progress. (See pp. 26-32)

The quality of resources (D) available to the IAEA is a problem which has two very different aspects. On the one hand, the provision of adequate hardware (D-1), training (D-1,D-6), utilization of instrumentation (D-6), data handling (D-7), and reference standards (D-8) is relatively easily solved given adequate funding and guidance. On the other hand, the provision of adequate numbers and quality of inspectors (D-1), and adequate management (D-2,D-3) may not be readily solved even with adequate resources because of related political issues. The problem of obtaining adequate funds (D-4) is an intermediate one, presumably solvable. In the last case, the improvement of efficiency, especially as regards balanced utilization of resources, can be of some help. (See pp. 32-42)

Finally, in all the complementary issues (E), there are only one or two that can be directly influenced by current initiatives. Those are improved physical protection (E-4) and supplier guidelines (E-3). As for the rest, only an overall improvement in world wide perception of the abilities and overall effectiveness of the IAEA can help with the political nature of the problems involved. (See pp. 42-51)

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Appendix A

U.S. Assistance to IAEA Safeguards[A-1]

A major route for providing assistance is through the U.S. Program of Technical Assistance to Safeguards (POTAS), by which the U.S. provides technical assistance to enhance the ability of the IAEA to apply safeguards effectively.

The United States provides substantial other assistance to the IAEA safeguards program including: efforts through the Nuclear Suppliers Group to extend the application of IAEA safeguards; participation in the IAEA Standing Advisory Groups on Safeguards Implementation; development and promotion of multinational, regional fuel cycle centers including international regimes for spent fuel or plutonium storage; implementation of the agreement for application of IAEA safeguards to all U.S. nuclear facilities, excluding those of direct national security significance; and, strong assistance to planned growth of the IAEA safeguards program. Various agencies contribute including the Department of Energy (DOE), the Arms Control and Disarmament Agency (ACDA), and the Nuclear Regulatory Commission (NRC). These agencies also provide an input to the POTAS through the Technical Support Coordination Committee and their overall effort on support of IAEA safeguards is coordinated through the Action Plan Working Group (APWG).

In February 1978, the U.S. enacted the Nuclear Non-proliferation Act of 1978, of which Title II encourages the U.S. to contribute funds, technical resources, and other support to assist the IAEA in effectively implementing safeguards.

I. POTAS

The POTAS contributions complement other resources available to the IAEA based on funding from its regular budget. These contributions provide reaction to identified urgent needs to improve effectiveness more quickly than can be achieved through normal IAEA administrative procedures. Special expertise is made available to strengthen IAEA capabilities in areas where such expertise is limited. Where U.S. research has developed and tested advanced technical capabilities for safeguarding, results are made available to IAEA. Under POTAS, members of the IAEA staff are given opportunties to become experienced with actual operating conditions at nuclear facilities, conditions which they will encounter in the discharge of their safeguards duties. POTAS responds to other requests for assistance, but those outlined above have the highest urgency.

POTAS task numbers incorporate a single letter code, A through F (or certain special designations) which are keyed to the following broad categories:[A-2]

A. Measurement Technology
B. Training
C. System Studies
D. Information Processing
E. Containment and Surveillance
F. Field Operations
SP. Special Tasks

T. Tastex Project (Tokai Advanced Safeguards Technology Exercise), joint with France and Japan.

The following table (Table A-1) lists those tasks which are currently active or completed (deleted, incomplete tasks are omitted) in a format keyed to the "Framework" in part II of this paper. This necessarily brief listing includes only minimal information. Under a number of the tasks, instrumentation has been provided to the IAEA for test and evaluation and/or use. Such tasks are identified in the Table. The sources of the information shown are references A-2 and A-3 with appropriate updating. In addition, reference A-4 is a listing of reports available for the completed projects as of May 1981.

TABLE A-1

POTAS Tasks

Task No.	Title	Current Active	Completed	Framework Key
A.1	Senior NDA Expert		X	All of B
A.2	NDA/Computer Data Processing Expert		X	D-2,D-7
A.3	NDA/Instruction & Procedures Expert		X	D-1,D-6
A.4	NDA/Physical Standards Expert		X	D-6,D-8
A.5*	Gamma Spectroscopy & Neutron Techniques for Unirradiated Nuclear Material		X	D-5
A.6*	Neutron Techniques for Unirradiated Fuel Assemblies		X	D-5,D-6
A.7*	Equipment for Measurement of Plutonium Scrap or Waste in Drums		X	D-5
A.8*	Active Well Coincidence Counter		X	D-5,D-6
A.9*	Plutonium Assay Calorimetry		X	D-5,D-6
A.11*	Gamma Spectroscopy Technique for Unirradiated Uranium Samples		X	D-5,D-6
A.13*	Hand-Held Germanium Detector Probe		X	D-5,D-6
A.14	Gamma Absorptiometer Expert		X	D-1,D-6
A.15	Track-Etch Technique; Processing & Read-out of Tapes		X	D-1,D-6
A.16	Technical Assistance in Application of IAEA Two-Stage Spectrometer		X	D-6
A.17	Acquisition of IAEA NDA Equipment and Appropriate Reference Materials for Training Programs at LASL		X	D-5,D-1
A.18	Autoradiographic Verification of Enrichment in Unirradiated Fuel Assemblies		X	D-5,D-6
A.19	Vehicle for Instrumented Safeguards Inspection System (Europe)		X	D-5
A.22	Access to U.S. Facilities and Calibration Standards		X	D-8
A.23	Spent Fuel Assemblies		X	D-8
A.24	Mass Spectrometer Filaments		X	D-5
A.25*	Personal (Pocket) Radiation Monitors		X	D-3
A.26*	Portable Neutron Well Coincidence Counter		X	D-5
A.27	Senior NDA Expert		X	D-6
A.28	Senior NDA Expert		X	D-6
A.29	NDA/Computer Data Processing Experts		X	D-7
A.30	NDA/Instruction and Procedures Expert		X	D-6,D-1
A.31	Active Neutron Technique for Unirradiated Fuel Assemblies Based on Neutron Generator Containing No Radioactive Material		X	D-6

* Instrumentation provided to IAEA for test and evaluation and/or use.

Task No.	Title	Current Active	Completed	Framework Key
A.33	Track-Etch Technique; Field Test of Reactor Power Monitor		X	D-6
A.34	Demonstration of the Application of Resin Bead Technology in the Analysis of Irradiated Fuel Solutions		X	D-6
A.35	Autoradiographic Verification of the Plutonium Content of Plutonium-Bearing Fuels		X	D-6
A.36	Vehicle for Instrumented Safeguards Inspection System (Europe)		X	D-5
A.37*	Equipment for Vehicle for Instrumented Safeguards Inspection System		X	D-5
A.38*	Portable Neutron Well Coincidence Counter		X	D-5,D-6
A.39	Determination of the Multiplication in Assay Samples		X	D-6
A.40	UF_6 Mass Determination		X	D-5
A.42	Measurement of the Minor Isotopes of Uranium Using the IAEA Two-Stage Mass Spectrometer		X	D-6
A.43	Active Assay of Highly Enriched Uranium in Unirradiated Fuel Assemblies or Containers		X	D-6
A.44	Provision of Spiking Material for Isotope Dilution Mass Spectrometer Analysis		X	D-8
A.45*	Plutonium Assay Calorimetry		X	D-5,D-6
A.46*	Procurement of Two Intrinsic Germanium Coaxial Detectors with Amplifiers		X	D-5
A.47	Prediction of Calorimeter Equilibrium	X		D-6,D-5
A.48	In-Storage Pond Spent Fuel Burn-up Verification with Minimum Movement of Irradiated LWR Fuel Assemblies	X		D-6
A.49	Application of Neutron Measurement Technologies for the NDA of Irradiated Fuel Assemblies		X	D-6
A.51*	U^{235} Content Determination of HEU with the Active Well Coincidence Counter		X	D-5,D-6
A.52*	NDA Instrumentation and Supporting Equipment for Agency Vehicle (Europe)		X	D-5
A.53	NDA Applications Technical Assistant		X	D-6
A.54*	Highly Portable, In-Place UF_6 Mass Determination		X	D-5
A.55*	Gamma Spectrometry and Neutron Techniques for Unirradiated Nuclear Material - BSAM Modification		X	D-5
A.56	Measurement Procedures and Standard Reference Materials to Optimize Implementation of Resin Bead Techniques		X	D-7,D-8

* Instrumentation provided to IAEA for test and evaluation and/or use.

Task No.	Title	Current Active	Completed	Framework Key
A.58	International Air Shipment of Irradiated Plutonium on Resin Beads to Facilitate International Safeguards		X	D-6
A.59	Air Shipment of Plutonium Samples to Facilitate International Safeguards	X		D-6
A.62	Determination of the Pu Content in Mixed Oxide Fuel Assemblies Using the HLNCC		X	D-5,D-6
A.63*	Microprocessor for In-Field Processing of Agency Multichannel Analyzer (MCA) Gamma Ray Measurements		X	D-5
A.64	Implementation Procedures for Fast Response Calorimeters		X	D-5,D-6
A.65	High Precision Pulse Counting Mass Spectrometry Analysis of Nanogram-Size U and Pu Samples		X	D-6
A.66	Detection and Correction of Interference in the Chemical Determination of Fissile Elements		X	D-6,D-8
A.67	Supply of U^{233} and Pu^{244} Spike Material with Specific Chemical and Isotopic Purity	X		D-6,D-8
A.68*	Supply of a Well-Type High Resolution Semiconductor Detector for Gamma Spectrometry		X	D-5
A.69	Analytical Techniques to Reduce Number of Physical Standards		X	D-7,D-8
A.70	Development of an Inspector Data Verification and Evaluation System for the Automated Electromanometer	X		D-7,D-2
A.71	Access to U.S. Facilities and Calibration Standards (Continuation of A.22)		X	D-8
A.72	Ion Chamber and Neutron Detector for Spent Fuel Measurements		X	D-5,D-6
A.73	Special Neutron Measuring Head for the HLNCC	X		D-5
A.74*	Battery-Powered Multi-Channel Analyzer	X		D-5
A.75*	Neutron Techniques for Unirradiated Fuel Assemblies	X		D-5,D-6
A.76	Implementation of Improved Isotopic Data Analysis Procedures	X		D-7
A.77	Calculational Program for MTR-Type Fuel Assemblies		X	D-7
A.79	Methods for Adapting K-edge Densitometer and Gamma Spectrometer for IAEA	X		D-5,D-6

* Instrumentation provided to IAEA for test and evaluation and/or use.

Task No.	Title	Current Active	Completed	Framework Key
A.80	Supply of U^{233} and Pu^{244} Spike Material with Specific Chemical and Isotopic Purity	X		D-8
A.81	Selection of a High Accuracy Surface Ionization Mass Spectrometer		X	D-5,D-6
A.82	High Precision Pulse Counting Mass Spectrometry Analysis of Nanogram-Size U and Pu Samples		X	D-6
A.83*	Study of 1000 Channel Silena Analogue Circuits		X	D-5,D-6
A.84	Qualitative Verification Criteria - Material Authenticity	X		D-7,D-8
A.85	Field Evaluation and Implementation of U.S. Instruments and Methods		X	D-6
A.86	Technical Assistance in Operation of Two-Stage Mass Spectrometer		X	D-6
A.87	Senior NDA Expert		X	D-6,D-1
A.88	Computer Data Processing Expert		X	D-7
A.89	NDA/Instruction and Procedures Expert		X	D-6,D-1
A.90	Access to U.S. Facilities and Calibration Standards	X		D-8
A.91*	Provide Commercially Available Safeguards Equipment		X	D-5
A.92	Expert in Forecasting of Safeguards Equipment Requirements		X	D-6,D-3
A.93*	Desktop Computer System for Analysis		X	D-5
A.94	NDA/Instruction & Procedures Expert		X	D-6
A.95*	Program for Implementing Use of HLNCC	X		D-5,D-6
A.96*	Program for Implementing Use of AWCC	X		D-5,D-6
A.97*	Program for Implementing Use of Gamma and Neutron Chambers for Spent Fuel Measurements	X		D-5,D-6
A.98*	Program for Implementing Use of Portable Measurement Equipment to verify UF_6 Mass Determination	X		D-5,D-6
A.99	Special Measuring Heads for Neutron Coincidence Counting of Samples	X		D-5,D-6
A.100	Senior NDA Expert	X		D-6
A.101	NDA/Instruction and Procedures Expert	X		D-6
A.102	Cost-Free Expert/Effectiveness Implementation	X		D-2,D-6
A.103	Implementation of Active Neutron Coincidence Collars	X		D-5,D-6
A.104	Implementation of LLNL Microprocesses for Pu Isotopic Analysis	X		D-5,D-6
A.105	Implementation of Portable MCA	X		D-5,D-6
A.106	Management of Technical Support	X		D-2,D-3

* Instrumentation provided to IAEA for test and evaluation and/or use.

Task No.	Title	Current Active	Completed	Framework Key
B.1	Planning of Safeguards Training		X	D-1,D-3
B.2	Provision of Lecturers for IAEA-Sponsored Training Courses		X	D-1,D-6
B.3	IAEA Participation in U.S.-Sponsored Training Courses		X	D-1,D-6
B.4	Individualized Instruction		X	D-1,D-6
B.5	Funding for Training Participation		X	D-1,D-6
B.6	An Advanced SSAC Course Based on the Application of a National System of Accounting and Control with Special Reference to Bulk Fuel Processing Facilities		X	B-2
B.7	A Manual for the Examination of Nuclear Material Records		X	A-1
B.8	Cost-Free Training Expert		X	D-1,D-6
B.10	IAEA Participation in U.S.-Sponsored Training Courses		X	D-1,D-6
B.11	Individualized Instruction		X	D-1,D-6
B.12	Provision for Training Aids for Classroom Work		X	D-1,D-6
B.13	Preparation of a Video Training Course on the Use of the High-Level Neutron		X	D-6
B.14	Preparing a Complete Inspectors Basic Training Course		X	D-1
B.15	Training in Nuclear Fuel Plant Processes	X		D-1
B.16	Funding for Training Participation	X		
B.17	Cost-Free Training Expert		X	D-1
B.18	Provision of Lecturers for IAEA-Sponsored Training Courses		X	D-1,D-6
B.19	IAEA Participation in U.S.-Sponsored Training Courses	X		D-1,D-6
B.20	Individualized Instruction	X		D-1,D-6
B.21	Training Manual for Examining Nuclear Material Records		X	D-1
B.22	Prepare Inspector's Basic Training Course		X	D-1
B.23	Management Training Program		X	D-3
B.24	Cost-free Training Expert	X		D-1
B.25	Cost-free Training Expert	X		D-1
B.26	Cost-free Expert	X		D-3
B.27	Cost-free Training Expert	X		D-6
B.28	Facility Familiarization	X		D-1
B.29	In-field Training on HEU Fuel Fabrication Inventory Verification	X		D-1,D-7
B.30	In-field Training on MOX Fuel Fabrication Inventory Verification	X		D-1,D-7

Task No.	Title	Current Active	Completed	Framework Key
C.2	Integral Exercises - LWR Power Plant		X	B-1
C.3	Integral Exercises - LEU Fabrication Facility		X	A-1
C.4	Integral Exercises - Reprocessing Facility		X	B-1,B-4
C.5	Estimation of Inspection Effort for Chosen Inspection Procedures		X	B-2,B-3
C.6	Material Flow and Inventory Data Processing in Typical Nuclear Facilites		X	A-1
C.7	Safeguarding Fast Breeder Reactors		X	B-1,B-2, B-3
C.8	Consultant to Consider Safeguards Aspects Related to Heavy Water		X	B-1
C.9	Explanatory Notes and Examples for Design Information Questionnaire		X	B-1,B-4
C.10	Dynamic Material Control		X	B-2
C.12	Material Operation Control Monitoring		X	B-2
C.14	Study of Technical Problems of Implementation of Safeguards at Uranium Enrichment Facilities		X	B-2
C.16	Diversion Analysis for Nuclear Fuel Cycle		X	B-3
C.17	Safeguards System for Critical Facilities		X	B-2
C.18	Safeguards Data Base and Forecasting Model		X	B-2,B-3
C.19	Model for Analysis of the Impact of the Safeguards Criteria (Categorization of Nuclear Material, Significant and Goal Quantities)		X	B-1
C.20	World-Wide Allocation of Inspection Effort		X	D-2
C.22	Evaluation and Quantification of Safeguards Effectiveness	X		B-2,B-3
C.23	Possible Use of Performance Assessment Methodology for International Safeguards		X	D-2,B-2, B-3
C.24	Diversion Hazards for LWR's		X	B-3
C.25	Design of Nuclear Facilities to Make International Safeguards Easier and More Effective		X	D-2,D-3
C.28	Models for Safeguarding Generic Types of Facilities		X	B-2
C.29	Safeguards Database and Forecasting Model (Continuation of Task C.18)		X	A-1,B-3, D-7
C.30	Development of Short Detection Time Inspection Procedures for Reprocessing MOX and HEU Facilities		X	B-2,B-3

Task No.	Title	Current Active	Completed	Framework Key
C.31	Development of Guidelines for Practical Implementation of the Elements of SSAC	X		C-2,C-3
C.32	Diversion Analysis for LEU Conversion/ Fabrication Plants		X	B-3
C.34	Diversion Analysis Consultant (LWR)		X	B-3
C.35	Calculation of Parameters for Inspection Planning and Evaluation	X		B-1,B-2
C.36	Independent Verification at Reprocessing Facilities with Installed Instrumentation as Tested in the TASTEX Program		X	B-3
C.37	Simulation of Cumulative Detection Capabilities over Multiple Material Balance Periods	X		
C.38	Diversion Hazards Possible with Multiple and Interdependent LWR Fuel Cycle Facilities		X	B-3
C.39	Long-Term Forecast of Nuclear Activities		X	D-3
C.41	Diversion Analysis Consultant (MOX)		X	B-3
C.43	Diversion Analysis and Safeguards Measure for Liquid Metal Cooled Fast Breeder Reactors (LMFBR)		X	B-2,B-3
C.44	Diversion Analysis for Nuclear Fuel Cycle		X	B-3
C.45	Seminar on System Studies Related Topics		X	All of B
C.46	Computerization of PWR Anomaly Assessment Modules	X		B-3,A-2
C.47	Safeguards Effectiveness Assessment Methodology, Reprocessing Plants	X		B-2,B-3
C.48	Safeguards Effectiveness Assessment Methodology, MOX Fuel Fabrication Plants	X		B-2,B-3
C.49	Cost-free Expert/SSAC Guides	X		C-2,C-3
C.50	IAEA Safeguards Approach for High Power Research Reactor	X		B-2
C.51	Review of Safeguards Effectiveness Assessment Methodology	X		A-4,D-3
D.1a	Assist in Acquiring New Computer		X	A-1,A-2
D.1b	Assist in Acquiring New Computer at an Earlier Date		X	A-1,A-2
D.2a	Computer Terminals		X	A-1,A-2
D.3	Remote Data Terminal with Dial-Up Capability		X	A-1,A-2
D.4	Study and Possible Conversion of Statistical Software Packages		X	A-1,A-2
D.5	Concept for Implementation of, and Instruction in Safeguards Information System		X	A-1,A-2
D.6	Design and Coordination of Safeguards Forms		X	A-1,A-2, A-3

Task No.	Title	Current Active	Completed	Framework Key
D.7	Cost-free Experts - Senior Analysts/ Programmers (2)		X	A-1,A-2
D.8	Cost-free Experts - Analysts/ Programmers (2)		X	A-1,A-2
D.9	Evaluation of Effort Required for Development of New Advanced Safeguards Information System		X	A-1,A-2, A-3
D.10	Evaluation of Technical Requirements for Operation of the New Advanced Safeguards Information System		X	A-1,A-2, A-3,D-7
D.11	Provide the IAEA with Two Word Processors		X	A-2
D.12	Reducing Copying Machine		X	A-2
D.13	Computer Terminals		X	A-2
D.14	Direct Transmission of Safeguards Data		X	A-1,A-3
D.15	Cost-Free Expert - Senior Analyst/ Programmer		X	A-1
D.16	Cost-Free Experts - Analysts/ Programmers (2)		X	A-1,A-2
D.17	Calculational Procedure for Production of SNM in Reactors		X	A-1,A-2
D.19	Cost-Free Expert - Junior Analyst/ Programmer		X	A-1,A-2
D.21	Safeguards Information Treatment (SGIT) Exchange Seminar in the U.S.A.		X	A-1,A-2, A-3
D.22	Mini-Computer for Inspection Data Evaluation		X	D-7
D.24	Computer Graphics Hardware Acquisition		X	D-7
D.25	Cost-Free Experts - Analysts/ Programmers (2)		X	A-1,A-2
D.26	Software Support for the Field Computer System		X	D-7
D.27	Leasing of Reducing Copy Machine		X	A-2
D.28	Cost-Free Expert - RECOVER		X	D-6,[illegible]
D.29	Cost-Free Experts - Analysts/Programmers (3)		X	A-1,A-2
D.30	Expert for Designing and Documenting Procedures for Handling of Inspection Data		X	A-1
D.31	Expert for Developing Methods of Evaluation and Processing of Inspection Data		X	A-2
D.32	Exchange of Experience with NRC Safeguards Inspectors		X	D-1
D.33	Assistance in Application of POTAS Developments		X	(See A.85)
D.34	Special Travel by IAEA Safeguards Personnel to U.S.A.	X		A-4,C-1, D-2,E

Task No.	Title	Current Active	Completed	Framework Key
D.35	Establish ICT Procedures for Use by Inspectors at Reprocessing Facilities Under IAEA Safeguards		X	D-6
D.36	Records Examination and Check Lists		X	D-1
D.37	Expert for Development of Methods for Evaluation of Inspection Data		X	B-2,B-3
D.38	Expert for Developing Methods of Evaluation and Processing of Inspection Data		X	A-1,D-7
D.39	Senior Expert in Evaluation of Safeguards		X	B-2,B-3
D.40	Cost-free Expert Analyst/Programmer		X	A-1,A-2
D.41	Cost-free Expert, Safeguards Evaluation Methodologies	X		B-2,B-3
D.42	Cost-free Expert, Analyst Programmer	X		A-1,A-2
D.43	Development of Safeguards Evaluation Methodologies	X		D-2
E.2	Modification of Irradiated Fuel Bundle Counter		X	D-5
E.3	Semi-Automatic TV Tape Scanner		X	D-5
E.4	IAEA TV System Transmission Security		X	D-6
E.5*	Design of a Battery Powered Portable TV Surveillance System		X	D-5,D-6
E.6*	Provision of Environment-Resistant TV Surveillance Systems		X	D-5
E.7	Study of Before-the-Lens Tamper Detection for Camera and TV Surveillance Systems		X	D-6
E.8	Study and Possible Development of On-Line Interrogation of Surveillance and Sealing Systems		X	D-6
E.10	Study of Feasibility of Slow Scan TV Surveillance System		X	D-6
E.11*	Development of Electronic Fiber Optic Seal System		X	D-5,D-6
E.12*	Improved Fiber Optic Seals		X	D-5,D-6
E.13*	Temporary Seals for Identification of Containers (Pressure Sensitive Tape)		X	D-5
E.14	Sealing System for UF_6 Cylinders		X	D-6
E.16	System for Sealing LWR Fuel Assemblies		X	D-6
E.17	Intrusion/Motion Detection for Surveillance/Containment		X	D-6
E.18	Tamper-Resistant Tamper-Indicating Containers		X	D-6
E.19	Methods of Tamper Detection/Indication		X	D-6
E.20	Status Monitoring (Alternative to Optical Surveillance)		X	D-6
E.21*	Irradiated Fuel Monitor		X	D-5,D-6

* Instrumentation provided to IAEA for test and evaluation and/or use.

Task No.	Title	Current Active	Completed	Framework Key
E.22	Solar Cell Gamma Detector		X	D-6
E.23	Portal Monitors		X	D-6
E.24*	Reactor Power Monitor		X	D-5,D-6
E.25*	Development of a Reliable Advanced TV Surveillance System		X	D-5,D-6
E.26	Expert to Perform Reliability Analysis and Recommend Maintenance Procedures for In-Field Video Surveillance System		X	D-6
E.27*	Design of a Semi-Automatic Scanner for Super 8-mm Movie Film		X	D-5,D-6
E.28*	Metallic Seals		X	D-5,D-6
E.29	Seals for Unirradiated LWR Fuel Assemblies		X	D-6
E.30	Expert in Containment and Surveillance		X	D-6
E.31	Professional Experienced in Containment and Surveillance Techniques		X	D-6
E.33	Functional Evaluation of Film Cameras Suitable for Surveillance		X	D-6
E.34	Hardware and Procedure to Prevent Before-the-Lens Tampering	X		D-5,D-6
E.35*	Underwater Identification of Fuel Assembly Numbers		X	D-5,D-6
E.36	Optimum Design of Containers to Accommodate Seals		X	D-6
E.37*	Production of Electronic, Fiber Optic Seal Systems		X	D-5
E.40	Supply Portable Battery-Powered TV Systems	X		D-5
E.41	Radiation Detectors as Yes/No Monitors for Safeguards		X	D-6
E.43	Identify Recording and Verification of Type-E Seals		X	D-6
E.44	Improved Reliable Film Camera System	X		D-5
E.45	Integrated Monitoring System for Light Water Reactor Spent Fuel Storage Area	X		D-5
E.46	Cassette-Type Video Tape Recorder Evaluation	X		D-6
E.47	Portable Super 8-mm Film Developer Kits		X	D-6,D-5
E.48	Loop Used With a Type-E or Other Seal Closures		X	D-6
E.50	Improved Cerenkov Measurement System	X		D-5
E.51	Containment and Surveillance Equipment Reliability Techniques		X	D-6
E.52	Expert in Containment and Surveillance		X	D-6

* Instrumentation provided to IAEA for test and evaluation and/or use.

Task No.	Title	Current Active	Completed	Framework Key
E.53	Professional Experienced in Containment and Surveillance Techniques		X	D-6
E.54	Program for the Implementation of the Task E.25 Advanced TV Surveillance System	X		D-6
E.55	Evaluation of RECOVER Monitoring System	X		A-1
E.56	Expert in Remote Monitoring, Data Transmission, Surveillance		X	D-6
F.2	Exchange of Experience with NRC Safeguards Inspectors		X	D-1
F.3	Statistical Analysis of Analytical Data		X	D-7
F.4	Sample Plan Calculation and Application		X	D-7,B-2
F.5	Detection of Irregularities in Overall Fuel Cycle Transaction Reports		X	A-2
F.6	Expert for Development of Methods of Evaluation of Inspection Data		X	A-2
F.7	Cooperative Study with NRC at GE-Wilmington		X	D-1
F.8	Review of Part F of Safeguards Technical Manual		X	D-7
F.9	Development and Application of Isotopic Safeguards Techniques		X	D-6
F.10	Senior Expert in Safeguards Implementation		X	D-6
F.11	Expert for Designing and Documenting Procedures for Handling of Inspection Data		X	D-7,A-2
F.12	Expert for Developing Methods of Evaluation and Processing of Inspection Data		X	A-2
F.14	Senior Expert in Safeguards Implementation		X	D-7
F.15	Senior Expert in Evaluation of Safeguards		X	D-7
F.16	Volume III of Part F of Safeguards Technical Manual		X	D-7,B-2
F.17	Senior Expert in Evaluation of Safeguards		X	B-1,B-2, B-3
F.18	Technology Transfer of Developed Methodology for Applying the Kalman Filter		X	D-7
F.19	Expert for Development of Methods of Evaluation for Safeguards Data		X	D-7
F.20	Exchange of Experience with NRC Safeguards Inspectors		X	D-1
SP.1	Seibersdorf Analytical Lab Wastes	X		D-3
SP.3	Isotopic Safeguards Techniques		X	D-6
SP.4	RECOVER Evaluation	X		A-1
SP.5	International Spent Fuel Management Program		X	D-6
SP.6	Data Specialist to Korea for SSAC Training		X	C-3,C-4
SP.7	SSAC Training Course		X	C-3,C-4
SP.8	Reduced Enrichment Research and Test Reactors Program		X	E-3

Task No.	Title	Current Active	Completed	Framework Key
SP.9	C/S and Facility Design at Reprocessing Plants		X	B-4
SP.10	INFCE		X	All of E
SP.12	IAEA Travel Support		X	C-3,C-4
SP.13	NBS Handbook on Safeguards Approach Effectiveness Evaluation		X	B-2,B-3
SP.14	Measurement of Cerenkov Radiation at Canadian Facility		X	D-6
SP.16	Review and Modify IAEA Safeguards Effectiveness Evaluation Methodology		X	B-2,B-3
SP.17	Hexapartite Safeguards Project		X	B-1,B-4
SP.18	DSC, Implementation of Aggregate Measure	X		B-3
SP.19	LWR Evaluation Procedures	X		A-2
SP.20	U.S Experts, Assistance to IAEA	X		A-2
T-A**	Evaluation of Surveillance Devices, Spent Fuel Receiving Areas		X	D-6
T-B**	γ-Spectra of Irradiated Fuel Assemblies		X	D-6
T-C**	Hull Monitoring System		X	D-6
T-D**	Loadcell Demonstration for Accountability Vessels		X	D-6
T-E**	Electromanometer Demonstration for Accountability Vessels		X	D-6
T-F**	DYMAC Application Study		X	D-6
T-G**	K-edge Densitometer for Pu Product Solutions		X	D-6
T-H**	High Resolution γ-Spectrometer for Pu Isotopics		X	D-6
T-I**	Pu Product Area Monitoring		X	D-6
T-J**	Resin Bead Sampling Technique		X	D-6
T-K**	Isotope Safeguards Techniques		X	D-6
T-L**	Gravimetric Method for Input Measurements		X	D-6
T-M**	Tracer Methods for Input Measurements		X	D-6

** All "T" tasks refer to Tokai Advanced Safeguards Technology Exercise.

II. Department of Energy Initiatives

The Office of Safeguards and Security of the Department of Energy (OSS/DOE) has a number of programmatic responsibilities which bear either directly or indirectly on international safeguards. Of direct significance is a major goal to provide "international safeguards technology and expertise in support of nonproliferation commitments" including "administering technical assistance to the IAEA and fulfilling consultation, training, and international physical security review requirements of the NNPA of 1978".

A part of OSS responsibility is to oversee management of the POTAS program (see above). Additional responsibilities include the sponsorship of a number of R and D initiatives, and there is also a physical security review program which is a complementary adjunct to the IAEA safeguards systems. Table A-2 lists the important activities in the above categories that are a part of the "international support activities" of OSS, that is, those activities directly and specifically for the purpose of strengthening international safeguards. Most of the activities listed are currently underway.

In addition, OSS, of course, supports R and D efforts which are primarily for the enhancement of domestic safeguards. Much of the effort in this program, however, is useful for international safeguards as well. Hence, Table A-3 provides a listing of such appropriate OSS sponsored tasks related to the measurement of Strategic Nuclear Materials. To a certain extent the lists in these tables are redundant because many of the entries have been included in POTAS.

OSS also sponsors research involving Physical Protection. Although the IAEA is not directly concerned with physical protection, this is important to international safeguards as the quality of any State's security system directly affects their qualification to receive sensitive materials from supplier States like the U.S. (Ref. Framework Key: E-3, E-4). Some of the active OSS sponsored programs in this field involves:

- (a) Development of advanced hardware for delay, detection, and response to adversary action and unauthorized SNM removal
- (b) Development of performance specifications
- (c) Assessment of equipment operations
- (d) Development of advanced interior sensors
- (e) Development of video motion detector analyser for exterior sensing
- (f) Development of reliable explosives detector
- (g) Development of improved SNM portal detectors
- (h) Development of electronic badge system
- (i) Development of automated personnel verification

Table A-2

DOE Initiatives for International Safeguards Support
(other than POTAS Management)

Task Area/Description	Status*	Framework Key
Enrichment Plant Safeguards		
Define/Develop Safeguards System for GCEP	P	B-1 to B-3,D-2
Provide Assistance to IAEA (incl. Hexapartite Project)	P	B-1 to B-3,D-2
In-line Enrichment Monitor	P	D-5
In-line Tails Monitor	P	D-5
Neutron and γ-ray Monitoring Studies	P	D-6
Reprocessing Safeguards		
Study of Integrated MA and C/S Concept	C	D-2
Near Real-Time Verification Techniques	P	D-2
Prototype Compact Densitometer	P	D-5
Inventory Estimate Methods	P	D-7
Identify Needed Instrumentation	P	D-2
Underwater Monitors	P	D-5
Evaluate and Modify Unattended Portal Monitors	P	D-5
Critical Facilities Safeguards		
Fuel Assay Sampling Plan	C	D-7
Passive In-Core Autoradiography	C	D-5
Active In-Core Inventory	C	D-5
Out-of-Core Measurements	C	D-5
Seals	C	D-5
Seals and C/S		
Fiber Optic Seal, Developed and Provided	C	D-5
Develop LWR Fuel Assembly Identification Device (FAID)	C	D-5
Field Test of FAID	P	D-6
UF_6 (Shrink Tube) Cylinder Seals, Development	C	D-5
UF_6 (Shrink Tube) Cylinder Seals, Evaluation	P	D-6
FBR FAID Development	P	D-5
Lightweight Air-Transportable Accident Resistant Container (PAT-2)	C	D-5

* C = essentially complete, P = in progress, NA = not applicable

Task Area/Description	Status*	Framework Key
Misc. Technical Support		
Review of Portsmouth GCEP Safeguards Implementation	P	B-2,B-3
Analysis of Advanced Isotope Separation Safeguards	P	D-2
Review of IAEA Safeguards Implementation Report	P	D-2
Review of Improved Effectiveness from U.S. R&D and Technical Support	P	B-2,B-3
Participation in Development of International Pu Storage System	P	E-5
Studies of U Enrichment International Safeguards Methods	P	D-2
Safeguards Effectiveness Evaluation for Reprocessing	P	B-2,B-3
Assistance for Implementation of U.S. Offer to Accept IAEA Safeguards	P	E-2
Preparation of a Safeguards Instrumentation Catalog	C	D-2
Training		
Physical Protection	NA	E-4
State System of Accounting and Control (SSAC)	NA	C-3
Technical Exchanges		
U.S.-Euratom (agreement approved - January 1982)		
Computer Code Evaluation	NA	A-2
Development of Security Seals	NA	D-5
Reference Standards	NA	D-8
Computer Modeling of MOX Processes	NA	D-2
U.S.-FRG (agreement approved - 1977)		
Transportation for Pu and U	NA	D-2
Critical Facilities	NA	D-2
Test and Evaluation of Sensors	NA	D-5
Evaluation of Methodology for Systems	NA	D-2
Spent Fuel Containers	NA	D-5
U.S.-U.K.		
Exchange of R&D Results of Material Measurements	NA	D-7
U.S.-Canada and U.S.-France		
Informal Technical Exchanges	NA	--
U.S.-Australia, Canada, France, and Japan		
Active Discussions underway	NA	--

* C = essentially complete, P = in progress, NA = not applicable

Task Area/Description	Status*	Framework Key
Physical Security Review Program (with NRC, Dept. of State, and ACDA participation)		
Review of Physical Protection in States Receiving U.S.-Origin Fuel	NA	E-4
Bilateral Technical Exchange Programs	NA	E-4

* C = essentially complete, P = in progress, NA = not applicable

Table A-3

DOE Sponsored R&D Useful for International Safeguards
(but primarily for domestic use)

Task Area and Description	Laboratory	Application	Framework Key
NDA Instrumentation			
Fast Interrogator	LANL	U Scrap/Waste and Spent Fuel	D-5,D-6
K-edge Densitometer	LANL	Pu Product Solutions	D-5,D-6
L-edge Densitometer	LANL	U and Pu/U Solutions	D-5,D-6
Active Well Coincidence Counter	LANL	N-Reactor Scrap, Al/U Material	D-5,D-6
Gamma-Ray Spectrometer	LANL	Pu Oxide Product, Scrap, Metal	D-5,D-6
Neutron Interrogator	LANL	Spent Fuel Bundles (Pu/U)	D-5,D-6
Dual Range Coincidence Counter	LANL	Pure Metal, Pu Oxide	D-5,D-6
Macro and Micro Calorimeter	Mound	Pu Inventory Verification	D-5,D-6
X-Ray Fluorescence Spectroscopy (Wave Length Disp.)	Mound	Pu/U Solution Assay	D-5,D-6
Combined X-Spec. and Calorimetry	Mound	Portable Pu Assay	D-5,D-6
γ-Ray Spec. Application and Software	Mound	Hetero. Pu Isotopics	D-5,D-6
X-Ray Fluorescence Anal. (Energy Disp.)	LLNL	Pu/U Solution Assay	D-5,D-6
γ-Ray Spec.	LLNL	Misc. Pu Assay	D-5,D-6
Laser-Based Fluorimetry	LLNL	Pu/U, Inaccessible Places	D-5,D-6
Automated Instruments			
Electro Analyzer	LANL	Low Level Pu Solutions	D-5,D-6
Spectrophotometer	LANL	Pu, U, Pu/U Solutions	D-5,D-6
Complexometry	LANL	U in Rare Earth Solutions	D-5,D-6
Laser Molecular Excitation	LANL	Low Level U Solutions	D-5,D-6
Other Instrumentation			
Optical Spectroscopy (ICP-AES)	Ames/ORNL	Pu/U Isotopes in Solution	D-5,D-6
Resin Bead Technology	Ames/ORNL	Sub-Micro Quantity of Pu/U	D-5,D-6

Task Area and Description	Laboratory	Application	Framework Key
Standards			
Holdup	LANL	UF_6, PuO_2	D-8
Ref. and Working	LANL	Pu Product, Pu/U Scrap and Waste	D-8
Writing Group Stds. and Calibrations	LANL	Pu/U	D-8
Calorimetry	Mound	Pu^{238} Heat Source for Pu Assay	D-8
Gamma-Ray Spect. Ref. Guides	Mound/LLNL	Routine γ-Ray assays	D-8
Resin Bead	Ames/ORNL	Mass Spect. Calib., Pu/U Isotopes	D-8
Nuc. Materials	NBL	All	D-8
Certified Reference	NBL	All	D-8
Measurement Technology	NBL	All	D-6
Measurement Services	NBL	All	D-6

III. ACDA Initiatives[(A-5)]

Since 1968, the Arms Control and Disarmament Agency has sponsored an external research program to bolster international safeguards and still plays an active role in this regard. There are four main areas into which individual projects fall. These are:

(a) Fuel Cycles and Facilities - which is concerned with the development of safeguards approaches
(b) System Development - which is concerned with developing requirements and criteria for record keeping, reporting, inspections, etc.
(c) Instruments and Methods - which is concerned with specific equipment for potential use by the IAEA
(d) Remote Verification - i.e., the RECOVER project.

Table A-4 lists those projects which are currently underway or have been within the last 6 years. (Presumably the output of older projects has either led to implementation or been discarded. It is recognized that some older projects in the table may fall into this category as well.) In some cases, there is some redundancy with projects listed in other tables in this appendix; a prime example is the study of RECOVER supported by ACDA through DOE.

For referral purposes identifying numbers have been assigned to the projects (for this work only) such that the initial letter corresponds to the main areas as listed above. Initial fiscal year is included in the table as well. The actual project titles have sometimes been somewhat altered for compactness.

Table A-4

Current or Recent ACDA - Sponsored Research Programs

Reference No.	Abbreviated Title	Fiscal Year	Framework Key
A-1	Development of Isotope Safeguards Techniques for Reprocessing Plants	76	D-2
A-2	MIST* III for Enrichment Plants	76	D-2
A-3	Application and Evaluation of MIST* for Inspection of Enrichment Plants	77	D-2
A-4	Heavy Water Accountability	77	D-2
A-5	Design of D_2O Production Plant to Facilitate Safeguards	78	B-4
A-6	Application of International Safeguards at Portsmouth GCEP	78	D-2
A-7	Application of International Safeguards at Portsmouth GCEP	78	D-2
A-8	Impact of Proliferation Resistant Fuel Forms on International Safeguards	78	E-1
A-9	International Safeguards for Alternative Fuel Cycles	78	E-1
A-10	University Program for International Safeguards	79	--
A-11	Implementation of Safeguards at D_2O Plants	80,81	E-3
A-12	Analysis of Research Reactor Proliferation Potential	81	B-1,B-4
A-13	Analysis of IAEA Safeguards Implementation at Reprocessing Plants	81,82	B-2,B-3
A-14	Graphite Export Study	82	E-3
A-15	Safeguards Approach for Aerodynamic Uranium Enrichment	82	B-2,B-3
B-1	Technical Studies Supporting International Safeguards	76	--
B-2	International Safeguards System Development	78	--
B-3	Technical Support for Verification of Core Load at TRR	78	D-2
B-4	IAEA Safeguards Evaluation Procedures	79	B-2,B-3
B-5	Evaluation of US-Supplied IAEA Safeguards Equipment	79	D-6
B-6	IAEA Safeguards Diversion Detection and SSAC Analysis	79	C-4
B-7	Assistance to IAEA for Development of Safeguards System	80	D-2
B-8	IAEA Safeguards Evaluation Procedures (II)	80	B-2,B-3
B-9	IAEA Decision Structure	80,81	D-2,D-3
B-10	Assistance to IAEA Safeguards System Development	81,82	All of B

* MIST = Minor Isotopes Safeguards Techniques

** AIS = Advanced Isotope Separation

Reference No.	Abbreviated Title	Fiscal Year	Framework Key
C-1	Feasibility of Passive Assay for Spent HTGR Fuel	76	D-6
C-2	Fiber Optics Seal Development	76	D-5
C-3	IAEA Safeguards-Surveillance Instrumentation	76	D-5
C-4	Linear Assay Seal System	77	D-5
C-5	Transmission and Analysis of TV Imagery	77-78	D-6
C-6	Electronic Seal Verification Methods Development	78	D-5
C-7	Advanced Elect. Verifiable Seal Development	78	D-5
C-8	Level-Sensing Seal Modification	79	D-5
C-9	Electronic Verification for Existing Surveillance Devices	79	D-5,D-6
C-10	Instant Film, Remote-Diagnostic Surveillance System	79	D-5
C-11	Polavision Surveillance System Application	80	D-6
D-1	Feasibility and Design for Adaptation of PATTER	76	A-1
D-2	RECOVER Feasibility	76-77	A-1
D-3	RECOVER Exhibit Display	77	A-1
D-4	Test and Demo. - RECOVER, C/S Devices	78	A-1
D-5	Initial Implementation and Demo - RECOVER	78	A-1
D-6	International Test of RECOVER	79	A-1
D-7	IAEA Coordination for RECOVER	79	A-1
D-8	Support for IAEA/ACDA Research Agreement	79,80,81	A-1
D-9	International Demo. and Evaluation of RECOVER, etc.	80	A-1
D-10	Worldwide RECOVER	81	A-1
D-11	Develop and Test TRANSEAVER	81	A-1
D-12	RECOVER as IAEA Data Communications Network	82	A-1
D-13	RECOVER Advanced TV Interface	82	A-1
D-14	International Test of TRANSEAVER	82	A-1

IV. NRC Initiatives(A-6)

While NRC is primarily involved with safeguards issues from a domestic regulatory point-of-view, and its research and technical assistance interests are mainly to develop information to help resolve regulatory interest, the expertise available within the Commission is sometimes extended to issues of international safeguards.

Domestically, NRC safeguards is mostly involved with physical security problems. Some of this experience is useful to international safeguards through NRC participation in the Physical Security Review Program (Appendix A-II). The NRC is directly involved with export licensing and therefore exercizes some additional responsibility in reviewing the quality of the importing State's safeguards system (Framework E-4,E-5).

The Commission is also an active participant in the Action Plan Working Group (APWG) and the Technical Support Coordinating Committee (TSCC). See page App-1. The latter manages the POTAS program (Appendix A-I) while the former is involved in coordinating all U.S. efforts to strengthen IAEA safeguards. An important area in which NRC contributes to the APWG is the improvement of SSAC programs. For example, assistance has been provided to South Korea in this regard as well as to a number of other countries through visits to NRC by their representatives. Some direct assistance to the IAEA is planned to help with the preparation of detailed SSAC guidelines (Framework C-2).

The Office of Nuclear Material Safety and Safeguards (NMSS) directly funds a series of studies to facilitate application of IAEA safeguards at various types of facilities. These include studies of reprocessing, light-water reactors, mixed-oxide fabrication, and low-enriched uranium fabrication. The studies were initiated in FY80, FY81, and FY82, respectively (Framework B-4).

Although recently curtailed by limitations on travel, NMSS staff has also assisted the IAEA with the provision of experts on the evaluation of safeguards inspection information, development of quality assurance programs, and for other consultation. NMSS has also participated in international safeguards training programs sponsored by DOE and IAEA (e.g., see page 27) (D-1). Table A-5 lists most of the NRC activities in support of IAEA safeguards.

Table A-5

NRC Initiatives

In Support of APWG	Framework Area	Effort* FY 80	FY 81	FY 82**
Participation and Planning	(Many)	0.2	0.2	0.2
Safeguards Design Features	(B-4)	0.2	0.2	0.3
SSAC Improvements	(C-3)	—	—	0.6
Input to POTAS				
Participation in TSCC	(Many)	?	?	0.5
Direct Assistance to IAEA		nil	nil	0.5
Safeguards Evaluation	(B-2)			
Consultant's and Advisory Group on Safeguards Practices	(Many)			
International Safeguards Training Programs	(D-1,D-6)	?	?	0.3
International Safeguards Guidelines				
INMM-14 Standards Committee (International Safeguards Standards)	(Many)	?	?	0.2

* man-years.

** estimated.

Appendix B

Euratom Support for International Safeguards[B-1]

The Commission of European Communities (CEC) has established and implemented a safeguards system in the EC countries* as required by treaty. This independent system also contributes to safeguards as defined by the NPT. Since 1969, it has carried out an R and D program in safeguards at a number of "Joint Research Centres" (JRCs). These are located at Ispra (Italy), Karlsruhe (FRG), and Geel (Belgium).

A formal cooperative support program, between the IAEA and Euratom has recently been signed which proposes to exchange technical expertise in R and D and its implementation by inspectors of European nuclear facilities. The following table (Table B-1) lists the tasks currently in the Euratom program.[B-2] These are identified by prefixes related to three main areas (in addition to an ongoing inspector-training program) as follows:

C/S - Containment and Surveillance

MT - Measurement Technology

NMA - Information, Data Treatment, and Evaluation

The training task provides training for IAEA inspectors in NDA Methodologies and Ultrasonic techniques and relates to items D-1 and D-6 of the "Framework".

* The "Communities" consists of nine countries; Belgium, Denmark, FRG, France, Ireland, Italy, Luxembourg, the Netherlands, and the UK, some of which maintain an independent formal support program for the IAEA.

Table B-2

Current Euratom Tasks

Task No.	Title	Framework Key
C/S-1*	Implementation of CANDU Seals	D-5, D-6
C/S-2*	Provide General Purpose Seals and Field Test	D-5, D-6
C/S-3*	Provide Ultrasonic Identification Equipment	D-5
C/S-4	Application of Ultrasonic Signature System	D-6
C/S-5	Fast Reactor Fuel Identification	D-6
C/S-6	MTR Rivet Seal Identification	D-6
C/S-7*	Multilock TV Systems	D-5, D-6
C/S-8	Shrink Tube Seals for UF_6 Cylinders	D-6
—	Training (see text)	D-1, D-6
MT-1	Criteria and Procedures for NDA Measurement Data Transfer	D-6, A-1
MT-2	Pu Isotopic Ratios by NDA	D-6
MT-3*	Sb-Be Interrogation Devices	D-5, D-6
MT-4	NDA Calibration Lab	D-8
MT-5*	UF_6 Sampling Instrument	D-5, D-6
MT-6*	Transportable Mass Spectrometer	D-5, D-6
MT-7	Review Measurement Techniques for Input Accountancy Tanks (Reprocessing Plant)	D-7
MT-8	Spiking Technique for Input Accountancy Tank Calibration	D-7
MT-9	Data Bank for Isotope Correlation Techniques	D-7
MT-10	Spike Reference Materials for IAEA-SAL	D-8
MT-11	Characterization of Ref. Materials	D-8
MT-12	Interlaboratory Test Sample Preparation	D-8
MT-13a	Interlaboratory Measurement Evaluacion Program (Uranium in UO_2 Pellets)	D-8
MT-13b	Interlaboratory Measurement Evaluation Program (UF_6 Isotopics)	D-8
MT-14	Automatic Data Evaluation (Reprocessing Safeguards Analysis)	D-6, A-5
MT-15	NDA Standards Implementation (in Facilities)	D-8
NMA-1	NUMSAS** Package Implementation	A-1, A-2
NMA-2	ISADAM*** System Implementation and Evaluation	A-1, A-2
NMA-3	Near Real Time Accountancy	D-7
NMA-4	Code for Sample Size Calculation	D-7
NMA-5	Field Data Processing with Portable Microcomputer	D-7

* Instrumentation provided to IAEA for test and evaluation and/or use.
** Nuclear Material Statistical Accountancy System
*** International Safeguards Data Management

Appendix C

The Canadian Support Program(C-1)

Canada currently maintains a support program which is, at present, officially described as in support of safeguards at Canadian-designed reactors. It is expected that the present program will be essentially completed by 1984 and, at that time, the thrust of the program (and presumably its size) is likely to change. After 1984, the support program is likely to be more general in its coverage, however, specific reactors may be covered as the situation warrants.

In the current situation, R and D related to the 600 mWe units is nearly complete and attention is shifting to the large, multi-unit, power stations. The following table (Table C-1) includes current tasks and previously completed tasks but not those that were cancelled prior to completion. The list was actually current for a year ago (August 1981)(C-2) and may therefore be out-of-date in some respects. Task numbering includes a two- or three-letter prefix, which except for a group of miscellaneous items, have the following meaning:

- CFE - Manpower Assistance (Cost Free Experts)
- ESS - Manpower Assistance (Engineering and Scientific Support)
- S - Systems Studies
- B - Equipment (Bundle Counters)
- C - Equipment (Seals)
- V - Equipment (Fuel Verifiers)
- SC - Equipment (Surveillance Cameras)
- FF - Equipment (Fresh Fuel Measurement Devices)

Table C-1

Canadian Support Program for IAEA Safeguards

Task No.	Title	Current Active	Completed	Framework Key
CFE-1	Safeguards System Analyst	X		B-1,B-2,B-3
CFE-2	CANDU Safeguards Expert	X		D-6,D-5
CFE-3	CANDU Reactor Design Expert	X		B-1,B-4,D-2, D-6
ESS-1	Seminars on CANDU Reactor	X		D-1
ESS-2	Safeguards Equipment Training	X		D-6,D-1
ESS-3	Technical Meeting Attendance by IAEA	X		D-2
S-1	Safeguards Scheme for 125MW CANDU	X		D-2,C-1,B-4
S-2	Safeguards Scheme for NAX-type Reactor	X		D-2,C-1,B-4
S-3	Safeguards Scheme for 200 MW CANDU	X		D-2,C-1,B-4
S-4	Safeguards Scheme for Bruce-A Station	X		D-2,C-1,B-4
S-5	Safeguards Scheme for Pickering-A Station	X		D-2,C-1,B-4
B-1*	600 MW CANDU Bundle Counter Development	X		D-5,D-6
B-2*	Provide Bundle Counters for 4 - 600 MW CANDU Stations	X		D-5,D-6
B-3*	Provide Fuel Flow Monitors for Bruce-A Station	X		D-5,D-6
B-4*	Provide Fuel Flow Monitors for Pickering-A Station	X		D-5,D-6
C-1*	Develop Sealing System for 600 MW CANDU Spent Fuel Storage Bay	X		D-6
C-2	Provide Sealing System for 4 - 600 MW Station Storage Bay	X		D-5
C-3*	Provide Sealing Systems for Spent Fuel Storage of Existing Canadian-supplied reactors	X		D-5
C-4*	Provide Sealing System for Bruce-A Spent Fuel Storage	X		D-5,D-6
C-5*	Provide Covers and Seals for Pickering-A Spent Fuel Storage	X		D-5,D-6
V-1	Develop Spent Fuel Verifier for 600 MW CANDU	X		D-6

* Instrumentation provided to IAEA for test and evaluation and/or use.

Task No.	Title	Current Active	Completed	Framework Key
V-2*	Provide Spent Fuel Verifiers for 4 - 600 MW CANDU Stations	X		D-5,D-6
V-3	Provide Spent Fuel Verifiers for existing Canadian-Supplied Reactors	X		D-5
V-5*	Provide Spent Fuel Verifiers for Pickering-A Station		X	D-5,D-6
V-6*	Develop Optical Empty Position Detector for Bruce-A Primary Storage Bay	X		D-6,D-5
V-7	Evaluate Cerenkov Attribute Test Device for CANDU Fuel	X		D-6
V-8	Evaluate and Develop Cereknov Device for Bruce-A Storage Bay	X		D-6
SC-1	Develop Surveillance Cameras for 600 MW CANDU	X		D-6
SC-2*	Provide Surveillance Cameras for 4 - 600 MW CANDU Stations	X		D-5
FF-1	Develop and Demonstrate Fresh Fuel Interrogation Device for CANDU Reactor		X	D-6
FF-2*	Demonstrate Prototype Fresh Fuel Interrogation in CANDU Reactor	X		D-5,D-6
FF-3	Develop Fresh Fuel Counter for Bruce-type CANDU	X		D-6
HW-1	Safeguards Control of Heavy Water	X		B-1
PS-1	Provide Physical Sandards	X		D-8
TS-1	Technical Support	X		D-6
OR-1	Use of Operating Records for Verification	X		D-2
FM-1	Study Measures to Determine Fissile Control of Spent Fuel		X	D-2,D-6
SS-1	Unique CANDU Bundle Identification Study		X	D-2

* Instrumentation provided to IAEA for test and evaluation and/or use.

Appendix D

FRG Support Program for IAEA Safeguards[D-1]

The Federal Republic of Germany, in addition to active participation in Euratom (see Appendix B) maintains an independent R and D program. Contributions are made by the Research Centers at Karlsruhe and Jülich, by utilities and other companies involved in the nuclear fuel cycle, and by some specialized firms. There are four major areas - System Design, Data Collection and Evaluation, Measurement Methods and Technology, and Containment and Surveillance Methods. Task numbers begin with the letters A, B, C, or D which refer to the four areas, respectively.

Table D-1 includes information[D-2] for all current or completed (at least partially) tasks but excludes tasks deleted prior to any accomplishment.

Table D-1

FRG Support Program

Task No.	Title	Current Active	Completed	Framework Key
A.1	Nuclear Fuel Cycle Center	X		B-2,B-3
A.2	Advanced Reactors: Sodium-Cooled Fast Breeder Prototype	X		B-2,B-3
A.3	Advanced Reactors: Thorium High Temperature Reactor Prototype	X		B-2,B-3,B-4, D-2,D-6
A.4	Nuclear Research Centers	X		A-1,D-6
A.6	Safeguards Implementation Model for State's Typical Fuel Cycles Including External Links	X		D-2,B-2,B-3, B-1
B.1	Verification Models		X	B-3
B.2	Procedures for Monitoring the Quality of Analytical Data	X		D-8
B.3*	Improved Computerized Safeguards Information System (ISIS), Agency Headquarters Vienna	X		A-1,A-2
B.4	Information System for Nuclear Facilities	X		D-2,A-1
B.5	Senior Expert in Evaluation of Safeguards	X		B-1,B-2,B-3
B.6	Setting up a Material Bookkeeping for Dry Stored Fuel Elements	X		C-3,C-4
C.1	Neutron Well Counter for Pu Waste Measurement		X	D-2
C.2	Uranium and Plutonium Concentration Measurements in Solutions	X		D-5,D-6
C.3.1	Plutonium Isotopic Determination by NDA	X		D-6
C.5*	Automated X-Ray Spectrometer System	X		D-5,D-6
C.6	Automated Mass Spectrometric Laboratory		X	D-6
C.7	Service Analysis and Training of IAEA Staff in Anaytical Chemistry of Nuclear Fuels	X		D-6
C.9	Expert on Isotopic Correlation Techniques (ICT)	X		D-2
C.10	Mass Determination of UF_6 in Cylinders	X		D-2

* Instrumentation provided to IAEA for test and evaluation and/or use.

Task No.	Title	Current Active	Completed	Framework Key
C.12.1	Trace Technique to Validate Calibration of Accountability Vessels of a Fuel Reprocessing Facility at WAK Site	X		D-2
C.12.2	Trace Technique to Validate Calibration of Accountability Vessels of a MOX Fuel Fabrication Plant at ALKEM Site	X		D-2
C.13	Improved Analytical Methods for Accurate Analysis of U/Th Fuel Product and Waste Streams	X		D-2
C.14	Field Testing of NDA Equipment	X		D-6
C.14.1	Intercomparison of NDA and DA for Plutonium Assay on LWR Spent Fuel	X		D-6
C.14.2	Calorimetry of Small Samples, i.e. Powder, Pellets and Pins	X		D-6
C.14.3	Auto-radiographic Techniques for Inspecting Unirradiated LWR Fuel Assemblies	X		D-6
C.14.4	Active and Passive Assay of Highly Enriched U in Unirradiated Fuel Assemblies or Containers (Random Driven Neutron Coincidence Counter)	X		D-6
C.14.5	Mass Determination of UF_6 in Cylinders	X		D-6
C.14.6	Test of the New Portable Microprocessor Developed by Lawrence Livermore ("The Blue Box")	X		D-6
C.15	Resin Bead Technology	X		D-6
C.16	Determination of Trace Uranium in Safeguards Samples by Pulsed Laser Fluorometry	X		D-6
D.1*	Containment/Surveillance Systems	X		D-5,D-6
D.2*	Sealing Systems	X		D-5,D-6
D.3*	Assurance of Identification and Integrity of LWR Fuel Assemblies (Development of LWR Fuel Assemblies Seals)	X		D-5,D-6
D.5*	Development of Optical Surveillance Systems	X		D-5,D-6
D.6	Sealing Techiques for Research Reactor Fuel Elements	X		D-6
D.7*	Demonstration and Testing of the Recover-System	X		A-1
D.8	Developing an Improved Adhesive Surface Seal	X		D-6

*Instrumentation provided to IAEA for test and evaluation and/or use.

Appendix E

The UK Safeguards R and D Support Program[E-1]

The UK formal program was offered to the IAEA in July 1980. Prior to that time, and since 1968 (NPT signing) the UK contributed support in similar ways but informally. In addition the UK participates in the Euratom program (see Appendix B). The work is carried out at a number of laboratories of the UKAEA including those at Harwell, Winfrith, Risley, Springfield, and Dounreay. In addition, the government owned British Nuclear Fuels Limited also contributes to this program.

The program shown in the table (Table E-1) is believed to be up-to-date.[E-2] However, no information was readily available on status and completion dates. It is known that the two concluding items represent one-time contributions and have been completed. The numbered tasks contain an initial letter which indicates the general area of the task as follows:

- S - Service Programs
- G - Generic Programs
- P - Plant Studies
- E - Enrichment Plant Safeguards
- F - Field Trials
- X - Exploratory (Short) Projects

Sometimes, however, the distinctions between areas are blurred.

Table E-1

UK Support Program Tasks

Task No.	Title	Framework Key
S.1	Calibration of reference and other samples as service to IAEA	D-7
S.2	Training of IAEA Inspectors	D-1
S.3	Individual Training Visits	D-1,D-6
S.4	Production of instruction manuals	D-6
S.5	Support for Isotope Mass Spectrometer	D-5,D-6
S.6	Cost-free Expert for Safeguard Evaluation	B-1,B-2,B-3
G.1	Tamper proofing	D-2
G.2	Neutron interrogation	D-6
G.3	Ultrasonic and mechanical inspection of welded and rolled closures on SNM containers	D-6
G.4	Review of Specification Requirements for Safeguards instrumentation	D-2,D-6
G.5	Modelling of the application of Near Real Time Accountancy and Process Monitoring to plants	D-2,B-2
G.6	Application to advanced statistical techniques to plants	A-1,A-2
G.7	The Standardization of Nuclear Reference materials and Measurement Procedures for Safeguards purposes	D-8
P.1	Assessment of hold up in Boxes	D-2,D-6
P.2	Uncertainty in Waste Measurement	D-7
P.3	Correlation of NDA methods for Hulls and insoluble material from Head End of AFBR Reprocessing Plant	D-6
P.4	Examination of factors affecting the use of weigh tanks in reprocessing plants	D-6
P.5	Application of acoustic techniques to determine the volume of dissolving tanks and similar vessels	D-6
P.6	Identification and verification of fast reactor sub-assemblies under sodium	D-6
P.7	Design and evaluation of seals and other C/S devices	D-6
E.1	Design study of Package monitor for Centrifuge Enrichment Plant	D-2
E.2	Design study of interrogation system for U^{235} content of Sodium Fluoride Traps	D-2
E.3	Monitoring of U enrichment in Plant Pipework	D-6
F.1	Field trial of use of computer file interrogation packages for Audit and Safeguards purposes	D-2
F.2	Field trials of rapid physical inventory taking systems	D-2,D-7
F.3	Operational trials of platform monitors	D-6

Task No.	Title	Framework Key
X.1	Charge Amplifier	D-6
X.3	Study of use of commerical electronic theft monitors for safeguards	D-2
(no number)*	Provision of a Mass Spectrometer to the IAEA at Seibersdorf	D-5
(no number)	Safeguards Demonstration Program at Capenhurst (Centrifuge Enrichment Plant)	D-1,D-6

* Instrumentation provided to IAEA for test and evaluation and/or use.

Appendix F

Japan's IAEA Support Program (JASPAS)(F-1)

Although Japan has been cooperating with others in helping develop IAEA safeguards, only recently (1981) has there been established the formal support program, Japan Support Program for Agency Safeguards (JASPAS). Prior to that there were numerous bi- and multi-lateral projects, for example, the TASTEX exercise (see Appendix A).

Because the JASPAS is relatively new, detailed information is sketchy for some projects and the "Framework Key" assignments in the following table (Table F-1) may be inaccurate. The tasks are designated by an alphanumeric system in which the <u>second</u> letter designates the applicable area as follows:

A - System Designs and Approaches
B - Safeguards Data Collection, Treatment and Evaluation
C - Measurement Methods and Techniques
D - Containment and Surveillance

Table F-1

JASPAS Tasks

Task No.	Title	Active	Completed	Framework Key
JA.1	Support for RECOVER-TRANSEAVER Field Tests	X		A-1
JA.2	Demonstration of Safeguards Technology at Ningyo Uranium Enrichment Pilot Plant	X		D-2
JA.3	Plutonium Product Area Monitoring System	X		D-6
JB.1	Evaluation and Development of Software for Data Collection and Treatment	X		D-7,A-1
JC.1	Electromanometer for Volume in Accountability Vessels		X	D-6
JC.2	K-edge Densitometer for Pu Product Concentration		X	D-6
JC.3*	High Resolution γ Spectrometer for Pu Isotopics	X		D-5,D-6
JC.4	Resin Bead Sampling	X		D-6
JC.5	Isotopic Correlation Techniques	X		D-6
JC.6*	Elmo- 8 mm Surveillance Camera	X		D-5,D-6
JD.1*	Electronic Seal and Remote Verification System	X		D-5,D-6
JD.2*	Surveillance in Spent Fuel Receiving Area		X	D-5,D-6
JD.3	C/S Measures with Portal Monitor Field Tests	X		D-6
JD.4	Auto-Identification Fiber Optic Seal	X		D-2
JD.5	Thermoplastic Film Seals	X		D-5,D-6

* Instrumentation provided to IAEA for test and evaluation and/or use.

Appendix G

Australian Support Program for IAEA[G-1]

Australia supports a small, formal support program and has done so since 1980. Prior to that Australia provided some "ad hoc" assistance mostly in the form of providing a cost-free expert for information processing and other professional personnel. The following table (Table G-1) lists the current program tasks. In addition, Australia participates in the RECOVER and TRANSEAVER projects and in the Hexapartite Project on centrifuge enrichment plant safeguards (See Appendix A). Australia also has contributed, financially, to the International Plutonium Storage Study.

Table G-1

Recent and Current Australian Support Programs

Task Title	Framework Key
Systems Analysis for Enrichment Plant Safeguards	B-1,B-2,B-3
Ruggedized Portable Multi-Channel Analyzer*	D-6
NDA Equipment for Enriched Uranium Assay-Gas Phase Monitor	D-5,D-6

* Work on this project has halted in view of U.S. Developments. However, computer codes and cost-free expert were provided to IAEA.

Appendix H

States Recently Proposing Formal Support Programs

In addition to the support programs described in Appendices A through G, a number of States have either recently announced the initiation of formal support programs or are known to have begun discussions which are likely to lead to such programs. These States have already been actively engaged in Safeguards R and D in cooperation with the IAEA or other States. Parenthetical alphanumeric notations refer to the framework.

1. USSR

It has recently been announced that the USSR has agreed to formalize its support program[H-1] which, in the past, has been of relatively major importance. The support program will consist of[H-2]:

a)	Training courses on SSACs	(C-2)
b)	Training courses for Inspectors	(D-1)
c)	Systems Studies for fast critical assemblies and fast breeder reactor	(B-1,B-2,B-3)

No details were available.

2. France

It has recently been announced that France will enter into a formalized support agreement shortly.[H-1] No details of the program have been forthcoming. In the past, France has actively participated in several safeguards efforts[H-2] including the TASTEX exersize (see Appendix A) and in Euratom (see Appendix B).

3. Belgium

It is reported that Belgium is considering a formal support program[H-2]. Meanwhile Belgium has been very active in Euratom (see Appendix B), being the host of a major JRC at Geel. Numerous field studies and demonstrations of U.S. developed instrumentation have been held at nuclear fuel cycle facilities of all kinds in Belgium (D-6). These include neutron coincidence enrichment instruments (incl. the prototype neutron coincidence collar (D-5)) and the calorimeters developed, by Argonne National Laboratory, for plutonium measurements in fuel rods (D-6).

Proposed task areas[H-3] for the formal support program may include:

(a)	System study for MOX Fabrication Plant	(B-1,B-2,B-3)
(b)	Study of the use of the neutron collar in UO_2 fuel fabrication plant	(D-6)
(c)	Electronic Seals	(D-6)
(d)	Reprocessing Plant Safeguards Studies using HERMES* facility	(--)
(e)	Laboratory Standards	(D-8)

* Head-End Research Mock-up Engineering Scale

Appendix I

Other States Contributions to IAEA Safeguards[I-1]

In addition to those states mentioned in Appendices A through H, which have, or intend to have formal support programs, a number of other states have contributed in small, but significant ways to international safeguards R and D. Such states, as listed in the following table (Table I-1) have provided facilities for the demonstration and/or field testing of equipment developed by others, have provided some expertise for various procedural or systems development efforts, have helped materially with the development of seals or other C/S devices, or have participated in large scale international projects or demonstrations such as Euratom, RECOVER, etc. No attempt has been made here to key these efforts to the Framework because they are relatively minor and not very specific.

Table I-1

Other Contributions to Safeguards R and D

	Seals and Other C/S Devices	TRAN-SEAVER/ RECOVER	Field Tests and Equip. Demos.	Proc. & Systems Related Efforts	Training Exercises and/or Facilities	Participant in:	
						Hexa-partite	Eura-tom
Argentina	X		X				
Austria		X	X				
Bulgaria		X	X				
Czechoslovakia				X			
Denmark							X
German Democ. Republic					X		
Hungary				X			
Ireland							X
Italy	X		X				X
Luxembourg							X
Netherlands						X	X
Romania			X	X			
South Africa	X						
Spain				X			
Sweden			X				

Appendix J

IAEA Initiatives

The IAEA itself conducts very little R and D, relying heavily on the support programs and other assistance from the States organizations like Euratom (See Appendices A through I). However, there are numerous means by which the IAEA assists the States in their efforts to help the IAEA and certain other efforts within the Agency that fill in and smooth out the benefits accruing from the other programs. In this regard, the following may be considered as current IAEA initiatives which help strengthen the IAEA safeguards system:

• Initiation of requests for R and D for particular purposes.

• Input to conduct of R and D programs, especially in the implementation stage (e.g., TASTEX, see p. 38).

• Systems Studies providing guidance as to needs of inspectorate and goals and objectives of safeguard systems (e.g., publication of STRs for different types of facilities, pp. 17, 18, 22, 23).

• Promotion and liaison for safeguards training courses provided by States (e.g., p. 27).

• Mediation and expediting of international efforts like RECOVER and TRANSEAVER. (See Appendices A through I.)

• Arrangements for demonstration of safeguards equipment developed in one State at facilities of another (e.g., POTAS Task No. A.98 and FRG Program Task C.10).

• Research on analytical procedures and work on reference standards at the Safeguards Analytical Laboratory (SAL) at Seibersdorf.

• Publication of directives (INFCIRCS) and guidelines (e.g., SG/INF series, see p. 31).

• Development and implementation of improved information handling systems (ISIS, TFIR, etc. pp. 6, 7, 12).

• Development of safeguards evaluation methods (p. 23, 24).

• Development of data base in support of SIRs.

• Promulgation of methods for material measurement data collection and analysis.

• Organization of consultants meetings to further specialized technical effort (e.g., Design features consultants (p. 25), safeguards effectiveness (p. 23), IWG-RPS (p. 21), advisory groups that led to STRs on safeguards approaches (pp. 17, 18, 22, 23)).

• Sponsorship of and participation in technical meetings.

Appendix K

NRC Framework for IAEA Safeguards

This appendix consists of the framework for IAEA Safeguards provided by the NRC (K-1) and a discussion of the differences between it and an alternate used in this paper (appearing as Table 1 in Section II).

The differences include:

Under I.D., (new A4), the "public" is more explicitly defined as the international community. Public relations, in its usual sense, has been moved to the last main heading, complementary issues. Under I.E., (New A5), the entry is restated in the form of the problem which the IAEA must resolve.

In section II, (corresponding to new B), exception has been taken regarding standardization of approaches, procedures, etc. Because of the variations existing among facilities even of the same type, such standardization may be impossible if not undesirable. What is needed are standardized evaluation methods. The new framework reflects this. In addition, F and G are really resources and are already included under Section IV because the provision of resources is meaningless unless they are properly functional. D has been reworded (new B4), and E and H are included in the new B3.

In section III, (new C), A and B are combined into C1. The new C3 is expanded to include minimization of interference with States and facility operators as a means of enhancing cooperation. G and H are political issues and are included elsewhere. G is considered under C4 and is encouraged by actions under C3. In the case of H (sanctions), IAEA does not have such power (except in a very limited sense). The issue is covered for discussion purposes under the new heading E8. F is included in the new C4.

Under section IV, (new D), A and B are combined into D1 for purposes of discussion because of the close relationship of these issues. C has been reworded to reflect the management-related nature of the problem (new D2). H has been moved to D3. E and F have been combined and restated as D5. IV-G has been expanded and clarified. Two new entries have been added; D7 which is concerned with data reduction techniques and D8 which is concerned with reference standards (moved from old V-G with expanded meaning).

For section V, (new E), the wording of D has been clarified (E4), F reworded (E6), G combined into D8, and 3 new entries added (E7, E8, E9).

Table K-1

NRC Framework for IAEA Safeguards

I. Information Needs

A. Timely and accurate information from States to the IAEA.

B. Effective communications within the IAEA (including an efficient data processing system).

C. Effective feedback from the IAEA to States inspected.

D. Effective reporting by IAEA to the BOG and the public.

E. Confidentiality of safeguards information.

II. Safeguards System Design

A. Achieveable short-term and long-term technical objectives and inspection goals.

B. Standardized IAEA safeguards approaches for all types of facilities, fuel cycles, and States where inspections are carried out (consistent with inspection goals).

C. Standardized inspection activities and verification procedures.

D. Cost-effective design of nuclear facilities to facilitate safeguards.

E. Safeguards evaluation methodology to assess inspection data.

F. Reliable containment and surveillance equipment.

G. Suitable nondestructive assay (NDA) equipment and standards.

H. Effective quality assurance program for safeguards program.

III. State Systems of Accounting and Control (SSACs)

A. Adequate safeguards agreements and interpretations.

B. Adequate subsidiary arrangements and interpretations.

C. International standards and guidelines for national authorities and operators.

D. Well-developed SSACs and cooperative national authorities.

E. State compliance with IAEA standards and guidelines.

F. Adequate access to facilities where inspections are carried out.

Table K-1 (cont'd.)

G. Unrestricted designation of inspectors.

H. Sanctions enforced.

IV. Resources

A. Adequate quality and number of safeguards inspectors.

B. Adequate training for safeguards inspectors.

C. Effective and efficient utilization of inspectors in the field and at Headquarters.

D. Adequate funds to carry out safeguards inspection program.

E. Adequately available NDA equipment.

F. Adequately available equipment for containment and surveillance.

G. Effective and efficient utilization of safeguards equipment.

H. Adequate management of safeguards program (communications, decision-making, personnel matters, organization, planning, human factors).

V. Complementary Issues

A. Adherence to NPT (re: safeguards).

B. Fullscope safeguards in non-NPT States (NNWS).

C. Nuclear Supplier Guidelines (re: safeguards).

D. Physical protection.

E. Institutional arrangements (e.g. IPS, CAS).

F. NPT safeguards vs. non-NPT safeguards.

G. International standards program.

Appendix References

A-1 The material in Appendix A is taken from many sources, some of which are unpublished. Available source material used is referenced below where appropriate.

A-2 Annual Report on the US Program of Technical Assistance to Safeguards of the IAEA (POTAS), Jan.-Dec. 1977, Report No. BNL-50869, March 1978.

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A-4 Report on the U.S. POTAS, Report No. BNL-51440, May 1981.

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A-6 NRC Testimony for the Subcommittee on Energy Research and Production of the House Committee on Science and Technology, August 3, 1982.

B-1 R. Klersy, M. Cuypers, B. Love, "Main Features of the Euratom - IAEA Safeguards R and D Cooperation Programme", Paper presented to 23rd Annual INMM Meeting, Washington, D.C., July 1982, Nuc. Mat. Man. XI, 2, 35-40 (1982).

B-2 Cooperative Support Programme in the Field of R and D in Safeguards between the IAEA and the Commission on behalf of the European Atomic Energy Community, July 1982 (unpublished).

C-1 R.M. Duncan, J.G. Hodgkinson, R.M. Smith, "The Canadian Program in Support of IAEA Safeguards", Paper presented to 23rd Annual INMM Meeting, Washington, D.C., July 1982.

C-2 Canadian Safeguards R&D in Support of the IAEA, Program Document, Report No. AECB-1136/Rev-1, March 1980; Status of Tasks in AECB 1136, August 13, 1981.

D-1 U. Ehrfeld, D. Stünkel, "The Joint Programme on Safeguards R&D Between the FRG and the IAEA", Paper presented to 23rd Annual INMM Meeting, Washington, D.C., July 1982.

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E-1 A.T.G. Ferguson, "The UK Safeguards R&D Support Program", Paper presented to 23rd Annual INMM Meeting, Washington, D.C., July 1982.

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G-1 P. O'Sullivan "Australia's Program of Assistance to IAEA Safeguards", Paper presented to 23rd Annual INMM Meeting, Washington, D.C., July 1982, Nuc. Mat. Man. XI, 2, 41-47 (1982).

H-1 A. von Baeckmann, Opening remarks at a session on IAEA Support Programs, 23rd Annual INMM Meeting, Washington D.C., July 1982.

H-2 "Cooperative Programs of Support", Compiled by ISPO, Jan. 1982 (unpublished).

H-3 Belgian Support Program, unpublished notes, Nov. 1981.

K-1 "Framework for IAEA Safeguards", Attachment to letter from K.R. Geller to D. Schweller with NRR Order No. 60-82-363 (July 1982).

PDR

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