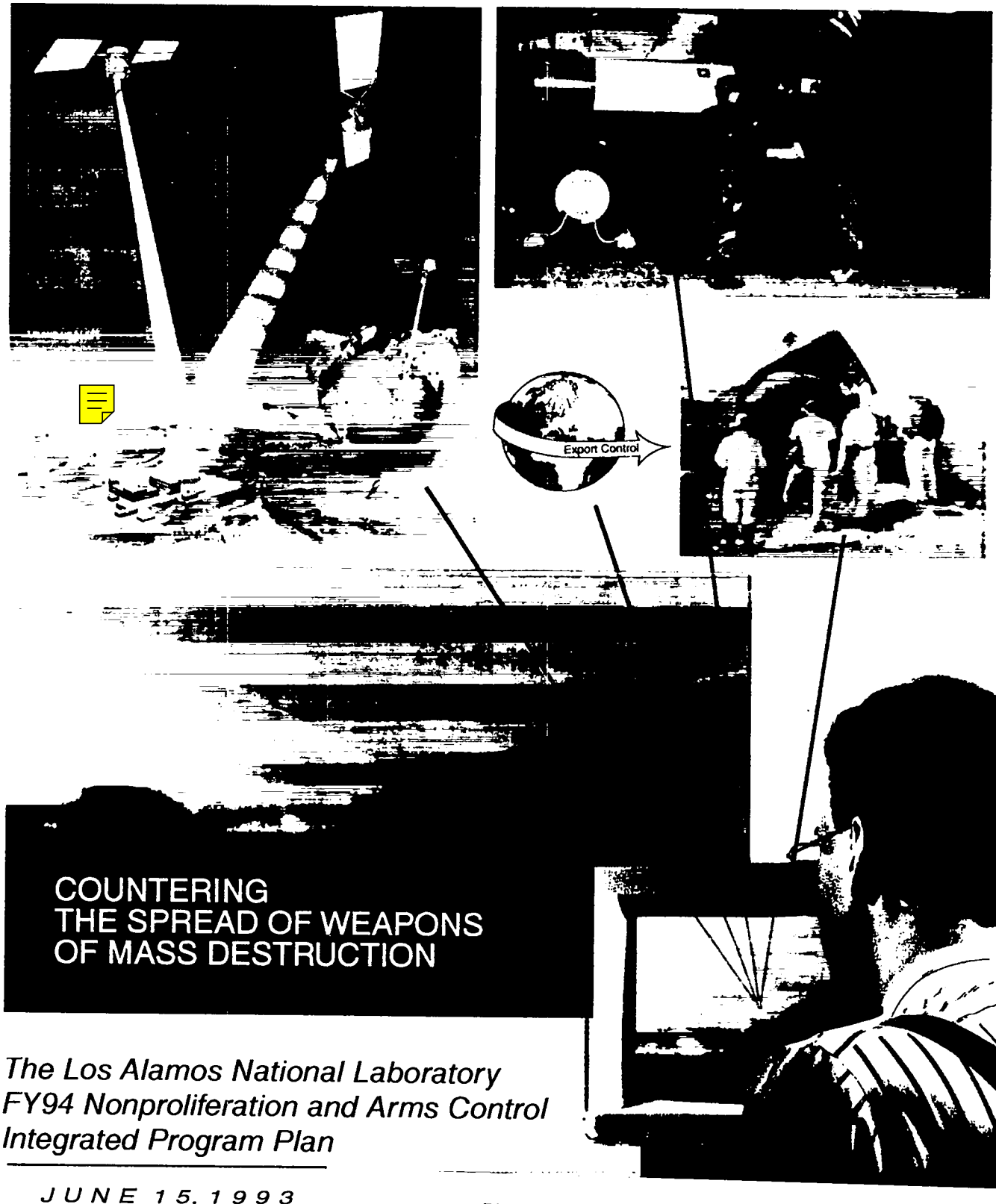

COUNTERING THE SPREAD OF WEAPONS OF MASS DESTRUCTION

The Los Alamos National Laboratory FY94 Nonproliferation and Arms Control Integrated Program Plan

JUNE 15, 1993

Distribution

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Countering the Spread

of

Weapons of Mass Destruction:

The Los Alamos National Laboratory
FY94
Nonproliferation and Arms Control
Integrated Program Plan

June 15, 1993

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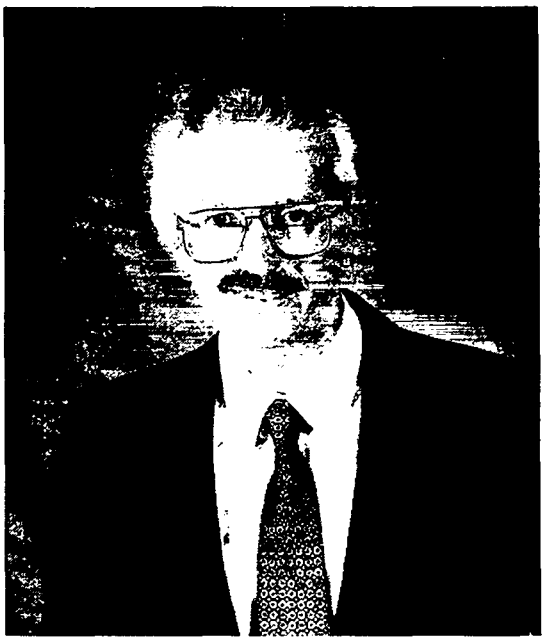
ACRONYMS

AACA	Atmospheric Aerosol Chemistry Analyzer
ADEM	Analytical Digital Electron Microscope
AEC	Atomic Energy Commission
ALEXIS	Array of Low-Energy X-ray Imaging Sensors
AN	Office of Arms Control and Nonproliferation
AN-10.2	Office of Policy and Technical Analysis
AN-30	Office of Export Control and International Safeguards
APDC	Advanced Photon Detection Concepts
CCD	charge-coupled device
CDL	crossed-delay line
CFE	Conventional Forces in Europe agreement
CIS	Computational and Information Sciences Division
CLS	Chemical and Laser Sciences Division
CNSS	Center for National Security Studies
COCOM	Coordinating Committee on arms-related exports
CORRTEX	Continuous Reflectometry Radius versus Time Experiment
CRADA	cooperative research and development agreement
CSU	Colorado State University
CTBT	Comprehensive Test Ban Treaty
CW	chemical weapons
CWC	Chemical Weapons Convention
DNA	Defense Nuclear Agency
DOE	Department of Energy
DoD	Department of Defense
DP	Office of Defense Programs
EDIT	Explosion Detection using Ionospheric Techniques
EE	Energy and Environment Directorate
ELF	extremely low frequency
EMP	electromagnetic pulse
FEWS	Follow-on Early Warning System
FORTE	Fast On-Orbit Recording of Transient Events
FP	fission product
FSU	former Soviet Union
GC/ITS	gas chromatograph/ion-trap spectrometer
GP	ground penetrating
GPS	Global Positioning System
GVLS	Global Verification and Location System
HGMS	high-gradient magnetic separation
IAEA	International Atomic Energy Agency
IDGS	isotope dilution gamma-ray spectrometry
IN	Office of Intelligence
INF	Intermediate Range Nuclear Forces Treaty
IT	International Technology Division
LAG	Laboratory Advisory Group
LA-ICP-MS	Laser Ablation-Inductively Coupled Plasma-Mass Spectrometer
LIBS	laser-induced breakdown spectroscopy

LRAD	Long-Range Alpha Detector
LTBT	Limited Test Ban Treaty
MCA	multichannel analyzer
MC&A	materials control and accounting
MCTL	Militarily Critical Technologies List
MTI	Multispectral Thermal Imager
N	Nuclear Technology and Engineering Division
NAC	Nonproliferation and Arms Control
NACSAC	NAC Program Science Advisory Council
NAVI	Nuclear Arms Verification Instrument
NDE	nondestructive evaluation
NDS	NUDET detection system
NED	Nuclear Explosion Detection
NEST	Nuclear Emergency Search Teams
NPN	Nonproliferation Newsletter
NPT	Nonproliferation Treaty
NRC	Nuclear Regulatory Commission
NSD-70	National Security Directive 70
NTRB	Nuclear Technology Reference Book
NTS	Nevada Test Site
NUDET	nuclear detonation
NWT	Nuclear Weapons Technology Division
OAC	Office of Arms Control
OTH	over-the-horizon
P	Physics Division
PCA	Plasma Composition Analyzer
PINS	Proliferation Information Network System
PDT	Proliferation Detection Technology
PLC	Prelicense Check
PNET	Peaceful Nuclear Explosions Treaty
PSV	Postshipment Verification
PT&A	Policy and Technical Analysis
RDP	reduced displacement potential
ROSTER	Remotely Observed Signatures in the Thermosphere of Explosive Releases
RULLI	remote ultralow light level imaging
SAR	synthetic aperture radar
S&T	Systems and Technology
SFT	Sequential Fragmentation/Transport
SNM	special nuclear material
SOPA	sparse optical phased array
SSAC	state system of accounting and control
SST	Space Science and Technology Division
START	Strategic Arms Reduction Treaty
TRG-15	Technical Review Group on Nuclear Technology
TRU	transuranic
TTBT	Threshold Test Ban Treaty
UGT	underground test
VOC	volatile organic compound
WBS	work breakdown schedule

1.0 MESSAGE FROM THE DIRECTOR



Two years ago, we celebrated the apparent collapse of communism in Eastern Europe. Last year, with the failure of the coup in the Soviet Union and unprecedented arms reduction actions by President Bush and President Yeltsin, it was apparent that the parameters of the Cold War and the global nuclear equation were fundamentally and irreversibly changed. Today, the Soviet Union is no more.

While these changes were occurring, United Nations investigating teams in Iraq uncovered a large and systematic effort to develop a clandestine nuclear weapons program. These findings, together with revelations about other potentially proliferating nations, are reminders that the nuclear weapons genie is not back in the bottle and never will be. The essential physics of nuclear weapons is widely known, and sufficiently determined governments can mount credible and dangerous weapons programs.

President Clinton has indicated that the proliferation of nuclear weapons is one of the gravest national security threats we face today. At Los Alamos we are marshalling our capabilities to help mitigate that threat. The disintegration of the Soviet Union and the continuing unrest in Russia represent the most immediate concerns. On the other hand, the democratization of Russia also offers a great window of opportunity to work with the Russians in countering proliferation around the world, since the threat of other nations or terrorists obtaining such weapons remains one of our gravest long-term threats.

The three Department of Energy defense laboratories possess all of the technical skills—including detection, prevention, mitigation, and response—to provide an integrated approach to countering the spread of weapons of mass destruction. Los Alamos is applying its multidisciplinary skills in traditional areas such as weapons design and engineering, nuclear materials processing, nuclear materials safeguards, materials control and accountability, and nuclear accident response to the nonproliferation programs of the Department of Energy and the intelligence community.

In addition, we are applying our core technical competencies in areas such as high-performance computing, lasers, and sensors to better export control methodologies and to improve monitoring, detection, and remote sensing. We will fully exploit the synergism between the nonproliferation programs and other Laboratory programs such as the nuclear weapons program and environmental programs. An excellent example is adapting the Los Alamos lidar to look for tell-tale signs of proliferation activities. Our lidar was built for possible use in Desert Storm and was subsequently refined for air pollution measurements.

We will continue to develop an integrated approach managed by our newly formed Office of Nonproliferation and Arms Control to counter the proliferation threat faced by our nation.

2.0 THE NONPROLIFERATION AND ARMS CONTROL PROGRAM OFFICE

Maurice Bryson

Bob Jeffries

Ralph Castain

Roy Woodruff

Stephanie Cisneros

Elsie Trujillo

2.1 BASIC ADMINISTRATIVE STRUCTURE

2.1.1 Program Director

A program director at Los Alamos National Laboratory reports to an associate director of a major Laboratory programmatic area. Nonproliferation and Arms Control (NAC) programs are under the overall direction of the Program Director, Roy Woodruff, who in turn reports to John Browne, the Associate Director for Computational and Information Sciences. The program director is responsible for

- Serving as the Laboratory's point of contact with Department of Energy (DOE) headquarters and other government agencies on issues associated with nonproliferation and arms control;
- Representing the Laboratory in the development of U.S. policies relating to nonproliferation and arms control and in interactions with outside agencies that will affect the Laboratory's responsibilities in this arena;
- Managing Laboratory programs sponsored by the DOE Office of Arms Control and Nonproliferation (DOE/AN), including the appointment of program managers;
- Working with Laboratory management, DOE, and other DOE laboratories to develop long-range strategic plans for the Laboratory's nonproliferation and arms control activities;
- Coordinating all Laboratory programs relating to nonproliferation and arms control regardless of sponsoring agency; and
- Ensuring technical excellence in all Laboratory nonproliferation and arms control programs and that program and line managers effectively utilize the Laboratory's capabilities in support of NAC programs.

In performing these activities, the program director will be assisted by a small office staff of technical and administrative personnel.

2.1.2 Science Advisor and Science Advisory Council

The NAC program science advisor is Ralph Castain. The responsibilities of the science advisor include

- In collaboration with the NAC program director, chairing the NAC Program Science Advisory Council (NACSAC), which will recommend technical proposal evaluation criteria, review and rank proposals for technology development, assist with the oversight of the peer review process for work in NAC program areas, and suggest new opportunities for research to be supported by the NAC program;
- Establishing standardized review procedures for existing projects to monitor technical progress and ensure quality work;
- Under the direction of the program director, conducting special reviews of existing programs as required;
- Working with the technical staff and organizations within (and outside) the Laboratory to develop and/or evaluate new technical concepts for addressing the emerging requirements in nonproliferation and arms control. The objectives for these activities will be to generate work proposals that are relevant to national requirements, to build on (and support) Laboratory capabilities, and to encourage teaming with other institutions and private industry.
- In collaboration with the NAC Program Office and the Laboratory's technical organizations, working to improve technical communications with the external communities involved in nonproliferation and arms control.

2.1.3 Program Managers

Each program consists of several individual projects. Typically, each program manager will have NAC projects worth $5–$20 million designated as his responsibility. The program manager will usually, but not necessarily, be a member of the division that performs the majority of the technical work in that program area. Program managers will be responsible for

- Coordinating proposals and ongoing projects within the managers' areas of responsibilities to develop a comprehensive integrated effort;
- Working with sponsors at DOE/AN and elsewhere to develop programs and ensure sponsor awareness of Laboratory capabilities;
- Providing technical oversight of program activity to ensure satisfaction of the requirements set by DOE/AN or other sponsors, completion of milestones on time, and the timely delivery of specified deliverables;

- Ensuring sound financial management of projects within their areas of responsibility; and
- Ensuring technical excellence and full utilization of the Laboratory's technical staff in all efforts within their programmatic areas.

2.1.4 Technical Divisions

As in all Laboratory activities, divisions will be responsible for the technical work done in their own areas. The divisions will exercise this responsibility through project leaders, appointed by program managers in coordination with division and group managers. The assignment of personnel to specific projects will be the responsibility of division and group managers, who are expected to ensure through such assignments that the objectives of the individual projects can be effectively met. Division leaders are expected to meet regularly with the NAC program director to ensure that program goals are being met. As soon as information about funding is available, the division leaders will work with the program director to determine the approximate levels of funding that will be available and to ensure that the necessary facilities and staff are available.

When practicable, a specific technical division will be assigned the lead responsibility in a core technical competency area (e.g., nuclear weapon phenomena, safeguarding special nuclear materials, or effluent chemistry). These divisions will be responsible for maintaining and reviewing the program's technical capabilities and facilities in their assigned area. Program managers responsible for developing and managing projects associated with these core technical competencies will normally be administratively assigned to the appropriate lead division.

2.2 RELATIONSHIP TO OTHER LABORATORY ACTIVITIES

There are many Laboratory activities in which NAC is involved, although the primary responsibility for them lies elsewhere. As such areas are discovered, it will be necessary to delineate responsibilities on an ad hoc basis. The following are examples of areas now known.

2.2.1 Intelligence Program

Los Alamos technical capabilities have been supporting the monitoring of arms control treaties for many years. These monitoring technologies are also applicable to monitoring for the proliferation of weapons of mass destruction, the principal difference being the technologies' potential application in a noncooperative environment. Proliferation monitoring may need to be done without help from the monitored party, perhaps even without its knowledge, and intelligence rather than compliance verification may become the more important factor guiding the technologies' development and/or use. In the superpower arms control arena, intelligence played an important supporting role in the verification of agreements, but for proliferation monitoring, intelligence will most likely move to center stage. The Associate Director for Computational and Information Sciences at Los Alamos is responsible for the Laboratory's nonproliferation, arms control, and intelligence programs and the appropriate interfaces with the intelligence community. Within the Laboratory, the intelligence program director is responsible for the coordination of Los Alamos intelligence activities with and in support of the Laboratory's nonproliferation and arms control programs. The intelligence program representative to the NAC Program Office is Diane Soran.

2.2.2 Nuclear Weapons Technology

The Nuclear Weapons Technology (NWT) program representative is responsible for coordinating activities between NAC and NWT in those special areas that overlap in programmatic responsibility, such as test limitation discussions, warhead dismantlement agreements, evaluation of optimal levels of weapon program transparency, and weapons program impact of proposed agreements in nonproliferation and arms control. In addition, the NWT program representative will be responsible for ensuring that the full spectrum of nuclear competency available from the NWT technical staff is effectively integrated into the NAC program. The NWT program representative is Paul White.

2.2.3 Center for National Security Studies (CNSS)

Developments in nonproliferation and arms control strongly affect, and are affected by, U.S. policy decisions. The CNSS has the primary responsibility of keeping Laboratory management apprised of strategic issues and of representing the Laboratory in policy discussions. The Center will coordinate with NAC to ensure that all parties concerned are aware of the mutual impacts of policy and technology. The acting CNSS program representative is Robert Pendley.

2.2.4 Warhead Disposition

Because warhead disposition will often involve cooperative activities with Russia or other former Soviet republics, there may be NAC involvement; however, the technical responsibility lies entirely within NWT. NAC will maintain close liaison with NWT to ensure that the Laboratory's interests are appropriately represented in interactions with DOE/AN and other NAC-related offices. In turn, NWT will ensure that the NAC office is kept fully aware of international activities in warhead disposition and, when appropriate, is represented at meetings on the subject.

2.2.5 Nuclear Material Management

The heart of nonproliferation activity is control of nuclear materials. Although the Laboratory's safeguards programs are responsible for monitoring technologies, an effective materials control regime requires interfacing with other programs having materials management responsibility. NAC will maintain close liaison with the Laboratory's Program Director for Nuclear Materials, who has the responsibility for Laboratory-wide nuclear materials management in accordance with relevant DOE orders and directives.

2.2.6 Nuclear Waste Management

The dismantlement of nuclear warheads within the United States and Russia will result in waste disposal issues. The Laboratory's waste management program will work with NAC to ensure that Laboratory capabilities are well presented to DOE/AN and other offices that may become involved.

2.2.7 Reactor Safety

Reactor safety programs are housed and managed within the Nuclear Technology and Engineering (N) Division. It is anticipated, though, that the serious safety problems in former Soviet republics will lead to increasing levels of international activity in this area. N Division will keep NAC informed of work in reactor safety, and NAC will in turn provide liaison for N Division with those agencies in DOE or elsewhere outside the Laboratory with whom NAC has frequent contact.

2.3 SPECIFIC PROGRAM AREAS

NAC programs have been divided into the following nine areas. Because of the rapid change in the external sponsor environment, it can be expected that there will be frequent changes in these areas and their definitions. Specific projects from sponsoring agencies will be identified by the NAC program director and assigned to a NAC program manager as appropriate. To the extent practical, these assignments will attempt to have the sponsor's responsibilities coincide with the Los Alamos program manager's responsibilities, although the rapidly changing sponsor environment and/or technical considerations may dictate other arrangements.

2.3.1 Treaty Support

Treaty support includes the variety of tasks associated with negotiations, technical support, and implementation of treaties and treatylike agreements. Much of the negotiations support is administratively housed in NAC, but technical support (e.g., for the Threshold Test Ban Treaty [TTBT] implementation) will be housed in the technical divisions. Additional responsibilities include those tasks associated with the Continuous Reflectometry Radius versus Time Experiment (CORRTEX) that are specifically concerned with meeting implementation responsibilities of the TTBT.

2.3.2 Arms Reductions

Arms reductions includes a wide variety of projects associated with the verification of treaty or agreement terms that specify limits on or elimination of specific weapons. These agreements include Strategic Arms Reduction

Treaty (START), Intermediate Range Nuclear Forces Treaty (INF), Conventional Forces in Europe (CFE) agreement, and Chemical Weapons Convention (CWC), as well as verification of follow-on bilateral agreements on arms reductions. Projects typically will include such monitoring technologies as radiation detection, on-site inspection, and measurement of physical characteristics. Many projects are sponsored by non-DOE agencies, particularly the Department of Defense/ Defense Nuclear Agency (DoD/DNA). Because of the large radiation detection component, N Division will have the largest single technical interest but will have considerable support from such divisions as Chemical and Laser Sciences (CLS), Space Science and Technology (SST), Design Engineering, International Technology (IT), and others. The program manager is Kenneth Apt.

2.3.3 Policy and Technical Analysis

This program area includes a variety of tasks supported by the DOE/AN Policy and Technical Analysis (P&TA) office. Specific tasks have included staff support in Washington or overseas offices, foreign travel support for discussions with other countries, support for information databases and statistical analyses in NAC-associated programs, and general activities covering DOE/AN issues. It is anticipated that this program area will eventually include systems integration and operational analysis activities as well as the long-term strategic and business planning functions for the NAC program. If so, a permanent program manager will be recruited. The acting program manager is Maurice Bryson.

2.3.4 Export Control

Export control includes all programs concerned with monitoring and approving technology transfer and the export of materials that have been identified as militarily critical by U.S. agencies. Programs are usually sponsored through the DOE/AN Export Control Division, and technical work is largely housed in IT Division. The program manager is Arvid Lundy.

2.3.5 International Safeguards

International safeguards includes international programs concerned with monitoring the flow of nuclear materials and ensuring compliance with treaties and agreements involving special nuclear material (SNM) issues. Usually, but not always, sponsorship within DOE/AN will be housed in the DOE International Safeguards Division. Technical activity is almost entirely within N Division; however, to the extent that warhead disposition is involved as an activity that generates nuclear materials, there will be coordination required with the weapons program. The program manager is Mark Mullen.

2.3.6 Nuclear Explosion Detection

Nuclear explosion detection includes the ongoing Space Nuclear Detonation (NUDET) Detection projects, all research and development work with regard to nuclear explosion detection in the atmosphere and space, and other monitoring systems that detect ocean, underground, or surface nuclear explosions. The scope of this work includes not only development of monitoring technology but also understanding nuclear explosion phenomena that will be helpful in the monitoring task. Principal technical activities are in Earth and Environmental Sciences, SST, and Physics (P) divisions. The program manager is David Simons.

2.3.7 Effluent Monitoring

This area includes the real-time tritium detector, portable mass spectrometer, and development of other technologies for on-site sampling of effluent and debris. The principal technical support divisions are CLS and Isotope and Nuclear Chemistry. The acting program manager is Allen Hartford; a permanent program manager will be recruited.

2.3.8 Remote Sensing

Current remote sensing projects at Los Alamos include lidar, thermal imaging, and active radio frequency spectroscopy. SST and P divisions have traditionally provided the majority of the technical support in this area, with significant contributions from CLS and IT divisions. The program manager is Robert Scarlett.

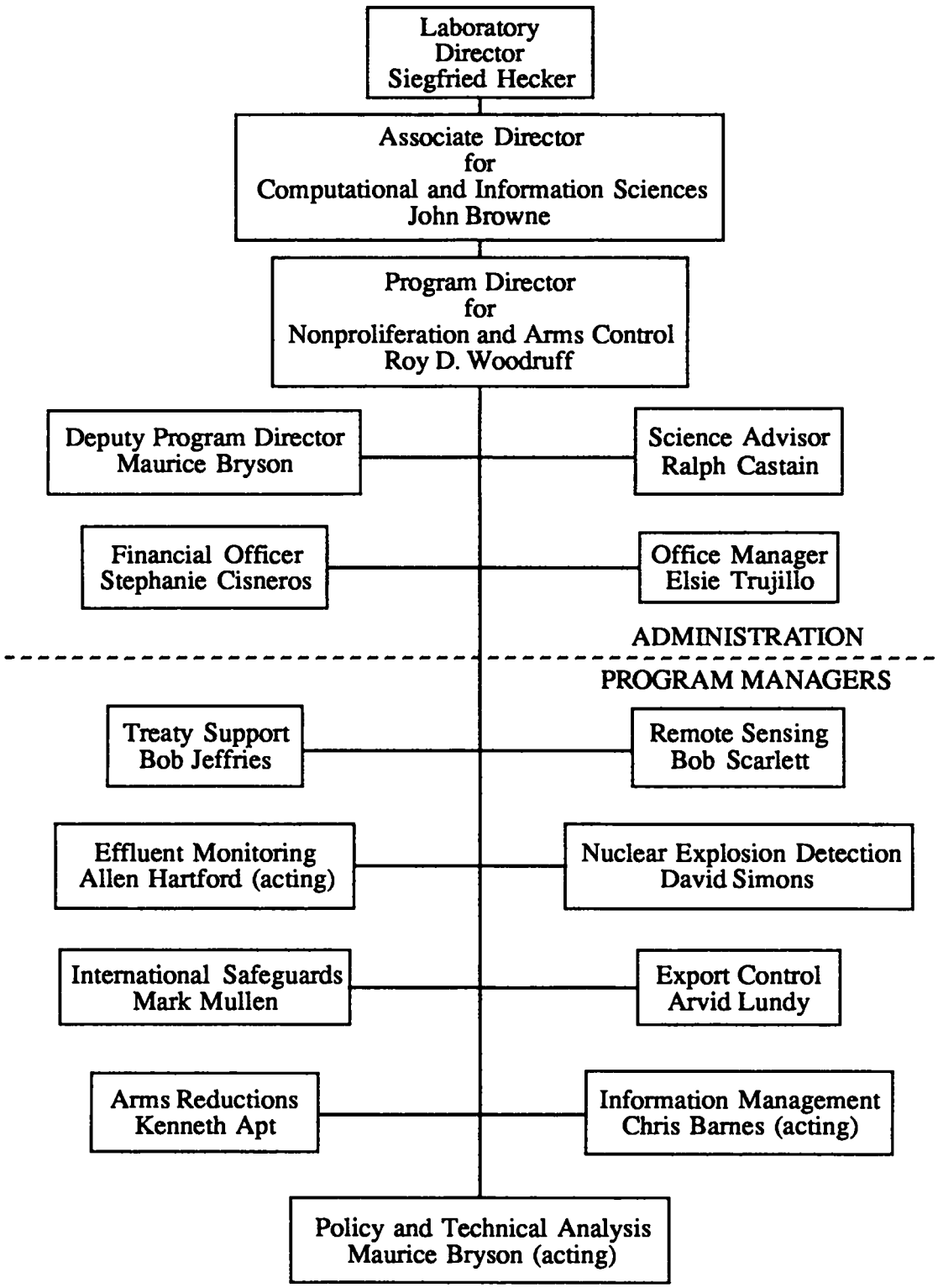
2.3.9 Information Management

The information management program is currently centered around the knowledge fusion project. This program is expected to grow over the years to encompass the generation of databases and the establishment of appropriate networks to share information with external

organizations. The broad interdisciplinary nature of the program is reflected in the participating organizations—technical staff from six Laboratory divisions (Administrative and Data Processing, Computing and Communications, Analysis and Assessment, Applied Theoretical Physics, N, and IT) are involved. The acting program manager is Chris Barnes; a permanent program manager will be recruited.

2.4 NONPROLIFERATION AND ARMS CONTROL PROGRAM ORGANIZATIONAL CHART

A NAC program organizational chart representing the program structure described in the preceding text is shown in the following diagram.



3.0 THE FY94 BUDGET PLANNING PROCESS

3.1 DEFINING A NEW PROCESS

In the fall of 1992, representatives from the three DOE national security laboratories (Los Alamos, Sandia, and Lawrence Livermore) met with top-level management of DOE/AN to help define a new way of doing business. Central to the discussions were the concepts of planning fiscal budgets on the basis of target funding levels to be provided annually by DOE/AN and enhanced multilaboratory collaboration during the budget planning phase to ensure minimal overlap between programs. At a subsequent Laboratory Advisory Group (LAG) meeting in December, Dr. Victor Alessi, Director of DOE/AN, issued a memorandum describing the following new budgetary process:

"1. DOE/AN will establish broad programmatic goals, requirements, and projected available resources.

2. *DOE/AN will identify resources for each of its offices and generate target funding levels for each of the laboratories so that the laboratories can make longer-range planning for their programs. This will be done before detailed decisions on projects and programs for the fiscal year are made. A relatively small amount will be set aside at DOE for unanticipated projects.*
3. *The laboratories will develop proposed programs based on the research goals and the target funding levels provided by DOE/AN. The programs should emphasize multi-laboratory collaboration whenever it reduces costs and improves effectiveness and responsiveness. The program plans, as well as the quality of past performance and the relevancy of the proposed projects, will be taken into account in determining the year's funding for each laboratory. However, the overall funding target for each laboratory will not be significantly changed. Individual projects within the programs will then be negotiated between each laboratory and DOE/AN."*

In response to the memorandum, Los Alamos, Sandia, and Livermore agreed to formulate a joint tri-laboratory program plan for FY94. The first tri-laboratory meetings took place January 25–29, 1993, with senior management representatives from the three laboratories touring the facilities of each laboratory. As a result of that meeting, the laboratories

1. Established three technical working groups—remote sensing (lidar, multispectral imaging, etc.), counterproliferation (detection of covert delivery attempts), and intelligence analysis (to include information management)—for interlaboratory cooperation. Each working group was tasked with developing a coordinated program plan and a process for continued interaction.
2. Agreed to exchange lifecycle plans for FY93 DOE/AN projects and to provide a one-hour summary of their overall programs at the next tri-laboratory meeting.
3. Agreed to continue the tri-laboratory process beyond the DOE/AN budget submission. The primary emphasis for the extended process would be on developing laboratory-level coordination between the nonproliferation efforts from DOE Intelligence (DOE/IN), DOE/AN, and DOE Defense Programs (DOE/DP). As part of this objective, the laboratories would formulate a tri-laboratory "vision paper" on their potential roles in the nonproliferation problem for the DOE as a whole.
4. Agreed to improve regular communications by establishing electronic mail connections between upper management at each of the laboratories, by using video conference centers for more frequent meetings, and by exchanging lists of assignees to agencies in the Washington, D.C., area.

During the time between the conclusion of the initial tri-laboratory meeting and the follow-on coordination meeting of early March, the working groups on remote sensing, counterproliferation, and intelligence met to define areas of overlapping interest. In addition, informal coordination of the nuclear explosion detection program area was also undertaken.

3.2 ESTABLISHING A TARGET BUDGET

For planning purposes, the three laboratories agreed to develop budget guidelines consistent with their funding history and available guidance from DOE/AN. Thus, in order to formulate an integrated program plan, the three laboratories utilized the following process:

- Based on the DOE/AN budget projections presented at the December 1992 LAG meeting, a base budget for DOE/AN in FY94 was established. A Los Alamos "share" of this was estimated on the basis of discussions with AN personnel.
- With the FY93 anticipated funding as guidance, the percentage of the total FY93 funds received from each directorate within DOE/AN was computed. This fraction was then applied to the anticipated FY94 funding levels as provided by DOE/AN.
- Available guidance on existing programs in remote sensing, export control, TTBT implementation, and advanced concepts was used to set FY94 targets for those areas.
- Strategic planning based on perceived national needs was used to reduce the target budget for nuclear explosion detection and to increase funding for effluent monitoring, international safeguards, and information management.

The resulting FY94 target budget guidance, shown in Table 1, was presented to the NAC program managers in mid-January in a general budget call meeting. In formulating the target budget, every attempt was made to preserve the anticipated funding separation between DOE/AN directorates contained in Dr. Alessi's December briefing. However, some ambiguity regarding assignment of responsibility for specific projects between the directorates in areas such as information management and international safeguards made the division of target funding difficult. Therefore, it was decided to establish the target budgets in those areas according to national priority, with separation of the funding according to DOE/AN directorate to be left for a later time.

Following establishment of FY94 target budgets, the respective program managers were tasked with formulating coordinated program plans. The projects included in the plans were established and reviewed according to a process defined in the next two sections.

3.3 PROPOSAL SUBMITTAL PROCESS

Each program manager was responsible for submitting an annual budget proposal to the NAC Program Office for his particular programmatic area. This prioritized list of proposed projects formed the core of the NAC Integrated Program Plan and was carefully constructed from proposals subjected to peer review within the Laboratory.

The submittal and evaluation process was composed of two major steps. Once a target budget number had been generated for a given programmatic area, the first step in the process was the submission of short-form proposals to the respective program manager. These proposals addressed the eventual applications of the proposed technology or analytical technique, its significance relative to current capabilities, and the technical issues to be resolved during the proposed project. The short-form proposal contained sufficient technical information to allow peer review of the proposed concept but did not include details such as cost, schedule, and deliverables typically found in a full proposal.

Each program manager then instituted a review process to evaluate all short-form proposals according to the criteria detailed in Appendix A. The goal of the process was to provide recommendations on the selection and prioritization of those proposed concepts to be further developed into complete proposals and the consolidation of similar ideas into larger projects. Each short-form submitter was subsequently notified in writing of the resulting recommendations, reasons, and actions by the program manager.

The second step in the process was to develop full proposals for the selected projects. These full proposals included project costs, both operational and for capital equipment, throughout its term or projected for at least five years, appropriate milestones and/or decision points, and specific deliverables. In addition, full proposals included a high-level work breakdown schedule (WBS) used to arrive at the quoted cost of the project. This was not meant to be a detailed WBS for program management, but rather a task-level breakdown to show the process used to develop the estimated project costs.

Throughout the proposal process, the NAC Program Office continued to emphasize that the final proposal is a contractual device—the individuals responsible for the programs are committing the Laboratory to accomplishing the described tasks within the specified funding. Therefore, proposals that based quoted costs on "level-of-effort estimates" were not generally accepted unless the sponsor had specifically requested a level-of-effort program to provide support for some activity.

3.4 FORMATION OF THE NAC INTEGRATED PROGRAM PLAN

Once the program managers had assembled their budget plans, the NAC Program Office met with them collectively to assemble the integrated program budget plan. At this time, trade-offs between the various programs (e.g., effluent monitoring, remote sensing, etc.) were made in order to meet the basic budget guidance provided by DOE and the guidelines established in the NAC Strategic Plan.

The final Integrated Program Plan is composed of two groupings. The Tier 1 grouping consists of those projects which together make up the "core" program—these are the projects we believe should be funded at the requested levels. The defined tasks within the Tier 1 projects were adjusted as required to ensure that the total funding request met the specified target budget guidance.

Proposals not selected for submission to DOE/AN as part of the core program under this process but considered worthy of further consideration were included in the second grouping, called Tier 2. This grouping is intended to provide some guidance should additional funds become available. Several of the projects in this grouping are actually requests for additional funds to augment projects in Tier 1. In these cases, the additional funds would be used to expand the scope of the project and/or accelerate the project's timeline.

4.0 MAJOR PROGRAMMATIC DIRECTIONS FOR FY94

4.1 NATURE AND STATUS OF THE PROBLEM

The spread of nuclear, chemical, and biological weapons—and the means to deliver them—poses a serious threat to regional and international security and to the interests of the United States, its allies, and friendly countries. With the end of the Cold War, this potential proliferation of weapons of mass destruction has become the greatest national security threat to the United States. While at present the United States is not directly threatened by aircraft and missile attacks from proliferant countries, a threat is posed to allies and to U.S. forces abroad in regions where proliferation has occurred. It may not be likely, but it is possible that the United States could be drawn into regional nuclear conflicts. The threat to the United States will clearly increase as the number of proliferant nations increases and as those nations acquire additional capabilities such as strategic ballistic missiles, blue-water navies with missile capabilities, and space support systems.

A key obstacle to countering proliferation is the inability in some cases to detect clandestine programs for the development of weapons of mass destruction at an early enough stage. Current intelligence efforts bring a variety of technical methods to bear on this problem which, in many cases, are sufficient to expose such programs. Iraq, however, presents a case study in their limitations. We now know that Iraq successfully concealed many key elements of a massive nuclear weapons effort. Although the West knew that Iraq had chemical weapons, it was unclear how many, of what types, and how varied were their means of delivery. In addition, there continue to be suspicions of a biological weapons program, although no hard evidence or details are available. Despite the war and the unprecedented U.N. efforts to identify and destroy Iraqi weapons of mass destruction and delivery systems, the full scope of the Iraqi programs may never be uncovered.

The example of Iraq raises serious questions about our ability to detect clandestine weapons programs with assurance and, even if they are detected, effectively neutralize them. The challenge to U.S. technology is to develop the necessary means to cost-effectively accomplish these goals in both cooperative and non-cooperative scenarios for nuclear, chemical, and biological weapons and their delivery systems. The ability to detect and neutralize clandestine programs must be developed for every step in the proliferation process, including political commitment, foreign assistance, research, testing, uranium and plutonium production, weapon fabrication, system testing, employment, training, stockpiling, and threatened or actual use either in regional wars or by covert delivery against U.S. interests.

With the end of the Cold War, the DOE national security laboratories, equipped with a wealth of nuclear weapons expertise and detection/monitoring technology, are ideally positioned to lead an aggressive national technical effort against the proliferation of weapons of mass destruction, especially nuclear weapons.

Because of the highly diverse nature of the nonproliferation problem, an integrated systematic approach covering all aspects of the problem is of paramount importance. The DOE national security laboratories (Los Alamos, Sandia, and Livermore) have teamed to define a vertically integrated, comprehensive program modeled after the highly successful nuclear weapons program. Through their several decades of "design-to-retirement" responsibilities in the nuclear weapons program, the thee laboratories have developed the unique knowledge of nuclear weapons development, fabrication, and effects required for successful implementation of the nation's nonproliferation program.

Preliminary efforts by the three laboratories have identified several major programmatic directions for FY94. These are discussed in the following sections.

4.2 TTBT IMPLEMENTATION

Based on discussions with DOE/AN, the laboratories do not currently anticipate receiving funding to support the implementation of the TTBT in FY94. With the dissolution of the former Soviet Union (FSU) and the new administration's support for a comprehensive test ban, the likelihood of underground nuclear tests being conducted during FY94 remains

uncertain. Should the TTBT signatories decide to resume testing and the U.S. government decide to exercise its rights of monitoring nuclear tests, funds for that effort will need to be identified at that time—the present Integrated Program Plan does not contain funding for such an effort.

4.3 SATELLITE PROLIFERATION DETECTION TECHNOLOGY PROGRAM

During the spring of 1992, Los Alamos and Sandia National Laboratories initiated a joint planning effort to review and redefine the satellite instrumentation program. The collapse of the Soviet Union and events in the Persian Gulf prompted a community-wide review of current requirements for nuclear test monitoring and a heightened recognition of the need for improved methods of proliferation detection. As a result, the Follow-on Early Warning System (FEWS) Payload 3 program was significantly reduced in scope with the intention of freeing resources that could be applied to a new program—the Satellite Proliferation Detection Technology (PDT) program.

The new program outline included three phases (or tracks)—Phase One involved conceptual evaluation of technologies for detection and characterization of proliferant activity; Phase Two provided for ground and/or aircraft testing; and Phase Three involved space demonstrations on small satellites. Technologies identified for development included multispectral thermal imagery, lidar, multispectral transient radiometry, low-light-level imagers, and others.

On December 17, 1992, Los Alamos and Sandia presented an integrated Satellite PDT Program Plan to DOE/AN Systems and Technology (S&T). This plan included a series of development launches of small satellites, building on the experience gained through nearly 30 years of building satellite instrumentation and on the expertise in small satellites recently obtained through the Array of Low-Energy X-ray Imaging Sensors (ALEXIS) project.

The purpose of the small-satellite launches is to demonstrate the potential application of new remote sensing technology to the detection of weapon proliferation in denied areas. The resulting technologies might also be applicable to operational airborne monitoring platforms. The satellite demonstrations begin with the 1995 launch of the Fast On-Orbit Recording of Transient Events (FORTE) experiment, followed by the Multispectral Thermal Imager (MTI) launch in 1997 and the launch in 1999 of an advanced nonproliferation lidar system. These will be major system demonstrations that will involve potential users and operators.

In parallel with these planned launches, a robust program of new technology R&D will provide the impetus for future small-satellite demonstrations. These new technologies can come from any of the laboratories participating in the DOE/AN program. The satellite instrumentation expertise at Los Alamos and Sandia will be available to assist in the adaption of appropriate new technologies to space.

As an integral part of the Satellite PDT program, an appropriate capability will be maintained to detect nuclear explosions in the atmosphere and near-earth space, thus fulfilling the 30-year commitment by DOE and its predecessor organizations to work in concert with the Air Force to provide this essential element of national security. In the next decade, the preponderance of this capability will be carried by the Global Positioning System (GPS). Over the next several years, the Global Verification and Location System (GVLS) will also be developed to exploit excess data processing capability aboard the GPS satellites to further the aims of the nation's nonproliferation and arms control efforts in new and innovative ways—for example, by globally tracking the location of warheads or other controlled items. The availability of this capability on one of the nation's premier satellite systems is a major enhancement of the DOE/AN program.

The Satellite PDT program has been incorporated into both Los Alamos' and Sandia's planning as a major element of our contribution to arms control and nonproliferation technology development. The program was reviewed in January 1993 by the JASON panel and given high marks. Activities at Los Alamos and Sandia are well under way, including coordination with Livermore and other DOE laboratories. In addition to the DOE laboratories, the program offers opportunities for sharing development and launch costs with other federal agencies. Los Alamos and Sandia believe that DOE/AN and the Satellite PDT

program can benefit greatly by pursuing collaborative programs with the National Aeronautics and Space Administration and DoD, not only from the perspective of cost savings, but also from the opportunity to establish relationships essential to the transition of these technologies to the user community. The technology developed under the satellite PDT program has both national security and civilian space applications, e.g., proliferation detection and environmental monitoring.

4.4 NONPROLIFERATION INFORMATION MANAGEMENT

The nation's nuclear nonproliferation initiative currently relies on the ability of human analysis to assimilate, integrate, and interpret complex information from diverse sources in order to track nuclear proliferation activities throughout the world. Several current trends, however, will continue to place additional stress on the ability of the current system to adequately perform this task. Increasing budgetary pressures on the general nonproliferation community (both in the United States and in the international arena), coupled with the growing number of countries with adequate technical competence to undertake a nuclear weapons program, will make it difficult to obtain sufficient staffing to properly assimilate the information from today's sources. In addition, the growing importance of other sources of information, both in the public domain (e.g., published literature) and otherwise (e.g., financial transactions and new intelligence systems), will greatly add to the diversity and flow of information which must be correlated and understood.

While there has been significant recent interest in developing the technology for large distributed databases, serious operational problems remain to be overcome before the nonproliferation community will be able to realize their full utility. Potential DOE contributions to this area include the following:

- ***Database formation:*** The DOE national security laboratories possess unique databases covering all aspects of the nuclear weapon development and production environment. This includes forensic data from every weapon ever tested in the atmosphere, effluent emissions information, etc., plus the results of decades of research into different technologies and paths for the development of nuclear weapons. This information, vital to the accurate assessment of a potential proliferant nation's intentions and status, comes in a variety of forms (text, numerical, and imagery) which must be integrated and indexed appropriately.
- ***National security information network:*** Los Alamos, in collaboration with industry and with participation from other DOE laboratories, has been working on establishing a nationwide computer information network for national security information in general. One ideal application of this network would be to link the DOE national security laboratories with the various interested intelligence agencies, thus providing the agencies with access to the information described above and providing the DOE national security laboratories with access to intelligence information required for accurately assessing the status of a potential nuclear proliferant nation. The impact on the nonproliferation community of a mechanism whereby intelligence analysts and policymakers could request and receive immediate expert assistance via a multi-media computer network with the DOE national security laboratories would be significant. While several technical obstacles remain to be resolved, a limited version of this network could potentially be installed fairly rapidly.
- ***Advanced data processing methods:*** Extracting relevant data and uncovering potential correlations from vast quantities of information from diverse sources is a difficult, manpower-intensive task. The DOE has already embarked on an effort to assist the intelligence analyst by automating some of these tasks, but this effort could significantly benefit from additional funds. Development of advanced data processing algorithms requires intimate knowledge of the nuclear weapon development and fabrication process and access to state-of-the-art computing equipment, both of which can be found at the DOE national security laboratories.

4.5 INTERNATIONAL NUCLEAR MATERIALS CONTROL

The DOE national security laboratories' current interactions with other nations, such as those in South America, the Pacific Rim, and the FSU republics, to spread the use of U.S. safeguards technologies need to be significantly enhanced. This is particularly true in the areas of dismantlement of the FSU nuclear weapon stockpile and control of plutonium generated by the civilian nuclear power industry. This latter area is of especial concern since several countries such as Japan are beginning to follow energy policies which will result in the creation of civilian stockpiles of plutonium equal to or larger than the plutonium found in the current military stockpile. The development and implementation of adequate safeguards methodologies to deal with this situation should be a high priority.

In addition to safeguards, the laboratories anticipate a growing U.S. role in supporting both short- and long-term monitoring of countries such as Iraq. The key to successfully meeting these growing requirements is the development of integrated systems for both monitoring declared and detecting the presence of undeclared nuclear facilities. While currently existing programs continue to develop individual instruments for specific purposes, a systematic approach to developing integrated instrumentation packages for both long- and short-term operational deployment has been missing. The improved capability for positive identification and tracking of activities at potential nuclear facilities provided by the measurement of multi-instrument signatures would significantly reduce the potential of a country developing a viable, clandestine nuclear weapons program.

4.6 FORENSIC ANALYSIS OF NUCLEAR EXPLOSION DEBRIS

The biggest challenges confronting the nuclear explosion detection arena are those of attribution and characterization. Once an explosion has been detected, it is vital to the nation's interests that we obtain in-depth information on the sophistication of the device and on its possible owners. Much of the information regarding device technology can be obtained through detailed forensic analysis of the debris from the explosion. Even more importantly, the results of such an analysis, when coupled with the data from weapons tests currently possessed by the DOE national security laboratories, can potentially be used to determine the probable origin of the device itself. If successful, this forensic analysis technique would provide a significant deterrent to any country's proliferation intentions.

4.7 INTERDICTION RESPONSE OPTIONS

Given solid evidence of a country attempting to develop a nuclear weapon capability, the U.S. government and the international community require a set of available response options. These may range from interdiction of critical equipment and personnel to the destruction of facilities and continuous inspection currently under way in Iraq. A systematic analysis of possible response options to determine their effectiveness and potential consequences is crucial to national security. The DOE national security laboratories' unique knowledge of nuclear weapons is vital to such an analysis.

4.8 DEFENSE AGAINST COVERT DELIVERY OF NUCLEAR WEAPONS

Although there is a major effort to develop defenses against a ballistic missile threat, it has been widely recognized that present and future threats for the use of nuclear weapons against the United States include a wide range of delivery options that must not be neglected. Today, the international community has little capability to defend itself against the covert delivery of such a device. While Nuclear Emergency Search Teams (NEST) are trained and equipped to search for a nuclear device and, if one is located, to attempt to disable it, these capabilities are currently limited.

International vulnerability to the covert delivery of nuclear weapons suggests that a new balance is needed among the programs that address proliferation threats. The three national security laboratories propose a focused DOE effort to develop the technologies that would significantly improve the U.S. capability to

defend against these threats. While the envisioned effort would involve elements of DOE/DP, DOE/AN, and DOE/IN offices, a detailed program plan has not yet been developed. The three laboratories are currently working on such a plan and expect to deliver it to DOE in mid-summer.

TIER 1 PROPOSALS: NAC CORE PROGRAMS

5.0 REMOTE SENSING

5.1 OVERVIEW

Detection of proliferation activities by remote sensing techniques forms the unifying challenge of this program. Current national capabilities have limited ability to detect a well-hidden proliferation program, as was demonstrated by discovery of the extent of the Iraqi nuclear weapon program. New technology may augment current approaches by identifying specific signatures indicative of proliferation activities. Los Alamos in partnership with Sandia is conducting a program of technology development and demonstration aimed at providing new detection tools to the nation. This program spans a range of technologies with both near- and long-term applicability. Two of the projects are aimed at space satellite demonstrations during this decade. Other projects explore advanced technologies for application to various aspects of the remote proliferation detection problem. An additional benefit of this program is the potential for dual use of the technologies, especially in environmental research and monitoring.

Bob Scarlett

5.2 SPACE-BASED LIDAR FOR PROLIFERATION DETECTION

Lidar uses measurement of scattered laser light to determine the distribution of substances in the atmosphere. This technology has broad applicability to a variety of important problems ranging from basic research to national defense.

The basic lidar approach is to emit a short pulse of laser light into the atmosphere and then make time-resolved measurements of the intensity of the scattered light arriving at a telescope located next to the laser. In this way the density of the scattering material can be determined as a function of range along the line of sight. The process is repeated as the system scans horizontally and vertically to build a three-dimensional image of the concentration of the scattering substance. The selection of source and receiver wavelengths allows tailoring the technique for measurement of a variety of materials. Some examples of applications include basic research in global climate change through measurement of the distribution of water vapor in the atmosphere; applied research to help understand atmospheric pollution; monitoring proliferation of weapons of mass destruction by applying lidar to the detection of substances indicative of nuclear, chemical, and biological weapon proliferation facilities; national defense problems ranging from missile defense to location of aircraft, ships, and tanks; and drug interdiction.

5.3 MULTISPECTRAL THERMAL IMAGER

Long-wave infrared radiation offers a means for accurate measurement of thermal signatures from proliferation facilities. The objective of the MTI project is to perform a rapid, low-cost flight demonstration of advanced technologies capable of providing enhanced satellite-based thermal and multispectral measurements vital to nuclear proliferation detection. The system will use state-of-the-art sensors, cryogenic refrigerators, and data-handling technology. The capabilities developed could be applied to improve the capabilities existing programs such as the Landsat Thematic Mapper by enhancements in radiometric calibration, spatial resolution, selection and number of spectral bands, and utilization of lightweight technologies. The program will also develop the

analysis and simulation tools needed to exploit the data collected for the proliferation detection problem.

Specific objectives of the project include identification and quantification of characteristic signatures and backgrounds; development of an optimized instrument design for the proliferation mission; construction, test, calibration, and deployment of a small satellite to demonstrate MTI capabilities; development of advanced technologies needed to support the experiment; and the development of tools for exploitation and analysis of MTI data. In this joint Sandia–Los Alamos project, Los Alamos will concentrate on understanding sensor response, calibration, and analysis and on exploiting of the data. Progress in all of the objectives is expected in FY94 in order to meet the projected launch date of late 1996.

5.4 ADAPTIVE HARDWARE

Most of the approaches for remotely sensing proliferation observables generate huge quantities of data. The volume of data which must be stored or, in the case of satellite systems, sent to the ground and processed is usually the principal limit to sensor capability. One approach to enhancing the ability of remote systems to fully exploit sensor capabilities is in the area of deployable data processing.

Recent efforts at Los Alamos have demonstrated that it is possible to train adaptive systems to uniquely recognize a specific complex pattern contained within a very large number of similar patterns, even when some of the data is missing or obscured by noise. The adaptive hardware project is applying these advances in adaptive processing to the development and rapid demonstration of deployable adaptive pattern recognition systems. Specific goals of the project are to (1) demonstrate the feasibility of applying the combination of advanced sensors and adaptive pattern recognition to proliferation detection, (2) demonstrate the feasibility of applying adaptive pattern recognition techniques to the detection of nuclear detonations, and (3) develop and deploy adaptive pattern recognition systems.

Neural networks represent a fundamentally new and different approach to information processing. These networks provide the first alternative to programmed computing, which has dominated information processing for the last 45 years. Used as classifiers, neural networks can perform three different tasks: pattern recognition (robust in the presence of input pattern noise), content-addressable or associative memory (useful when only a part of the input pattern is available and a complete pattern is desired), and vector quantization or clustering (useful for data compression). Of particular interest in field and space applications, neural networks are extremely fault-tolerant because of their intrinsic massive redundancy.

Neural networks represent a rudimentary attempt to mimic the organization of the brain. They consist of many simple processing elements, or nodes, that are highly interconnected to one another. Each interconnection can be assigned a relative weight, and essential nonlinearities are present in some form. Organizing the nodes and connections, and adjusting the weights in various manners, allows networks to be constructed to perform different tasks. Hundreds of different network architectures have been designed by different people, but only two classes of networks are relevant to the proposed program.

The goals of the project for FY94 are to explore application of adaptive processing techniques to FORTE event classification and data compression for the MTI as well as work on the more general development of hardware and algorithms.

5.5 REMOTE ULTRALOW LIGHT LEVEL IMAGING (RULLI)

RULLI is a project to develop and demonstrate advanced technologies for remote imaging under illumination as faint as starlight. RULLI systems could be fielded on ground-based, airborne, or space-based platforms. Essential to the RULLI concept is a state-of-the-art imager that combines high spatial resolution with high time resolution. Long exposures from moving platforms become possible because high-speed image processing techniques can be used to deblur the image. RULLI technology will expose proliferant activities previously hidden by cover of darkness, opening a new remote sensing channel that will complement daytime and thermal infrared imaging and synthetic aperture radar (SAR). The technical objectives of

RULLI include a ground-based proof-of-principle experiment and then an airborne demonstration experiment. The project will develop instruments that will permit imaging the earth's surface under cloudless conditions with only starlight illumination. Such instruments would allow the collection of images during moonless nights when optical imaging systems using sensors such as charge-coupled device (CCD) arrays are known to be ineffective due to their lack of time resolution. The instruments would provide a useful, high-sensitivity complement to daytime imaging systems.

Proliferation activities, in particular the isolation of SNM, require the movement of personnel and materials on large scales. Such movement can be detected by optical means, but our capability to image at a distance is greatly reduced at night. Opening the nighttime to high-resolution imaging will greatly augment the capability of space-based and airborne imagers, complementing existing remote sensing channels in the daylight visible/near-infrared, thermal infrared, and SAR.

FY94 tasks include ground-based evaluation of crossed-delay line (CDL) photon counters for RULLI application by a series of ground-based imaging experiments to evaluate the optical sensitivity, resolution, saturation levels, and blooming of the imaging system; algorithm development for the flight prototype instrument; identification of an appropriate airplane or balloon platform; and preliminary design of an integrated imager package.

5.6 LONG-WAVE SAR TECHNOLOGY

Advances in nuclear nonproliferation detection will be made by demonstrating the capability of detecting buried objects using an aircraft/satellite-borne SAR which uses either over-the-horizon (OTH) radar transmission for the illuminating signal or monostatic transmission from the SAR system.

The technological development of ground-penetrating (GP) SAR/OTHSAR will enhance the U.S. ability to monitor covert industrial and military activities commensurate with proliferant development. The GPSAR/OTHSAR would be used to detect, locate, and identify buried targets. Targets of interest include buried facilities, power lines, pipes, and equipment. The OTH illuminating radars have coverage that includes most areas of interest. Airborne SAR systems will have coverage distances of several hundred kilometers. The subsurface probing of the GPSAR/OTHSAR system could have been used to detect Iraq's subterfuge of hiding calutrons and power lines underground.

During FY1994 this new project will concentrate on measurement of scattering cross sections of buried objects, background clutter assessments, design of an airborne receiver system with the ability to suppress the dominant illuminating signal while extracting the weak scattered signal, data acquisition and processing system design, a ground propagation study to evaluate the feasibility of GPSAR/OTHSAR for detecting selected buried objects within 10 m of the surface, and system and airborne payload design.

5.7 FY94 REMOTE SENSING PROJECTS

ST016A: Remote Optical Spectroscopy for Nuclear Proliferation Detection
Status: Current

This project addresses the application of laser spectroscopy techniques for remote detection and characterization of sites involved in nuclear proliferation activities. Laser spectroscopy has potential for detecting the effluents from the mining, refining, reacting, reprocessing, and enrichment of SNM from ground, air, or space platforms, thereby pinpointing nuclear proliferation activities. This program will provide field validation, from ground and air platforms, of the detectability of key optical signatures indicative of proliferation activities. Knowledge and data gained from the field validation experiments will be provided to DOE/AN for use in guiding technology development, larger-scale demonstration experiments, and operational system development.

LA001: Lidar Remote Sensing for Nuclear Proliferation Detection
Status: New

This project addresses the development of operationally capable aircraft and satellite-based lidar systems for the remote detection and location of proliferation activities. Current technology will be analyzed, operational system architectures and component point designs will be developed, and aircraft and satellite-based demonstration experiments will be executed.

ST525A: Multispectral Thermal Imager (MTI) for Space-Based Proliferation Detection
Status: Current

MTI is a joint Los Alamos–Sandia project for passive detection and characterization from a small-satellite platform of nuclear proliferant activities. Los Alamos and Sandia propose to develop and demonstrate space operation of an MTI using state-of-the-art technology in detector arrays, mechanical cryogenic cooling, and data management. Its capabilities will improve significantly on existing similar assets such as the Landsat Thematic Mapper by providing significantly better radiometric calibration and spatial resolution, more spectral bands, lighter weight, better calibration, and less restrictive orbit requirements. The improved spatial resolution and spectral coverage are expected to advance the ability to characterize target facilities.

ST423: Deployable Adaptive Event Recognition and Processing Systems
Status: Current

This project will develop, functionally test, and environmentally test prototype neural network hardware to do adaptive event recognition and processing for a variety of applications, including small-satellite, airborne, and ground-based nonproliferation detection systems. Systems will be tested with data from proliferation instruments developed under other DOE/AN projects as well as with existing related sensor information (e.g., seismic data).

ST424A: Ground-Penetrating Synthetic Aperture Radar (GPSAR) using Monostatic and Over-the-Horizon (OTH) Transmissions
Status: Current

This is another joint project between Los Alamos and Sandia. Ground-penetrating radar may have significant applications to the detection of clandestine military and proliferation activities. For example, it may be possible to detect buried tanks or various types of hardware for the enrichment of SNM. Los Alamos will use the current OTH technology to illuminate the segment of terrain with FM in the 10- to 30-MHz range. One or more aircraft (or satellite) would pick up the reflected and scattered signal for SAR analysis of the Doppler-shifted information to produce an image of the region under surveillance. Sandia will investigate a monostatic configuration. Funding in subsequent years will adapt a Sandia SAR to provide a demonstration capability.

ST524A: Remote Ultralow Light Level Imaging (RULLI)
Status: Current

RULLI's objective is to develop advanced technologies for remote imaging under starlight illumination. RULLI systems may be fielded on ground-based, airborne, or space-based platforms. Long exposures from moving platforms become possible using a high time- and spatial-resolution detector because high-speed software techniques can be used to deblur the image. RULLI technology will expose proliferant activities hidden by cover of darkness. RULLI's objectives include a ground-based proof-of-principle experiment followed by an airborne (airplane or balloon) demonstration.

6.0 NUCLEAR EXPLOSION DETECTION

6.1 PROGRAM OVERVIEW

The Nuclear Explosion Detection (NED) program at Los Alamos predates the U.S. verification program for the Limited Test Ban Treaty (LTBT) dating back to the late 1950s. At that time, discussion of test ban treaties led to concern for technical monitoring for treaty compliance. Los Alamos and the other Atomic Energy Commission (AEC) weapons laboratories were involved in these discussions. As an outgrowth of these discussions, Los Alamos participated in two research programs to develop monitoring capabilities for atmospheric and space-based nuclear tests. One program, Vela Sierra, developed ground-based sensors for observations of atmospheric fluorescence. The other program, Vela Hotel, developed satellite-based sensors looking at direct radiations and optical signals. Los Alamos provided both central scientific expertise on detectable effects as well as actual sensor design and construction because it had experience with both low- and high-altitude atmospheric nuclear testing diagnostics and their interpretation. This effort grew naturally out of the nuclear weapons development and testing program supported by AEC Defense Programs (AEC/DP), and it continued under the aegis of the DOE/DP until recent years, when the AN office became an independent entity within DOE.

The Vela Sierra project successfully designed, constructed, and fielded a relatively low-cost detection system for monitoring space-based nuclear explosions until a satellite system could be fielded. As an interim solution, it was eventually replaced by satellite systems of greater overall sensitivity.

The first Vela Hotel satellite launch occurred on October 16, 1963, little more than two months after the LTBT was signed in Moscow on August 5, 1963. Los Alamos developed and designed the x-ray, gamma-ray, and neutron detectors for this satellite. Sandia was responsible for the associated electronic circuitry. Later in the Vela Hotel program, Sandia also designed and provided the detectors for monitoring the occurrence of low-altitude atmospheric nuclear explosions. The

David Simons

AEC funded the national laboratories' participation in the Vela Hotel program as a natural extension of its charter for maintaining the nuclear weapons expertise of the United States. The Advanced Research Projects Agency had the overall management responsibility for the project. The Air Force coordinated program activities and schedules and was responsible for development and launch of the satellites.

The satellites, launched into large geocentric orbits, could view nearly half the earth's surface and much of space while at the same time remaining out of the earth's trapped radiation belts. Six pairs of Vela satellites went into orbit between 1963 and 1970. Data from these satellites demonstrated that monitoring cosmic backgrounds was required to understand the functioning of the detectors in the harsh space environment. As the instrument designers and the experts on nuclear weapons performance, scientists at Los Alamos played the central role in developing methods of data interpretation supporting the operational arm of the Air Force. The AEC provided support for the close technology interaction with the Air Force as a natural part of the weapons development program at the national laboratories. The AEC encouraged the development of this complex body of scientific knowledge necessary for the interpretation of these data. Major advances in computer modeling of atmospheric

nuclear explosions were required for this effort. The critical core competencies required for data interpretation were then available when the Chinese and French carried out their atmospheric tests and when event 747 occurred. Maintaining this critical national science and technology base has always been a central feature of the DOE core program in NED.

The event 747 alert (1979) made it clear that multiple detection phenomena would be a critical part of any meaningful national technical means for treaty monitoring. Recognizing this, the Office of Arms Control (DOE/DP/OAC) encouraged a research program looking at a variety of technologies that might enhance this area. DOE/DP/OAC expanded the research base at Los Alamos to include a search for techniques to supplement seismic monitoring for underground tests as well as atmospheric tests. The ionospheric and infrasound research efforts at Los Alamos looked at remotely observable atmospheric effects from underground tests.

In the early 1980s, Los Alamos undertook an effort to detect underground explosions using extremely low frequency (ELF) electromagnetic waves (Schumann Resonance). This was followed by development of the hydrodynamic yield verification technique in the mid-1980s. With the increasing emphasis on the TTBT in the latter part of the 1980s, Los Alamos undertook research efforts to develop a nonintrusive yield measurement based on ground motion measurements, originally supported as part of the ionospheric and infrasound efforts as well as the containment program at the Nevada Test Site (NTS).

Los Alamos began the Source Region program in 1988 to examine the detailed physics involved in, and the impact of local geology on, the production of a seismic signal by an underground nuclear explosion. This work was undertaken in response to the realization that most of the U.S. seismic monitoring capability was based upon information derived from only a small number of well-known test sites around the world. The Source Region research has added significantly to our understanding of the many complexities of the generation of a seismic signal and holds some promise for greatly enhancing our forensic interpretation of signals originating from unknown or little-known test sites around the world.

The DOE/AN, which now supports the NAC Program Office at Los Alamos, has supported a varied and productive R&D program of which the NED effort is only one part. NED is expected to remain a cornerstone of the country's nonproliferation monitoring effort in the future because confidence in monitoring is a critical part of overall confidence building for nonproliferant nations and a critical element in gathering information for national decision-makers. Having said this, however, we believe that the overall portion of the NAC R&D budget devoted to NED can be decreased while fulfilling the critical mission requirements. This strategy is a central premise to the formulation of the FY94 and out-year budgets.

The nuclear test surveillance mission is now incorporated into the Air Force Defense Support Program and the GPS. Los Alamos and Sandia, supported by DOE/AN, retain the responsibilities for development of instrumentation to observe nuclear explosions in space and the atmosphere. Specifically, the two laboratories are responsible for instrument design, fabrication, test, calibration, launch, operational support, and data interpretation in support of the Air Force, which has the operational mission. The NED program at Los Alamos is now examining potential modifications to future satellite systems in response to a significantly modified geopolitical environment that will dictate an increased interest in the emergence of new nuclear-capable nations rather than the possible violation of the LTBT by a second superpower. It is our hope that the future space-based NUDET detection system (NDS) can be made more compact and may be carried aboard a single satellite system such as the GPS. We have begun a study of this possibility while waiting for the U.S. government to update the national monitoring requirements.

In the arena of atmospheric, underground, and underwater nuclear explosions, we feel it is necessary to consider the possible impact of either a Comprehensive Test Ban Treaty (CTBT) or an equivalently difficult-to-monitor, very low yield TTBT. There are many plausible evasion scenarios involving underwater, underground, atmospheric, and high-altitude explosions. Such potential evasion techniques should be clearly identified along with possible remedies. If current technologies are lacking, then supplemental technologies should be

identified and investigated. A thorough examination of the national technical means for nuclear explosion monitoring is in order, and we propose such a task for FY94.

The rising importance of detecting new nuclear-capable nations plus the potential requirements for verifying a new test ban treaty will make the use of multiple phenomena for detection and discrimination of nuclear events all the more critical. Accordingly, we have structured our NED research plan around the following activities:

- Development of an independent electromagnetic pulse detector for the GPS NDS. An experimental version of such a system will be demonstrated on-orbit upon successful completion of the FORTE project.
- Discrimination of seismic events from nuclear explosions associated with noncalibrated test sites or hidden amongst the world's quarrying activities. To accomplish this goal, we are redirecting the R&D activities associated with the hydrodynamic yield work to the technically related Low Pressure Equation of State project. This effort will supplement the continuing Source Region Analysis project which seeks to achieve a quantitative interpretation of seismic signals from noncalibrated test sites.
- Development of a new monitoring system for detecting atmospheric and partially buried explosions. If successful, the Remotely Observed Signatures in the Thermosphere of Explosive Releases (ROSTER) project could result in a new worldwide capability for detecting clandestine explosions.
- Discrimination of underground tests (UGTs) from earthquakes using infrasonics and from quarry blasts with a variation of the ionospheric detection system called Explosion Detection using Ionospheric Techniques (EDIT).
- Investigation of the possibility of utilizing existing hydroacoustic assets for oceanic monitoring.

6.2 FY94 NUCLEAR EXPLOSION DETECTION PROJECTS

ST140A: Blackbeard/FORTE
Status: Current

This project is directed towards the development and flight test of an advanced rf-detection and -characterization system aboard a small spacecraft. On-orbit capabilities and data collection will begin with the Blackbeard instrument aboard the ALEXIS spacecraft. Emphasis is on proliferation detection technology for discovery of covert nuclear weapons tests. Optical and rf signals are exploited simultaneously by means of joint FORTE efforts with Sandia. Major developments in rf and optical capabilities are being pursued at both laboratories to increase detectability and improve false signal discrimination for GPS Block-IIF. (Note: a portion of this project's operating budget is for developing a multipurpose satellite bus and is included in the FY94 program total for Remote Sensing projects, on p. 21.)

ST253: Source Region Analysis
Status: Current

The purpose of this project is to better understand how source region effects on verification signals can affect monitoring capabilities. A multidisciplinary effort involving an integrated analysis of ground-motion, seismic, atmospheric, and geologic data with calculations is used to improve our understanding of explosion-source phenomena. The results will be synthesized in a verification framework that can be used to formulate improved test ban monitoring strategies. Current emphasis involves analysis and modeling of NTS data through the inelastic zone (between ~10 and 100 m/kt$^{1/3}$) into the linear regime. Effects of different explosion-source processes on far-field seismic and atmospheric signals used for underground test monitoring will be evaluated through data analysis and modeling efforts. In order to

address test ban issues in a nonproliferation environment, the project will be extended to investigate phenomena in widely different geologic materials and emplacement conditions. This will be done through a series of intermediate-scale, high-energy explosion-source experiments conducted in widely different geologic media.

ST504: ROSTER
Status: Current

ROSTER is a method of characterizing explosions down to subkiloton levels by analysis of far-infrasound signals propagated in the ground-thermosphere waveguide over global distances.

ST005A: Satellite Flight Systems
Status: Current

This project provides satellite equipment supporting DOE missions for continuous monitoring for events within the earth's atmosphere or in neighboring interplanetary space. Treaty verification, proliferation detection, and military goals are supported. In keeping with the changing national priorities, the decision has been made to reduce the instrument fabrication rate from one system per year to one system per 18 months for the last three AVF systems. This will allow Los Alamos to meet Air Force schedules while saving DOE $5.2M in FY94–95.

LA027: GPS/NDS Block-IIF Definition
Status: New

In anticipation of policy and programmatic decisions currently being debated, this project will define an alternative method of meeting the nation's NUDET detection requirements. Specifically, the project will determine the technical and engineering feasibility, the performance achievable, and the costs of meeting future NUDET detection requirements from a GPS Block-IIF platform. Air Force acquisition schedules for Block-IIF dictate that this option be specified no later than mid-CY94, requiring intense activity until that time and continuing but lesser support of those activities afterwards. Key technical and programmatic issues will be addressed through analyses and confirming laboratory experiments, with space validation experiments defined as required. A utility assessment will be made emphasizing the detection, location, and characterization of entry-level nuclear weapons.

ST006A: Satellite User Support
Status: Current

The objective of this project is to provide technical support for users of satellite programs which detect events in space. The work also provides data analysis and interpretation of sensor outputs to meet mission requirements.

LA033: Explosion Data Management
Status: New

This project organizes all the data obtained in NTS field experiments that are relevant to the study of underground explosion phenomena into an integrated classified database. It establishes quality assurance measures, links with databases containing geophysical information needed for interpretation of the data, and links to other DOE databases. The project develops a standard reporting format that can be applied to the database for documentation of the field experiments. Products are reports and/or properly archived data from the nuclear testing program.

ST013B: Satellite Technology Development
Status: Current

This project provides the technology base for improving existing satellite detectors and developing new detectors to meet existing or future treaty verification and proliferation detection requirements. This effort includes (1) ALEXIS flight operations and data exploitation, (2) adaptation of the Plasma Composition Analyzer (PCA) to nonproliferation applications, and (3) Advanced Photon Detection Concepts (APDC) emphasizing adequate performance at greatly reduced power, weight, and volume requirements.

LA034: Assessment of Detection Evasion Methods
Status: New

This project assesses methods for suppressing or disguising the seismic signal from an underground nuclear explosion. Evasion

scenarios using cavities, rubble zones, or rock mass modification are examined in the context of common mining and petroleum industry practices. Numerical modeling of the seismic source region is used to gauge the effectiveness of these methods in preventing detection and discrimination by remote seismic monitoring. The product is a realistic appraisal of a set of methods that could be used to conduct clandestine tests.

LA035: Ocean Acoustic Monitoring for Explosions
Status: New

The Laboratory will work with other agencies to determine requirements for ocean monitoring of underwater explosions. Using its experience in nuclear phenomena, sensor design, and modeling, the Laboratory can participate in the development of an integrated program for explosion monitoring in the oceans, including areas with concerns regarding proliferation.

ST098: Theoretical Support of NUDET EMP Detection Program
Status: Current

This theoretical project will support the DOE's mission to detect and discriminate NUDETs in support of the government's nonproliferation and verification requirements. A strong theoretical understanding of nuclear weapons phenomena is essential to accomplishing this mission. Los Alamos will extend and maintain the capabilities of computer codes on fireball development and electromagnetic pulse (EMP) generation. In addition, Los Alamos will develop codes to investigate the physical phenomena associated with nuclear explosions. This project will provide the theoretical backbone for both the Los Alamos and Sandia efforts in this arena.

ST101A: FEWS Development
Status: Current

This project will support the development of generic technologies for Payload 3 instrumentation. The schedule and tasks are predicated on the resumption of funding for ST100A in FY95 and on the current FEWS schedule.

ST638: Low-Pressure Equation of State Experiments and Modeling
Status: Current

This work develops theoretical models, laboratory experiments, instrumentation, and computational algorithms required to characterize the behavior of geological materials subject to divergent stress waves in the pressure range of from several tenths to several tens of gigapascals. Products are constitutive equations, developed from first principles for different geological materials, that are required for calculations of the propagation through the inelastic zone of stress waves produced by underground chemical or nuclear explosions.

LA015: NDS System Model
Status: New

Los Alamos will undertake a study of the current U.S. capabilities for detecting, discriminating, and analyzing nuclear explosions worldwide and in near-earth space. The study will encompass the performance of current systems and of currently projected systems into the next century. To benchmark these system capabilities, we will develop a set of testing and evasion scenarios which we judge adequately span the foreseeable future. The performance of this NDS against this set of scenarios will be compared with the currently extant set of requirements as established by the interagency community (Joint Atomic Energy Intelligence Committee). The study will be divided into several areas which include monitoring for underground, partially buried, underwater, low-altitude, and high-altitude atmospheric and space nuclear explosions. This work will result in a written report and at least two extensive briefing packages to be presented to DOE/AN and the interagency community. The study will be completed by the end of January 1994.

ST679A: GPS/NDS Reserve Auxiliary Payload
Status: Current

Los Alamos will support the design of an instrumentation payload and processing system to use data from the GPS satellites' NDS optical and electromagnetic pulse sensors to significantly improve thresholds for detecting and locating low-performance explosions in the earth's atmosphere.

ST604: Effects of Nonlinear Wave Propagation on Seismic Monitoring
Status: Current

This project evolved out of an Advanced Concepts Project that was funded at Los Alamos in FY91–92. Laboratory measurements have been made that illustrate the effects of nonlinear elastic wave interactions on a seismic spectrum. The project will be expanded to investigate the effects of nonlinear wave propagation and attenuation from explosion sources at intermediate strain levels. The project involves both a laboratory component and a computational component. The goal will be to investigate the effects of nonlinear wave propagation acting at intermediate strains (10^{-3} to 10^{-7}) at scaled ranges of 102 to 104 $m/kt^{1/3}$ on explosion-source reduced displacement potentials (RDPs). The lab measurements will be compared with finite-difference calculations in an effort to quantify the potential magnitude of the effects on radiated verification signals. This project involves collaboration between Los Alamos (small-strain lab experiments and calculations) and Livermore (intermediate-strain lab experiments).

LA016: Survey of Large Mining Explosions in Potential Proliferant Nation
Status: New

The purpose of this project is to perform a survey of mining activity in potential proliferant nations. We will identify the mining regions most likely to be used to detonate a clandestine nuclear explosion so that they can be targeted for surveillance and special data collection efforts. We will concentrate on identifying mines that regularly conduct large chemical explosions that could be used to complicate signals from a simultaneously fired, decoupled nuclear explosion. Initial targeting of mining activities will be obtained from U.S. Bureau of Mines information, various international mining journals, and other sources. The types of mining activities and blasting operations will be described. Follow-on studies in subsequent years will involve expanding the survey to other countries and to initiate data collection efforts pertaining to the identified mining regions of concern.

ST680: Explosion Discrimination Using Ionospheric Techniques (EDIT)
Status: Current

EDIT will develop a system to discriminate among various types of seismic sources by observing their signatures in the ionosphere above the source using rf remote sensing techniques.

ST605: Acoustic Discrimination of Earthquakes
Status: Current

In the future, the United States may take part in a very low yield test ban or a comprehensive test ban. Under such constraints, the detection and identification of a UGT, as such, will be of some importance. Accurate discrimination against earthquakes will be required in order to identify a test with certainty. The low-frequency acoustic waves generated by many earthquakes can be used in the discrimination process, supplementing other systems through the addition of independent information. Such additional information will obviously be of more use when considering weaker signals from smaller events.

7.0 EFFLUENT MONITORING

7.1 PROGRAM OVERVIEW

Allen Hartford

Effluent Monitoring is an integral part of the DOE/AN Remote Sensing, On-Site Verification, and Regional Measurement programs. We have developed an integrated Laboratory program to provide support for treaty monitoring, special inspections (e.g., the U.N. Special Commission in Iraq), International Atomic Energy Agency (IAEA) safeguards, intelligence assessment, quick response requests, and related nonproliferation and arms control projects. Our research and development program is based upon the unique set of capabilities and expertise that exists at Los Alamos. Special attention has been devoted to coordinating our research and development activities with existing programs at other national laboratories to minimize duplication of activities. All parts of our program have been evaluated using the following set of criteria: technical merit (significant advance in current technology), applicability to current and anticipated national needs, value of data to assessment and policy making, and cost-effectiveness.

Effluent Monitoring projects are supported under all the areas of nonproliferation and arms control research and development. In this section we have only addressed those programs that are related directly to the collection, analysis, and assessment of gaseous, liquid, and solid samples. Other Effluent Monitoring projects, including lidar and radiation detection technologies, are discussed in other sections.

Prior to FY93 most of our research and development activities in effluent monitoring were in support of environmental monitoring, intelligence collection, and DoD chemical weapon programs. We had developed a number of portable and transportable instruments for the detection of trace compounds. One of our initial successes was the development and deployment of gas chromatography/mass spectrometer systems in support of DoD programs. This technology has served as the basis for a number of projects currently being supported under NAC programs. In the environmental arena we have developed the unique capability for detection of ultratrace quantities (10^6 to 10^7 atoms) of Pu in soil and water samples, with precise isotopic information from slightly larger samples. These plus similar technologies have been applied to solving many of the environmental restoration problems throughout the DOE complex. Ultraprecise mass spectrometry methods (more than an order of magnitude more precise than National Institute of Standards and Technology/New Brunswick Laboratory-certified standards) have been developed and transferred to the IAEA for use in nuclear safeguards verification.

We have projected significant increases in Effluent Monitoring programs at Los Alamos this year and into the future. This will involve expansion of the relatively small FY93 program explicitly categorized as Effluent Monitoring, as well as expansion of the closely associated programs in lidar and radiation detection. The combined programs should exhibit considerable growth in FY94, FY95, and FY96.

Many of the technologies that have been developed for weapons development and testing programs and for environmental monitoring programs are directly applicable to nonproliferation and arms control. Los Alamos has the only complete weapons fabrication capabilities existing within the DOE complex. We can handle all the hazardous and nuclear materials associated with a nuclear weapons

development program. This permits the direct evaluation of the instrumentation and techniques to real-world situations.

During the past year we have completed the demonstration of the photon burst method for the ultrasensitive detection of krypton-85 in air samples. This project represents the most sensitive method for detection of this fission product gas in the $10^{-10} - 10^{-15}$ range using a magnetic sector mass spectrometer and photon burst detection of the exiting ions. This technology is available for transfer; however, during this past year the mission of the primary customer of this technology has been redefined.

Three instrumentation projects have been initiated during this past year: Miniaturized Mass Spectrometer; U/Pu Isotopic Instrumentation; and Hand-Held Spectrometer. The miniaturized mass spectrometer is the size of a beer can and has a wide dynamic range and high sensitivity for the overt or covert field analysis of volatile organic compounds. The U/Pu isotopic system provides a rapid method for the isotopic analysis of U/Pu environmental samples. The portable (hand-held) spectrometer can be used to analyze both volatile organic compounds (gas-phase absorption) and surface films (fluorescence-excitation mode).

Research in the development of novel selective sorbents based upon modified zeolites has been initiated this year. These sorbents can be engineered with selectivity based on either surface properties or size exclusion properties.

For FY94 we have significantly expanded our Effluent Monitoring program to address the needs of DOE/AN Remote Sensing, On-Site Verification, and Regional Measurement programs for nonproliferation and arms control. We have developed a long-term research and development program focussed on five basic areas:

1. Instrumentation/methods for the rapid detection of unique signatures indicative of proliferation activities (Yes/No indicators). In addition to the U/Pu Isotopic Instrumentation and the Hand-Held Spectrometer, we have identified several projects in the area of analytical sensors that are directly applicable to current monitoring requirements. These activities will complement related activities being conducted at Sandia, Livermore, and Oak Ridge National Laboratory.
2. Instrumentation/methods for on-site analysis of environmental (swipe) or bulk samples. Several new technologies are being developed in this area. These include the development of instrumentation that will be able to reduce the detection limits for volatile organic compounds to several orders magnitude below existing technologies. Current detection requirements have been established in the parts-per-trillion (ppt) range. This technology will reduce the detection sensitivity limits to well below 1 ppt, or in the parts-per-quadrillion range. This will greatly extend the applicability of perimeter monitoring in nonproliferation and arms control.
3. Remote/off-site monitoring (overt or covert) for analysis of effluent samples. Proposals in this area include the measurement and correlation of carbon-14 in wood samples to the operating histories of reactors and reprocessing facilities, particle-size distribution analysis to discriminate the origin of particulates, and novel sample collection methods using high-gradient magnetic separation (HGMS). The HGMS method is independent of the chemical form of the actinide or fission product. This method has the potential of concentrating actinides and fission products in liquid samples five to six orders of magnitude better than the methods currently used—for example, in Iraq.
4. Sample collection and laboratory analytical instrumentation/methods. These projects include sample collection and laboratory analysis projects. The Laser Sampling Ion Trap Mass Spectrometry project will result in a rapid, highly sensitive method for the analysis of both organic and inorganic materials. This technique has the sensitivity to detect picograms of chemical compounds in 100 μg of soil.
5. Integration of effluent monitoring methods/systems. The results obtained from the various monitoring systems must be integrated into the assessment process; therefore, we have identified this area within the Effluent Monitoring program. In the future this area will expand to approximately 10% of our activities.

7.2 FY94 EFFLUENT MONITORING PROJECTS

ST104: Photon Burst Mass Spectrometry
Status: Current

This project is to develop a technique to measure noble gas isotope ratios to the 10^{-10} to 10^{-15} range using a magnetic sector mass spectrometer and photon burst detection of the exiting ions. This is a collaborative effort between Colorado State University (CSU) and Los Alamos. CSU will develop a highly selective photon burst detector for noble gas ions, and Los Alamos will research clean and efficient ion sources for our dynamic gas mass spectrometer. The detector and spectrometer will then be integrated.

ST342: A Highly Miniaturized Mass Spectrometer
Status: Current

Los Alamos will develop and demonstrate a highly miniaturized mass spectrometer based on advanced ion-trap and data processing technology for field analysis of airborne volatile organic compounds used in the production of nuclear and chemical weapons or in the development of directed energy weapons. The instrument will be hand-portable and battery operated. Data acquisition will be real-time. Results can be sent back via telemetry for interpretation by scientific personnel.

ST619: Field Instrumentation for Uranium and Plutonium Isotopics
Status: Current

Los Alamos will develop field instrumentation and analytical methods for isotopic analysis of solid uranium compounds. The analytical method is based on the oxidation of uranium compounds to volatile fluorides, which are mass spectrometrically analyzed for their isotopic signatures. The analytical instruments will be made field ready, complete with sample pretreatment manifold, mass spectrometer, and uninterruptable electrical backup systems.

ST592: Hand-Held Optical Spectrometer
Status: New

Los Alamos will develop, test, evaluate, calibrate, and field a prototype hand-held optical spectrometer based on an optical excitation source, miniaturized monochromator (or interference filter), CCD detector, Peltier cooler, and microprocessor control. The capability to detect materials used in the processing, reprocessing, and machining of nuclear materials and various radiochemical detector elements can provide valuable information relating to the processing of nuclear materials and the sophistication of a country's nuclear technology.

ST852: Selective Sorbents
Status: Current

This project will develop chemically engineered sorbents with special adsorption capabilities for binding chemicals of consequence in the production of nuclear and chemical weapons. These sorbents will be designed for use in the chemical industry to detect evidence of either violation of treaties or proliferation activities in both chemical and nuclear technologies.

LA009: Monitoring Carbon-14 Emissions from Reactors and Reprocessing Plants
Status: New

This project is a study to determine the efficacy of using measurements of carbon-14 retained in vegetation around a nuclear reactor and/or reprocessing facility to monitor the chronological history of the facility. Carbon-14 is produced in the fuel and moderator of neutron reactors. The woody plants downstream of a reactor will store the carbon-14 through photosynthesis. The extent to which elevated carbon-14 levels can be measured and used as a measure of reactor activity depends on many factors, including meteorological conditions and reactor design. These dependencies will be investigated.

ST614: Bubble Chamber Spectroscopy
Status: Current

Bubble chamber spectroscopy is a new concept for measuring absorption spectra of dilute solutions. It monitors the energy deposition of light absorbed from a laser beam into a superheated solution. The deposited energy nucleates bubbles which grow to visible size. Bubble chamber spectroscopy has the potential to be an extremely sensitive technique for detecting and identifying trace chemicals in solution.

ST615: Origin of Particulate Samples by ADEM/SFT
Status: New

The Analytical Digital Electron Microscope (ADEM) provides a rapid method for measuring the size, shape, and chemistry of individual particles in large population samples. The Sequential Fragmentation/Transport (SFT) theory predicts a particle-size distribution that is directly related to the population's history of formation and transport. Together, these techniques will be tested and developed to discriminate the origin of particulates sampled for surveillance of nuclear testing and SNM production.

LA005: Perimeter Monitoring for Volatile Organic Compounds
Status: New

Los Alamos will develop and field-demonstrate hardware for high-sensitivity detection of airborne volatile organic compounds (VOCs). This instrumentation consists of patented preconcentration technology combined with membrane-sampling ion-trap mass spectrometry. Membrane-sampling technology will be used to introduce the concentrated VOCs to a transportable gas chromatograph/ion-trap spectrometer (GC/ITS). The proposed instrument will work in both a fast screening and confirmatory mode using chromatographic separation of contaminants.

LA006: Portable High-Sensitivity Krypton-Xenon Isotope Analyzer
Status: New

The aim of this project is to provide a lightweight, portable mass spectrometry system capable of analyzing the isotopic abundance of krypton and xenon in realtime (<5 min/sample). The major advantage of the proposed system compared with competing systems (e.g., conventional time-of-flight mass spectrometers or residual gas analyzers) is portability coupled with high accuracy. In final form, such a system would be hand-held with rechargeable batteries. The expected accuracy for ratios of xenon isotopes is ~0.1%.

LA007: On-Site LA-ICP-MS for Determining Elemental and Isotopic Composition in Solids
Status: New

Analysis methods for use with a fieldable Laser Ablation-Inductively Coupled Plasma-Mass Spectrometer (LA-ICP-MS) will be developed and tested. The methods will be used for the determination of isotopic ratios in soil and of the elemental composition of metals and alloys.

LA010: Magnetic Capture of TRU/FP Effluents
Status: New

A new portable, high-efficiency method of transuranic (TRU) and fission product (FP) collection from effluents will be developed. Because all actinide and many elements are slightly magnetic, strong magnets and high magnetic field gradients can be used to extract these materials from fluids. Calculations show that concentration factors of more than 10,000 may be possible for these elements. The project will produce a prototype instrument and demonstrate the feasibility of this concept.

ST618: Analysis of Ultrasmall Air Samples for Stable Krypton and Xenon Isotopics
Status: New

Los Alamos will assemble and test an instrument for determining the isotopic compositions of stable krypton and xenon from 10 cm^3 of air with reproducibility of 1 part in 10^5. The approach combines an unusual, very high sensitivity ion source with a noncommercial mass spectrometer. Highly accurate isotopic analyses allow remote identification of fission processes in use by potential proliferants.

LA030: Integration of Effluent Monitoring Technology
Status: New

This project will develop an integrated approach to the acquisition and analysis of information from effluent monitoring and other technologies for detecting proliferant activities for chemical or nuclear weapons.

LA012: Ultrasensitive Detection of Weapon Signatures
Status: New

Los Alamos will develop analytical methodologies for the direct analysis of volatile, semivolatile, and nonvolatile organic compounds and inorganic materials sorbed in or on environmental samples or specialized sampling matrices such as zeolites or fiber probes. This methodology will be based on the combination of laser sampling and ion-trap mass spectrometry. Compounds of analytical interest are not only those used in nuclear weapons production, but also chemicals used in the development of directed energy weapons in the manufacture of chemical weapons.

LA008: A Field-Portable Instrument for Standoff Atomic Analysis of Materials Associated with Nuclear Weapons Production
Status: New

A prototype portable analyzer will be developed and constructed which will provide elemental analyses of materials at distances up to tens of meters. The instrument will be based on laser-induced breakdown spectroscopy (LIBS). It will use a small, battery-powered laser to form a microplasma at long distances. The light emitted from the plasma will be analyzed to detect the emitting atomic species. The prototype will be tested and evaluated for the detection of elements (U, Pu, Be) and for the identification of metals. The device will be easy to use, require no sample retrieval, and provide rapid, simultaneous detection of many elements.

LA011: Atmospheric Aerosol Chemistry Analyzer (AACA)
Status: New

The elemental composition of airborne particles emitted from nuclear and chemical facilities is a multivariate signature of the processes occurring within them. Los Alamos proposes to demonstrate the technical feasibility of a robust, transportable AACA that will provide a timely analysis of the elemental composition of atmospheric aerosols. The prototype instrument is expected to achieve detection limits of <40 ng/m^3 for most elements in the periodic table, with approximately a one hour or better analysis time.

LA003: Integrated Optical Chemical Sensors for Halogenated Hydrocarbons
Status: New

An ultrasensitive detector of trace chemical species utilizing all-optical waveguide techniques in conjunction with species-selective surface chemistry will be designed and tested. The instrument will take advantage of phase shifts in guided optical waves induced by refractive index changes due to the reaction of the analyte with a specially designed surface layer. The surface layers will consist of self-assembled multilayers of reagent species, having high selectivity for the analyte, covalently bonded to the oxide surface of the optical waveguide.

8.0 ARMS REDUCTIONS

8.1 PROGRAM OVERVIEW

Dramatic changes in the world political environment in recent years have shifted arms control emphasis from traditional bilateral treaty verification to more-challenging objectives such as accounting for the disposition of decommissioned nuclear weapons or detecting clandestine programs for weapons of mass destruction. The principal objective of the Arms Reductions program is to ensure that verification and monitoring systems needed to meet our changing national interests are adequate, achievable, and cost-effective. The program will meet these objectives through the following coordinated efforts:

- Interaction of technical experts from the Los Alamos with members of the arms control and nonproliferation community to obtain a full understanding of policy/ technology issues;
- Evaluation of arms control regime options and determination of the adequacy and effectiveness of monitoring approaches;
- Development of advanced technologies and methodologies meeting current and future arms control and nonproliferation needs; and
- Provision of technical support for DOE arms control negotiations.

The technologies and methodologies developed by the Arms Reductions program can be used in a wide variety of arms control and nonproliferation applications. These applications include the following:

- Verification of bilateral and multilateral arms control treaties, both extant and future;
- Monitoring approaches in support of nuclear warhead dismantlement or possible future measures controlling SNM used in nuclear weapons;
- Monitoring approaches (including transparency and other confidence-building measures) in support of unilateral strategic arms reductions, limitations, or demonstrations; and
- Ground-based, short- and long-term monitoring, supporting on-site inspections (with or without benefit of a formal treaty) to detect proliferation of weapons of mass destruction.

Kenneth Apt

An essential feature of arms control regimes has been the ability to monitor compliance. Often this ability translates to verifying highly technical aspects of an agreement. The multidisciplinary expertise of the Laboratory is being used to establish effective methods for verification and monitoring so that the credibility—and ultimately the long-term success—of arms control agreements can be assured. However, as emphasis on strict treaty verification gives way to less quantifiable "assurances" in arms control, methods and technologies must be adapted to new approaches for meeting national security objectives. Accordingly, the Arms Reductions program purview includes new concepts such as transparency and proliferation detection. Moreover, the framework for arms control monitoring is no longer strictly limited to the old bilateral superpower context but now includes new multinational contexts (such as the one experienced by the U.N. Special Commission in Iraq) as well as mutual, unilateral arms initiatives.

The technologies and methodologies developed in this program are aimed primarily at reductions in strategic nuclear weapons and other weapons of mass destruction. Treaties relevant to this objective include START, START II, and INF. Monitoring approaches for international agreements dealing with nonstrategic arms are also addressed by this program.

These agreements include CFE, CWC, the Open Skies Agreement, and the United States–Russia agreements to destroy their respective chemical weapon stockpiles.

Radiation-based technologies represent the mainstay of the Arms Reductions program. Strategic nuclear weapons (and SNM from weapons) have characteristic radiation signatures that can be exploited for purposes of detection, identification, and quantification. Traditionally, radiation detection and measurement systems have been applied to the verification of the START and INF agreements, but these capabilities also can be adapted to new requirements in arms reduction.

Los Alamos has been a leader in the development and exploitation of radiation-based technologies. As an example, the Laboratory developed the Nuclear Arms Verification Instrument (NAVI), a small, easy-to-use instrument for low-resolution gamma-ray spectroscopy designed to meet the needs of on-site treaty inspection. NAVI has utility in inspection scenarios involving distinguishability measurements (demonstrating that an item declared nonnuclear by a treaty signatory indeed harbors no significant amount of SNM) and in warhead counting (determining that a missile carries no more warhead reentry vehicles than permitted under treaty terms). In addition to its technical expertise, the Laboratory maintains the Los Alamos Simulation Facility, which is the only thin-walled structure in the United States that can accommodate multiple nuclear-explosive-like assemblies. These mock nuclear devices at the facility are used for training and for development and testing of systems used for on-site inspection.

The Laboratory will build on its strength in radiation-based technologies according to the nature of the new challenges in monitoring and verification. Because of the continuing importance of nuclear weaponry in bilateral strategic postures and in proliferation, radiation-based technologies are expected to play an important role in future monitoring and detection approaches. Specifically, radiation detection will need to be evaluated for (1) possible follow-on agreements to START and START II, (2) warhead identification and dismantlement scenarios, (3) measures aimed at international control of SNM used in weapons, and (4) nuclear proliferation detection. Proliferation detection can exploit many of the same nuclear technologies developed for treaty verification (e.g., for START and the Nuclear Nonproliferation Treaty [NPT]) and for nuclear material security. Thus, the Arms Reductions program maintains a strong programmatic focus in the area of radiation detection and measurement. New and continuing projects will focus on the development of radiation-based systems to meet these new and more challenging scenarios.

Additionally, the Arms Reductions program makes use of the Laboratory's broad technical expertise outside of the area of radiation detection. One such project involves the evaluation of nonradiation-based technologies that might be used in a warhead dismantlement regime. This project makes use of the Laboratory's diverse expertise in electronics, calorimetry, radiography, thermal imagery, and acoustics. In another area, the Laboratory's chemical detection and analysis capabilities have important applications in verification of the United States–Russia chemical weapon reduction agreement and the recently completed CWC. Advanced acoustic-based methods have been developed for nondestructive evaluation of chemical weapon items as well as larger treaty-limited items. We expect that innovative approaches for nondestructive evaluation of strategic and other arms will continue to be needed.

8.2 FY94 ARMS REDUCTIONS PROJECTS

ST656: Long-Range Alpha Detector (LRAD)
Status: Current

The LRAD system has the capability to sensitively detect alpha radiation from a distance of up to several meters. The scope of this project will include (as required) design and construction of a detector optimized for an on-site monitoring and long-term surveillance role, field demonstration of the detector, transfer of the technology to non-DOE agencies as applicable, complete documentation, and user training for (1) a medium-sized object monitor, (2) a small surface monitor, (3) a gaseous effluent monitor, (4) a liquid effluent monitor, and (5) a personnel monitor.

LA031: Integration of the Hand-Held Miniature MCA with Room Temperature Detectors
Status: New

This project will adapt the hand-held miniature multichannel analyzer (MCA) to compact, low-resolution applications for field detection and isotopic determination of SNM and for on-site inspection associated with proliferation activities. The miniature MCA is under development in DOE/AN/S&T project ST657A for high-resolution applications involving a compressor-cooled high-purity germanium detector.

ST657A: Robust, Portable Instrumentation for Monitoring Radioactive Materials
Status: Current

This project will further miniaturize the robust, portable MCA under development at Los Alamos and develop interfaces for coupling the analyzer with portable detector systems. The analyzer will be mated to a compressor-cooled detector system supplied by NRAD. For future applications, the miniaturized electronics architecture is being designed to accommodate front-panel customization and specialized packaging. The intent is to replace existing measurement systems with smaller, intelligent packages that can operate unattended.

LA022: Combined Gamma-Neutron Instrument
Status: New

This project will develop and evaluate a prototype, lightweight, combined neutron and gamma-ray spectrometer that can uniquely identify, characterize, and assay SNM and associated matrix material without removing them from their containment vessel. The instrument uniquely identifies and measures the energy of neutrons over a broad energy range spanning 0 to 10 MeV and of gamma rays over the energy range spanning 200 keV to 5 MeV. The detection technique lends itself to a modest directional-sensing capability for gamma rays, thereby decreasing backgrounds.

ST856: Alternate Methods of Warhead Identification
Status: Current

A series of broad-based measurement techniques will be developed that could be used to establish with high probability that an unknown item is a nuclear warhead. Properties to be measured would include, but are not limited to, physical dimensions and mass, thermal, and structural properties. Techniques used include calorimetry, ultrasonics, modal analysis, and acoustic resonance spectroscopy. Two to four of the most promising of these techniques will be evaluated for confidence in measurements and their intrusiveness. The efficacy of an analytical hierarchy employing these nonintrusive techniques will be evaluated.

LA014: Radiation Direction Finder
Status: New

This project will develop and demonstrate a detector to determine in realtime the intensity, direction, and type of an unknown radiation source, particularly for fission neutrons, at tens of meters. Los Alamos will then determine the feasibility of extending the project to produce a fieldable prototype.

ST135: AVT/Associated Particle Imaging
Status: Current

Associated particle imaging is an "active" neutron interrogation technique for nuclear discrimination warhead counting and rocket motor discrimination. The technique will generate low-resolution, three-dimensional images of selected materials and identify their elemental composition. The appropriate detectors, a neutron generator, and other hardware and software will be assembled and evaluated.

ST138: AVT/Simulation Facility
Status: Current

A facility will be maintained and used mainly to determine equipment performance and adequacy of test procedures. This function is a continuation from the previous fiscal year.

The equipment will also be used for training operators and for development and refinement of measurement test procedures. The Los Alamos facility is unique for testing verification experiments or equipment prototypes.

ST633: Application of Neutron Multiplicity Counters
Status: Current

This project will investigate the applicability of passive- and active-neutron multiplicity counters for identification and monitoring of dismantled nuclear weapons components.

ST655: Field Neutron Spectrometer
Status: Current

Los Alamos will develop and field-test a prototype neutron instrument that uniquely identifies SNM. The instrument has high sensitivity for fission neutrons and good rejection for other backgrounds, thus allowing detection of SNM at tens of meters.

ST076I: Tag Red Team
Status: Current

The Python Fiber-Optic Seal design will be reviewed during development to identify design faults from the viewpoint of an adversary. Additional vulnerability assessment efforts of Los Alamos/Pacific Northwest Laboratory tamper tapes, Argonne National Laboratory SSEM surface roughness tag, and EID devices will be conducted. Tag/seal system archival documentation will be supported as requested.

LA024: NDE Utilization Plan for CW Verification
Status: New

This project will establish a coherent utilization plan for nondestructive evaluation (NDE) methods used in verification of U.S.-Russian bilateral chemical weapons (CW) agreements and the CWC. A hierarchical utilization plan, based on a sequential measurement strategy of increasingly sophisticated NDE methods, will be developed for the NDE techniques selected for bilateral and multilateral CW verification. These techniques currently include the UPE, ARS, and PINS methods. The utilization plan will maximize confidence in stockpile NDE measurements and minimize costs, time, and other technical factors.

LA025: Driven Uranium-235 Multiplication
Status: New

This project draws on NEST hardware to develop procedures for measuring the neutron multiplication of uranium-235-bearing objects, a potentially unique identifier of such objects. The procedures require an external neutron source. Algorithms for deducing multiplication will be developed, and a dedicated multiplication system procured. Tests will be conducted against uranium-235 assemblies at the Los Alamos Simulation Facility and elsewhere.

LA032: Geophysical Detection Technologies
Status: New

Los Alamos will investigate the utility of different geophysical techniques for detection and location of suspect buried weapons facilities. Background information will be obtained regarding the nature of potential facilities to be targeted. Los Alamos will select realistic sites at which to conduct experiments to determine the sensitivity of the different techniques. Analogous sites will be evaluated and made available to all nonproliferation researchers to benchmark their detection and characterization instrumentation and methods.

9.0 INTERNATIONAL SAFEGUARDS

9.1 INTRODUCTION

More than 50 years after the discovery of nuclear fission, nuclear materials, technology, and facilities are now widespread around the world. Dozens of countries now have significant levels of nuclear activity. Although most of these nuclear activities, outside of a relatively small number of countries possessing nuclear weapons, are peaceful in nature, they present potential proliferation risks. Through a series of treaties and other agreements, the most prominent of which is the NPT, the world community has established a system of international safeguards to help limit these risks. The objective of international safeguards is to deter nuclear proliferation by implementing technical measures capable of detecting the diversion of nuclear materials or the misuse of nuclear facilities and technology. These technical measures are based primarily on nuclear materials accounting, containment, and surveillance by instruments or on-site inspectors.

International safeguards are one part of the overall nuclear nonproliferation framework, which consists of a broad array of technical and policy elements designed to work together to control the spread of nuclear weapons. In addition to international safeguards, these elements include treaties and agreements such as the NPT, a system of export controls to limit the diffusion of sensitive technologies, national intelligence programs to analyze proliferation trends and proliferant activities, programs and procedures to protect classified or sensitive nuclear information, and a variety of other technical, political, and diplomatic measures. In the past, these elements have not always been fully integrated. In the future, it is expected that international safeguards and other nonproliferation elements such as export controls and national intelligence programs will interact more closely than they have in the past. Strengthening these interactions is an integral part of the NAC program plan.

Mark Mullen

9.2 LOS ALAMOS AND INTERNATIONAL SAFEGUARDS

Since the 1960s Los Alamos has been the DOE's lead laboratory/center of excellence in nuclear materials control and accounting (MC&A). Because many of the fundamental technical measures used in international safeguards are based largely on MC&A, the Laboratory has played a significant role in creating the technical basis for international safeguards. For more than 25 years, the Laboratory has

- Developed and implemented nuclear measurement technology, including a significant fraction of the technology base for the IAEA's system of safeguards;
- Successfully transferred much of its safeguards technology out of the laboratory and directly into the hands of users and the commercial sector;
- Designed safeguards systems and procedures for the complete nuclear fuel cycle, with particular emphasis on the most complex and sensitive nuclear facilities such as spent fuel reprocessing plants, enrichment plants, and plutonium facilities;
- Trained international inspectors and other safeguards professionals from around the world;

- Developed and implemented advanced safeguards technologies, including safeguards applications of automation and continuous, unattended monitoring;
- Developed advanced safeguards data evaluation and information management methods and systems for international safeguards;
- Participated in international exchanges to improve safeguards; and
- Provided technical support to U.S. policy initiatives aimed at strengthening safeguards.

Figure 1 presents a sampling of current and recent Laboratory activities in international safeguards. The breadth and depth of capabilities and experience represented by the International Safeguards program at the Laboratory is unmatched by any other laboratory program in the world.

9.3 ANTICIPATED TRENDS IN INTERNATIONAL SAFEGUARDS

International safeguards have gone through several periods of rapid change in the past. Key events included

- The Atoms-for-Peace era and the foundation of the IAEA in the 1950s;
- The entry into force of the NPT in 1970; and
- The rapid worldwide growth of the commercial nuclear industry in the 1970s and the accompanying heightened interest in nuclear proliferation.

For the reasons discussed in Sec. 1 of this Integrated Program Plan, the next few years will be a period of equally significant change. Several examples are discussed below.

9.3.1 Special Inspections

Although the issue of IAEA special inspections had been raised earlier (e.g., at the last NPT Review Conference in 1990), the discovery of a vast, clandestine nuclear program in Iraq has given a high priority to a fundamental reexamination of the role of special inspections in international safeguards. The IAEA will face several difficult situations in the years ahead in which special inspections will be needed to investigate and resolve doubts about compliance with safeguards agreements or nonproliferation commitments. In essence, a special inspection is one that goes beyond the bounds of reported nuclear materials, facilities, and locations and looks for evidence of unreported activities. Because this situation is very different from the usual practice in international safeguards, new technical approaches, methods, and procedures are needed. The contributions of Los Alamos in this new area will continue to draw on the core disciplines of the safeguards program: radiation detection, radiation measurement, analytical chemistry, instrumentation engineering, information management, data evaluation, and systems analysis. In addition, sophisticated capabilities in information management, nuclear emergency search technology, environmental sampling and analysis, and remote monitoring will be drawn from other parts of the Laboratory to develop new special inspection approaches.

9.3.2 Former Soviet Union

The disintegration of the former USSR has created many urgent challenges for international safeguards. Critical needs include the following:

- Strengthening of the capabilities of the former Soviet republics to safeguard their nuclear materials and facilities against sabotage, theft, diversion, black-market sale, or unauthorized possession or use. Programs to meet this need are still in their formative stages. However, Los Alamos has already begun to work with several of the republics on improving MC&A, both at facilities and at the national level. Ultimately, these programs are expected to include technology exchange, training, MC&A system development, technical assistance in safeguards implementation, and the provision of modern equipment, software, and information systems.
- Cooperation with the Russian Federation on transparency measures. In addition to assisting with domestic safeguards systems in Russia and the other republics, the Laboratory is assisting the U.S. government in considering possible systems of transparency measures by which the Russian Federation could provide certain nonproliferation assurances. Although the measures are not yet defined in detail, it is expected that they would rely to a significant extent on MC&A methods and thus would be similar in some respects to existing international safeguards. However, because Russia

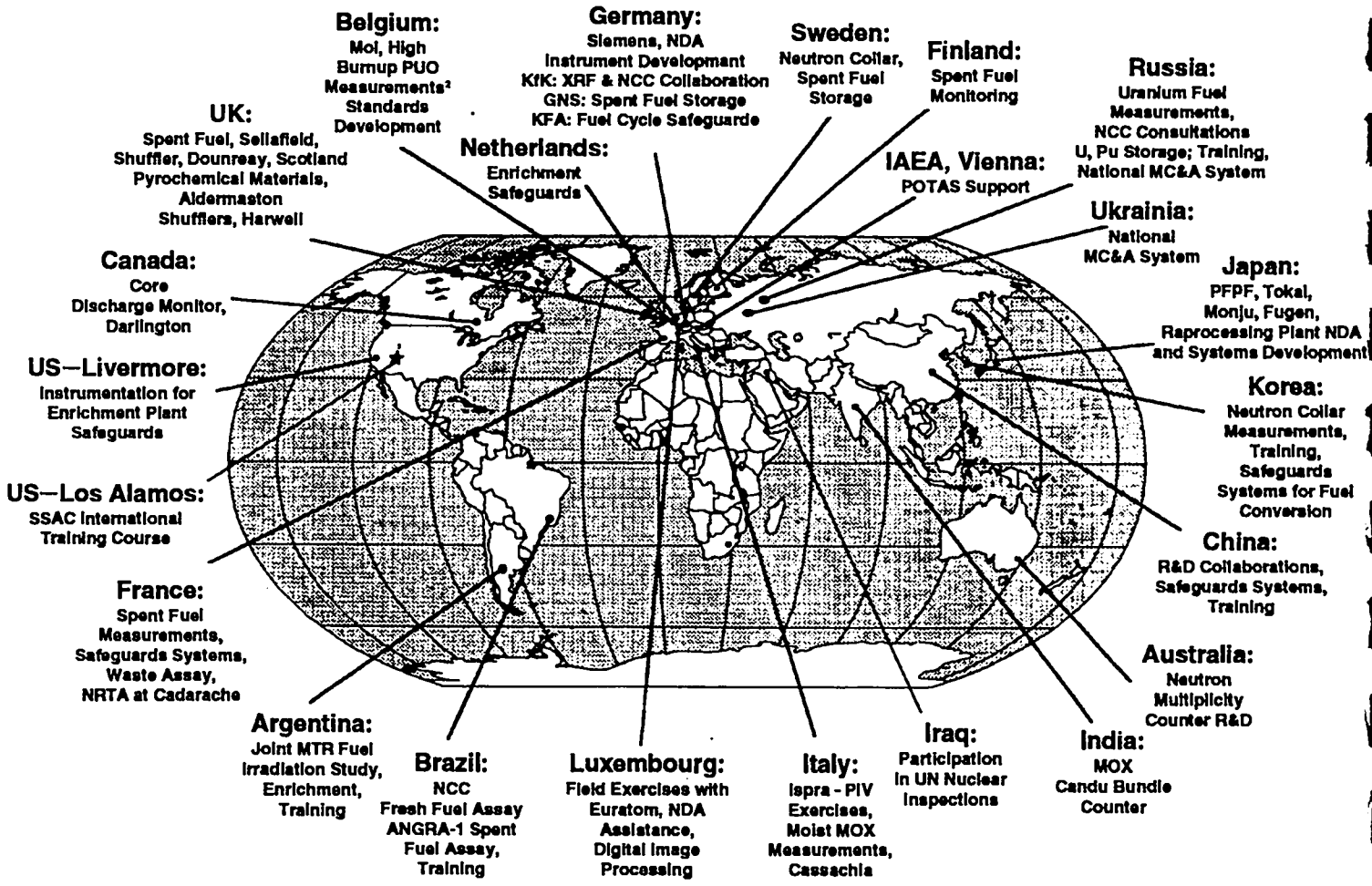


Figure 1. International Nuclear Materials Control Activities.

is a nuclear weapons state, among other reasons, there would probably be significant differences from traditional international safeguards. If transparency measures are agreed on and implemented, the Laboratory's international safeguards capabilities will be used for technical assistance and exchanges and for training and development of methods and technology.

- Support to possible future arms control initiatives. In addition to possible transparency measures, consideration has been given to recently proposed initiatives in arms control, including a verified cessation in production of fissile materials, comprehensive international safeguards on fissile materials, and verification of arms reduction. These ideas are not new, and Los Alamos has investigated many of them over the years. Their prospects for adoption are uncertain, although the recent dramatic changes in the nonproliferation and arms control climate have stimulated renewed interest in such ideas, at least in some quarters. Many of the technologies and approaches that have long been used in international safeguards are applicable in these contexts and will be brought to bear if these kinds of arms control initiatives are pursued.

9.3.3 Enhanced Safeguards for Nuclear Facilities

A continuing need exists for improvement of international safeguards at several key types of facilities, including reprocessing plants, enrichment plants, advanced reactors, research reactors, plutonium facilities, storage facilities, and long-term spent fuel repositories. These needs are driven partly by new facilities such as large-scale reprocessing plants and enrichment facilities using advanced aerodynamic nozzles and partly by trends in safeguards technology toward more use of automation, unattended monitoring, computerized inspection equipment, and other advanced technologies intended to improve effectiveness and conserve resources. In addition, many of the traditional practices of international safeguards need to be reexamined in the light of the political changes experienced in recent years. Los Alamos plans to continue making significant contributions toward enhancing safeguards, as we have in the past, by applying the Laboratory's broad technical capabilities to changing safeguards needs.

9.4 FY94 INTERNATIONAL SAFEGUARDS PROJECTS

SG010A: Safeguards Headquarters Support
Status: Current

This project provides a technical advisor to DOE/AN International Safeguards Division. The role of this advisor is to provide technical, management, and program direction advice to assist the International Safeguards Division in conducting its programmatic activities.

SG020A: Advanced Safeguards for BOG Issues
Status: Current

This project investigates advanced safeguards concepts, focussing on nuclear material measurement and integrated systems technology, that would enhance the verification techniques and capabilities of international, regional, and bilateral regimes to provide timely detection of a loss or diversion of nuclear material.

SG021A: Advanced Safeguards for Enrichment Plants
Status: Current

This project investigates advanced safeguards concepts, focussing on nuclear material measurement and integrated systems technology, that would enhance the verification techniques and capabilities of international, regional, and bilateral regimes to provide timely detection of a loss of enriched uranium or the production of highly enriched uranium at enrichment plants.

SG022A: Advanced Safeguards for Reprocessing Facilities
Status: Current

This project investigates advanced safeguards concepts, focussing on nuclear material measurement and integrated systems technology, that would enhance the verification techniques and capabilities of international, regional, and bilateral regimes to provide timely detection of a loss of nuclear material at a large-scale reprocessing plant.

SG023A: Advanced Safeguards for MOX Fuel Fabrication Facilities
Status: Current

This project investigates advanced safeguards concepts, focussing on nuclear material measurement and integrated systems technology, that would enhance the verification techniques and capabilities of international, regional, and bilateral regimes to provide timely detection of a loss of nuclear material at a MOX fuel fabrication plant.

SG024A: Advanced Safeguards for Spent-Fuel Storage
Status: Current

This project investigates appropriate safeguards approaches that would enhance IAEA capabilities, including nuclear materials measurement techniques and instrument calibration, for monitoring spent-fuel materials at nuclear reactors, spent-fuel reprocessing plants, and long-term storage facilities.

SG040A: Bilateral Technology Exchanges
Status: Current

This project supports technical exchanges and cooperation with other countries and international organizations to enhance the effectiveness and efficiency of international, regional, and bilateral safeguards and the international acceptance of new developments.

SG041A: Technical Exchanges—Former Soviet Republics
Status: Current

This project provides critical technical assistance to FSU republics to establish an effective national and facility system to account for, control, and protect nuclear material.

SG050A: International Training Course
Status: Current

This project fulfills DOE requirements under Section 202 of the Nuclear Nonproliferation Act of 1978 to establish and administer a training program for a state system of accounting for and control (SSAC) of nuclear material for individuals from other nations. The project will then transfer SSAC technology to IAEA member states, with emphasis on developing nations which have, or plan to have, nuclear facilities.

SG100A: General Technology Development
Status: Current

Los Alamos will investigate, evaluate, and utilize available technology to build small, robust, portable instruments that can be rapidly deployed and used to detect and/or quantify SNM in support of special inspections.

SG101A: Isotope Dilution Gamma-Ray Spectrometer
Status: Current

All plutonium isotopes with the exception of ^{242}Pu emit low-energy gamma rays in the 38- to 200-keV region. With suitable computer data-unfolding techniques, these gamma rays can be measured to yield information on isotopic composition and, with spiking with known amounts of ^{239}Pu, to yield information on total plutonium concentration. This project will develop field-portable instrumentation for a new technique, isotope dilution gamma-ray spectrometry (IDGS), capable of performing these measurements.

SG102A: Intrinsic K-edge Gamma-Ray Densitometer
Status: Current

Absorption-edge densitometry provides a means of measuring plutonium concentrations in reprocessing plant final products and intermediate solutions with minimal interference from matrix elements. Current equipment requires an external x-ray or gamma-ray source to generate the required radiation. This project will develop techniques and prototype instrumentation to utilize x-rays and gamma rays emitted by the sample itself to perform this measurement.

SG103A: Hybrid K-edge Densitometer
Status: Current

The hybrid K-edge densitometer is ideal for reprocessing plant safeguards. It can be used to assay dissolver solution and both uranium and plutonium product solutions. While the basic technique has been in use for several years, research is needed to investigate the effects of minor isotopes (Th, Np, and Am) on the Pu and U concentration determination. This project will develop and test a hybrid K-edge gamma-ray densitometer system and will investigate its application to mixed solutions with Pu/U ratios greater than 10.

SG104A: Integrated Systems
Status: Current

This project will develop equipment and techniques to integrate various types of safeguards instrumentation into unattended monitoring systems. Such systems can be used in complex fuel-cycle facilities to continuously monitor fuel movements and in conventional facilities to reduce inspection manpower requirements.

10.0 EXPORT CONTROL

10.1 PROGRAM OVERVIEW

The Los Alamos Export Control program is a multifaceted program which deals with all aspects of export control. Los Alamos is involved in

- Determining what exports should be controlled;
- Getting agreement for controls;
- Providing support for the licensing process;
- Developing computer tools to assist in the licensing process; and
- Providing training and education.

As the basis for determining what should be controlled, technology and country evaluations are performed in support of export control. Intelligence information on supplier and proliferant countries is used to supplement available open-source information. Technology experts from all parts of the Laboratory are consulted regularly and brought into specific projects. Los Alamos chairs the Technical Review Group on Nuclear Technology. This group, which provides DOE and other government agencies with information which can be used in making export control policy decisions, comprises representatives of all the DOE laboratories and associated government agencies. The Nuclear Technology section of the Militarily Critical Technologies List (MCTL) and the Nuclear Technology Reference Book (NTRB) are regularly updated as part of the Export Control program.

Los Alamos also has the responsibility for participating in the international export control arena in order to assist DOE in getting agreement for export controls. The Nuclear Dual Use List, which was formulated at Los Alamos, was adopted almost in its entirety by the Nuclear Suppliers Group, a multinational group of supplier countries. Los Alamos was heavily involved in the international negotiations for this export control regime by providing technical assistance to the DOE. Additionally, support is provided to the Coordinating Committee (COCOM) on arms-related exports, specifically for the Core List and for the Atomic Energy List, the Zangger List negotiations, and the Supercomputer Control Regime. Support is provided for participation in Department of Commerce Technical Advisory committees. Los Alamos technical input is often provided for international bilateral discussions.

Arvid Lundy

Support for the export licensing process is one of the core activities of the Export Control program at Los Alamos. Department of Commerce, DOE 810, Nuclear Regulatory Commission (NRC), Munitions List, and COCOM licenses are regularly sent to Los Alamos for review. Evaluations of the licenses are performed by technical experts using information regarding the capabilities of the end user. Computer tools have been developed and are actively used in this process. Los Alamos is often asked to cooperate on international export control problems by providing support to U.S. Customs and Commerce Enforcement in addition to providing support in the preparation of Demarches.

A very large part of the Los Alamos program this year has been the development of computer tools to improve effectiveness, communications, cooperation, and efficiency within the export control community. Two computer projects are currently under development as follows:

- ***Proliferation Information Network System (PINS):*** This is a national DOE secure computer network to link DOE's Office of Export Control and International Safeguards (DOE/AN-30) with supporting laboratories in order to support export control activities. Limited-access terminals

will also allow other U.S. government agencies involved in the export control process to communicate and share DOE databases.

- ***PINS International:*** This is a separate international database and communication system dedicated to rapid sharing of export licensing and nonproliferation information. It is proposed for use by the Nuclear Supplier Group countries and their associates.

Training and education is another important aspect of the Los Alamos program. Los Alamos acts as technical host for the Nuclear Nonproliferation Workshops and for an annual workshop on proliferation issues for policymakers. In addition, Los Alamos publishes the DOE's Nonproliferation Newsletter.

10.2 FY94 EXPORT CONTROL PROJECTS

EC001A: Export Control Case Support
Status: Current

Los Alamos will review export licenses and advise DOE/AN-30 on technical issues related to export license reviews. Emphasis will be placed on using PINS for direct entry of export license reviews.

EC002A: Export Control for STEM/Zangger/ COCOM
Status: Current

Los Alamos will review and update existing Nuclear Referral List entries and provide technical advice and support for STEM, Zangger, COCOM, and bilateral meetings. A complete review will be done of existing AEL and specific IL entries for COCOM "core list" activities. Any working group activities, meetings, and tours of the Los Alamos technical facilities that are required by U.S. and foreign officials will be included. Los Alamos will also support U.S. government negotiation of laser and other controls as appropriate and participate in bilateral discussions with other nuclear supplier governments as required.

EC030A: Nuclear Nonproliferation Workshops
Status: Current

Los Alamos will host Nuclear Nonproliferation Workshops that will include orientation in the nuclear fuel cycle and facility visits for groups consisting of U.S. government plus selected industry and foreign officials involved in nonproliferation-related activities. In addition, Los Alamos will conduct the field component of the nuclear weaponization cycle with emphasis on R&D activities.

EC034: Nonproliferation Newsletter
Status: Current

Los Alamos will continue to produce and publish quarterly newsletters. The Nonproliferation Newsletter (NPN) provides a review of subjects of interest to the U.S. export control and technology transfer communities. The NPN provides the only classified forum for publication of policy discussions relative to technology security and nuclear nonproliferation export controls. Proposed articles include the following: IAEA Safeguards Assay Instrumentation and Techniques, Nuclear Supplier Group and Dual-Use Controls, Laser Isotope Separation and Its Proliferation Potential, Integrated Fast Reactors and Their Potential for Plutonium Proliferation, SNM Management in the Post-Cold War Environment, Mixed-Oxide Fuel Production, Proliferation Pathways and Signatures, PINS, Economic Costs of Export Controls, and Proliferant State Strategies to Avoid Export Controls. Los Alamos will consult with other DOE laboratories for possible topics.

EC037E: Nuclear Technology Security/MCTL
Status: Current

Los Alamos will continue to update the NTRB and make it available on PINS, provide input for the nuclear section of the MCTL, coordinate MCTL interagency issues, provide the chairman of Technical Review Group 15 (TRG-15) and oversee operation of the sub-TRGs, serve as secretariat of the Nuclear Technology Security Program, and participate in the Energetic Materials TRG.

EC049: Export Control Workshop
Status: Current

Los Alamos will host a Nuclear Nonproliferation Policy Conference with senior representatives from responsible U.S. government agencies and nongovernment experts. Program will be chaired by DOE Office of Export Control and International Safeguards and supported by Los Alamos with assistance from SAIC. The purpose will be to acquaint U.S. government policy experts with U.S. nonproliferation policies, concerns, and resources. The two- to three-day conference will provide U.S. government policy experts with options and objectives in review of U.S. nonproliferation policies and priority concerns. A report on the conference will be published.

EC050: Nuclear Proliferation Technical Support
Status: Current

Los Alamos will provide technical support to DOE/AN-30 in the preparation and presentation of nuclear proliferation and national security export control documentation, briefings, and meetings in support of DOE participation in U.S. and international discussions and negotiations. Emphasis will be placed on technical support to AN-30 for assisting the Department of State in negotiating with other interested governments of the NSG dual-use control regime. Los Alamos will provide technical support to AN-30 in monitoring and negotiating dual-use export controls aimed at controlling nuclear technologies to potentially proliferant countries. Los Alamos will provide assistance to DOE for the nonproliferation presentation at the Department of State foreign service officers' annual meeting. Los Alamos will also provide technical experts to develop support documentation for AN-30 presentations to committees including PCCs, SNEC, ACEP, and EDAC.

EC057: Export Control Technical Analysis
Status: Current

Technical support will be provided to DOE in analysis of export control policies and objectives with primary focus on nuclear nonproliferation. Los Alamos, with support from Livermore, will provide a comprehensive technical overview and evaluation of the nuclear facilities, programs, and procurement activities of potential proliferants. Los Alamos will evaluate the effects of export controls on Iraq, Pakistan, Iran, and other countries of concern and analyze ways in which Iraq may reestablish its capabilities. The above study should focus on exports of noncontrolled items.

EC074: Advanced Reactor Technical Analysis
Status: Current

Los Alamos will provide DOE/AN-30 with technical support for fuel-cycle and reactor-related export requests and provide technical documentation required for anticipated COCOM negotiations relating to reactor safety. Los Alamos will attend TRG-15.2 meetings.

EC087: Computer Core List Working Group
Status: Current

A Los Alamos computer expert will serve as the DOE's technical spokesperson in interagency efforts involving international and multilateral agreements to limit the export of supercomputers to potential nuclear proliferants and serve as part of the U.S. negotiating team at COCOM on computer "core list" controls. The computer expert will also provide technical advice and review safeguard and security programs for supercomputer export proposals and will continue to work with other agencies in standardizing methods for measuring the performance of computers for export control purposes.

LA051: U.K. Computer Project
Status: Current

A joint DOE (Los Alamos)/U.K. MOD program on exports and export analysis focussed on suspect proliferation transfers of commodities will be pursued. Los Alamos will provide technical assistance to the United Kingdom for the implementation of a computer system that will allow the United Kingdom to interface with current DOE/Los Alamos systems.

LA052: Proliferation Information Network System (PINS)
Status: Current

Los Alamos will operate and enhance PINS to support technical evaluation at the DOE laboratories and decision-making at DOE/AN-30 and other government agencies of export application cases related to the threat of nuclear proliferation. Software and hardware will be operated and developed to support the AN-30 export case decision-making process and to obtain, store, retrieve, and modify a large number of databases relevant to technical analysis of export applications by the laboratories. Part of this project will be oversight of the development of the interlaboratory/AN-30 secure wide-area network that will allow 24 hour/day access to PINS databases and analysis tools.

LA053: CIS/EE Export Control Assistance Project
Status: Current

Los Alamos will provide assistance to DOE on the development and implementation of training briefings for East European countries and FSU republics on control of sensitive nuclear technology and equipment, on the international export control regime, and on the U.S. approach/system for nuclear export control, trends, and emerging issues. Support includes provision of expert technical representatives to bilateral discussions/briefings as requested. Specific tasking will be developed in conjunction with the FSU Monitoring Group chartered by the Export Control Operations Division.

LA054: Alternate Nuclear Fuels Assessment
Status: Current

This project concerns the full scope of potential use of transuranic elements in nuclear weapons and the international control of such elements should they be found useful. To accomplish this, studies and negotiations of issues surrounding the control of alternate nuclear fuels are expected to be necessary for several years.

LA055: International PINS
Status: Current

National Security Directive 70 (NSD-70) directs exchange of licensing information on a real-time basis to promote uniform international export controls and cooperation among members of export and safeguards regimes such as the Australia Group, Nuclear Suppliers' Group, IAEA, and Missile Technology Control Regime. Los Alamos will provide real-time information on export licensing denials by member countries, automatic generation of faxes to member states of denial information, and trend analyses, as well as maintain historical data on end use and end users. PINS will provide encrypted communications using commercially available technology and provide technical support for system demonstrations.

LA056: Impact of Advanced Proliferation Technology on Export Controls
Status: Current

Los Alamos will study the activities of a potential nuclear weapons proliferant attempting to avoid detection by the international export control community, assuming access to nuclear expertise and possession of sufficient SNM. The signatures of efforts required to produce a workable nuclear device will be identified. This study could lead to recommendations for potential changes to existing export control procedures.

LA057: All-Source Technology Export/Import Analysis
Status: Current

All nuclear proliferant countries require technology imports to conduct their nuclear weapons development programs. The required imports, however, differ greatly depending on the internal resources (personnel, equipment, raw materials) of the country and on the technological route or routes chosen for the weapons program. Export controls have closed the most obvious routes to nuclear weapons and forced proliferants to build from more basic imports, including many dual-use items that are not suitable for export control. Hundreds of

import items must be considered in the context of particular countries. The access of potential proliferants to these technologies will be studied with the computer tools being developed in other Los Alamos projects.

LA058: Computer Compliance Assurance
Status: Current

DOE's technical requirements for safeguarding supercomputers to be licensed in countries that are potential nuclear proliferants will be implemented, and further research will be carried out to develop automatic computer-based techniques for assuring compliance.

LA059: SCILS
Status: Current

Los Alamos will support the DOE/AN-30 effort to provide a database of information requests from sensitive countries.

LA060: New Initiatives in Export Control—Explosives
Status: New

Because proliferant countries are likely to have limited quantities of SNM and a need to keep down the overall size and weight of their nuclear warheads in order to fit them into delivery systems of limited throw-weight, the most desirable explosives would be HMX, RDX, TATB, PETN, HNS, and their formulations. Additionally, there are high-performance, experimental explosives, such as the tetrazines, presently being researched in U.S. laboratories. There also exists the possibility of proliferant countries obtaining a high-performance explosive that is easy to synthesize and manufacture from a technology breakthrough. Los Alamos proposes to develop and maintain a high-performance explosives database of existing proven and experimental explosives particularly suitable for nuclear weapons use. The database will allow closer tracking and accountability for these explosives and their formulations.

LA061: Prelicense Check/Postshipment Verification Handbook
Status: New

In order to verify the intent of an export, it is often necessary to perform a Prelicense Check (PLC) or a Postshipment Verification (PSV). Los Alamos will gather prelicense and postshipment information keyed to commodities, including schematics and photographs of specific hardware, and collate the information for availability on portable computer systems for the export control community. The commercial officers stationed in the embassies and consulates of the receiving countries could then use this handbook to assist in performing these checks.

11.0 INFORMATION MANAGEMENT

11.1 PROGRAM OVERVIEW

The nation's nuclear nonproliferation initiative currently relies on the ability of human analysts to assimilate, integrate, and interpret complex information from diverse sources in order to track nuclear proliferation activities throughout the world. Several current trends, however, will continue to place additional stress on the ability of the current system to adequately perform this task. Increasing budgetary pressures on the general nonproliferation community (both in the United States and in the international arena), coupled with the growing number of countries with adequate technical competence to undertake a nuclear weapons program, will make it difficult to obtain sufficient staffing to properly assimilate the information available from today's sources. In addition, the growing importance of other sources of information, both in the public domain (e.g., published literature) and otherwise (e.g., financial transactions, new intelligence systems), will greatly add to the diversity and flow of information which must be correlated and understood. While the recent interest in developing large databases of this information will help to organize the information and make it more available, serious operational problems remain to be overcome.

With the advent of fast computers with very large data storage capabilities, it has now become possible to formulate large integrated databases comprising many terabytes of information spanning a variety of subjects relevant to the nonproliferation problem. Unfortunately, the technologies required to automatically manipulate such large databases and effectively "process" their information have not achieved a similar level of development.

The objective of this program is to define the requirements for and research, develop, and test a set of machine-learning algorithms capable of automating and enhancing performance in several key steps in the analysis of nonproliferation-related information. The "knowledge fusion" technologies developed within this overall program will also be applicable to a wide range of problems in the data analysis area.

Chris Barnes

Five key elements which span the data analysis requirements associated with the nonproliferation problem have been identified. These elements are

1. Determination of data relevance—filtering of data for relevance prior to entry into global databases.
2. Verification of data integrity—checking formatted information for correct data.
3. Extraction of information from raw data—"mining" of raw data (e.g., free-text intelligence reports, spectra, etc.) for information that can be understood by humans and machines.
4. Detection of anomalous patterns—flagging of patterns of activity by an organization that are outside the bounds of typical behavior.
5. Detection of identified proliferation activity patterns—flagging of potential proliferation activities based on the correlation of data from a variety of sources.

11.2 RELATED WORK

The successful development of knowledge fusion technologies applicable to the nuclear nonproliferation problem requires the integration of state-of-the-art information processing

techniques with an in-depth knowledge of all aspects of the nuclear proliferation process. Machine learning techniques have been employed for many years by various groups at Los Alamos to solve a variety of problems. Although the applications span a wide range, there is a common thread underlying them—all involve the modeling of a system either by observation of its behavior or by examining data produced by it. The algorithms used by the Laboratory to perform this modeling function have either been invented at Los Alamos (in the case of several neural network algorithms) or improved here. These include neural networks, fuzzy logic, expert systems, and innovative combinations thereof.

Los Alamos has extensive experience in the application of all of these technologies to such problems as database inference, profitability prediction for a large U.S. bank, modeling of a free-electron laser design code, control of a negative-ion source for a neutral particle beam accelerator, detection and classification of underwater acoustic transients (submarine detection), prediction of flood tides in the Venice lagoon in Italy, identification of regions of DNA sequences which code for proteins, process and materials control systems, anomaly detection in safeguards and computer security systems, recognition of transient events (nuclear explosion detection), advanced personnel security systems (face verification), vehicle recognition and characterization from seismic signals, encryption, speech recognition, image processing, and automated spectral analysis for rapidly identifying and characterizing substances.

The application of advanced algorithms such as neural networks, fuzzy logic, cluster analysis, and expert systems to the detection of anomalous behavior and pattern recognition in general has been well documented. In the case of neural networks, for example, a great deal of effort has been expended over the last five years by the world community in analyzing the ability of the networks to be trained to recognize specific patterns and to identify previously unknown patterns from very noisy data. Results have shown that neural networks are quite successful when the application involves multiple data sources of unknown relation, precisely the situation in the nonproliferation problem. The combination of neural networks, fuzzy logic, and expert systems into so-called "holistic" pattern recognition systems represents the current state of the art in this arena.

11.3 FY94 INFORMATION MANAGEMENT PROJECT

ST421: Knowledge Fusion Technologies
Status: Current

The proposed five-year program will develop and test a set of machine-learning algorithms capable of automating and enhancing performance in several key steps in the analysis of nonproliferation-related information. Upon completion of the program, an integrated, documented, validated set of automation tools for the analysis of large all-source databases relevant to the proliferation problem will be delivered to DOE/AN for dissemination to the appropriate organizations.

12.0 POLICY AND TECHNICAL ANALYSIS

12.1 PROGRAM OVERVIEW

Policy and Technical Analysis projects at Los Alamos are conducted primarily for the DOE-AN's Policy and Technical Analysis Division. Although small in dollar volume compared with the Laboratory's programs in verification technology, the P&TA projects constitute an important, high-visibility component of Los Alamos activity. Through these projects, the Laboratory provides assistance to DOE in both governmental (interagency) and international negotiations and related activities. They provide an important vehicle for Laboratory input into the development of arms control treaties and other policy issues.

Maurice Bryson

Throughout its history, Los Alamos has provided national security policymakers with technical support, and Laboratory participation played a role in the negotiation of such treaties as the NPT in 1967–70 and the TTBT in 1976. However, the pace of Laboratory involvement quickened considerably in 1986 with the initiation of Nuclear Testing Experts meetings in Geneva. The purposes of these meetings were to provide a forum for discussions of U.S. and Soviet nuclear testing policies and specifically to negotiate improved verification protocols for the TTBT and the Peaceful Nuclear Explosions Treaty (PNET). These discussions were formalized into the Nuclear Testing Talks, a series of negotiations on protocol details that were developed in 1987–1990. The resulting 90-page Verification Protocol specifies in great detail the verification rights of the two sides in conducting hydrodynamic and other yield measurements to verify compliance with the treaties' 150-kt limit on nuclear explosion yield. More than a dozen technical and administrative personnel from Los Alamos participated directly in the framing and analysis of the verification protocols, which were signed and ratified in 1990.

Los Alamos personnel have also been deeply involved in follow-on activities for test ban treaties and other arms control treaties: there have been Laboratory participants on the Special Verification Commission for the INF treaty, the Joint Compliance and Inspection Commission for the START I treaty, and the Bilateral Consultative Commission for the TTBT.

With the drastic geopolitical changes that have taken place since 1989, Laboratory P&TA activities have included discussions with scientific counterparts in the Soviet Union and its successor states. These discussions have focused on issues surrounding dismantlement of nuclear weapons and warheads in the several countries and on the problems associated with preventing the proliferation of nuclear materials. Issues such as how best to store the SNM from dismantled warheads and how to provide for international inspections that might be called for in connection with dismantlement are among those that have recently been studied. Meanwhile, Laboratory personnel have participated in continuing policy discussions and reviews associated with proposals for a comprehensive ban on nuclear tests.

Because many aspects of Laboratory P&TA require a sustained on-site presence in Washington, P&TA projects have provided for change-of-station assignments that have resulted in the relocation of one to three Laboratory personnel to Washington, D.C., at any given time. Normally these are two-year assignments, providing DOE with top-flight scientific talent while providing the Laboratory with a greater awareness of the political and other factors driving the negotiations process.

Recent participants in the change-of-station project have included Allen Ogard (1989–91), Steven Gitomer (1991–93), and Donathan Krier (1991–present), all assigned to the Policy and Technical Analysis Division of DOE-AN, and Edward Dowdy (1992–present), assigned to the same office but utilized by DOE at the State Department to assist in the establishment of the International Science and Technology Centers.

12.2 FY94 POLICY AND TECHNICAL ANALYSIS PROJECTS

AC010A: Los Alamos Conference Support
Status: Current

This project provides support for foreign travel undertaken in connection with negotiations support, DOE participation in interagency discussions, meetings of arms control verification support committees, and other interactions involving foreign travel in support of negotiations-related activity. Specific trips are approved by DOE/AN and reported in quarterly summaries to DOE/AN-10.2.

AC013A: Los Alamos Staff Support
Status: Current

Los Alamos will supply personnel, with DOE/AN approval, for change-of-station assignments in Washington. Three employees have been supported in FY93, and it is anticipated that the same level of effort will continue in future years. Employees will be assigned to projects within DOE/AN as required by the needs of ongoing arms control activities. Funding from this project provides salary, fringe, off-site burden, and supporting expenses for the employees.

AC031A: Arms Control Issues Support
Status: Current

Los Alamos will work with the staff of DOE/AN-10.2 in identifying subprojects whose conduct will be required in support of ongoing arms control discussions, negotiations, and policy studies. Funding for the year is based on historical extrapolation. The procedure for defining subprojects will include submission of proposals for specific activities involving activity by one or more national laboratories, the details of the activity being negotiated between the laboratories and the appropriate program manager in DOE/AN-10.2. When a proposal is approved for funding, a new DOE project number will be assigned for accurate cost-tracking, and funds will then be transferred from the Arms Control Issues Support account to a new account established for the project.

TIER 2 PROPOSALS

13.0 TIER 2 PROPOSALS FOR DOE/AN-10.1

LA019: Augmentation of ST423
Status: New

This proposal calls for augmentation of the current project ST423 (Deployable Adaptive Event Recognition and Processing Systems). The additional funds will be used to accelerate the project's schedule and to provide dedicated hardware to specific DOE/AN projects.

LA038: Augmentation of ST043C
Status: New

This proposal calls for augmentation of the current project ST043C (Advanced Concept). The additional funds will be used to support an expanded project.

LA020: Augmentation of ST140A
Status: New

This proposal calls for augmentation of the current project ST140A (Blackbeard/FORTE). The additional funds will be used to ensure the timely completion of the project.

LA004: Sensors for Toxic Chemicals
Status: New

Los Alamos will develop sensors for toxic chemicals using thin-film enzyme composite electrochemical sensors. These devices will be optimized for response and lifetime. Easily adaptable preparation methods will be developed. Finally, these sensors will be integrated into a portable multisensing field unit.

LA013: Multicollector Airborne Sampling System for Effluent Monitoring
Status: New

Los Alamos will develop a prototype sampling system for integration into a low-speed pilotless aircraft that is now being developed by a collaborator in the private sector. The aircraft will allow covert sampling within the effluent plume of a suspected nuclear production facility or reprocessing plant. The samplers will incorporate technology developed within DOE and will be optimized to deliver high-quality effluent samples to DOE laboratories for analysis using techniques developed for effluent monitoring.

LA021: Augmentation of LA027
Status: New

This proposal calls for augmentation of the newly proposed project LA027 (GPS/NDS Block-IIF Definition). The additional funds will be used to develop and test prototype instruments identified by the study conducted in LA027.

LA037: Augmentation of LA033
Status: New

This proposal calls for augmentation of the newly proposed project LA033 (Explosion Data Management). The additional funds will be used to accelerate the project's proposed schedule and to expand its scope.

LA002: FANSE: A New System for Remote Detection of Radioactivity
Status: New

Los Alamos will evaluate the technical feasibility of two new, sensitive techniques for remote detection of radioactive sources. Testing will be performed along with field measurements. These measurements will be performed on Los Alamos property with a system including detectors for air conductivity and electric field strength, a photon-counting imaging system operating in the "solar blind" ultraviolet, and conventional scintillation counters. The goal is to remotely detect the presence and location of radiation sources. This capability would be important for limiting the spread of nuclear materials.

ST523: Sparse Optical Phased Array (SOPA) Sensors
Status: Current

This project will develop and demonstrate a real-time, analog system for edge enhancement with simultaneous background suppression.

ST817: Gallium Arsenide Gamma-Ray Detector
Status: Current

The proposed technology exploits the semiconducting properties of gallium arsenide to produce a gamma-ray detector with good energy resolution at room temperature.

LA017: Augmentation of ST013B
Status: New

This proposal calls for augmentation of the current project ST013B (Satellite Technology Development). The additional funds will be used to expand the project to include development and demonstration of advanced small-satellite technologies identified as vital to the nonproliferation and arms control effort.

LA028: Augmentation of ST098
Status: New

This proposal calls for augmentation of the current project ST098 (Theoretical Support of NUDET EMP). The additional funds will be used to expand the scope of the project to include a wider range of phenomena and potential scenarios of importance to the nonproliferation program.

LA018: Augmentation of ST679A
Status: New

This proposal calls for augmentation of the current project ST679A (GPS/NDS Auxiliary Payload). The additional funds will be used to accelerate the project's schedule and to develop prototype instrumentation of importance to the nonproliferation program.

LA023: Vulnerability Assessment for Containers
Status: New

This project evaluate SNM containers for their overall vulnerability to covert action. Preliminary focus will be on the AT-400 container designed by Sandia for storage of plutonium from Russian warhead dismantlement. Other containers would include the DOT-300 and Russian containers as appropriate.

LA026: Unattended Ground Monitor
Status: New

This project is a collaboration with EG&G/SBO to develop a standalone radiation detector, equipped with resources for telemetry and tamper-indication/proofing, that is capable of roadbed or portal monitoring under noncooperative and cooperative conditions. The objective of the work is to produce a hardware system suitable for monitoring choke points in locations such as suspected Iraqi weapon program sites. The project draws on NEST experiences and expertise for hardware and on IAEA and UNSCOM experiences to shape the anti-tampering features.

TT001: On-Site Monitoring
Status: Current

This project develops and maintains the U.S. capability mandated by national security directive to carry out CORRTEX measurements of the yield of underground nuclear explosions in Russia in verification of the TTB and PNE treaties. The product is a cadre of trained technical and operational team members and sets of required equipment in operating order that are ready to be deployed to Russia following receipt of a 200-day notice of a nuclear test to be conducted in either horizontal or vertical geometries.

TT007: TTBT Implementation
Status: Current

This project consists of technical operations in accord with the TTBT and PNET protocols to support the DOE as required to accommodate operations of (former) Soviet personnel at the U.S. Nevada Test Site.

ST100A: FEWS Flight Systems
Status: Current

Earlier host satellites (DSP) will be replaced by FEWS. FEWS will accommodate an exoatmospheric nuclear detonation detection system, Payload 3, to support treaty verification and noncooperative proliferation detection in the high-altitude region and in space. Los Alamos will develop and provide NDS in collaboration with Sandia. Although we are not requesting FY94 funds for this project, which is intended to support instrument-specific development of Payload 3, we are assuming a resumption of funding in FY95. The schedule and tasks, particularly for the out-years, are predicated on the current FEWS schedule.

14.0 TIER 2 PROPOSALS FOR DOE/ AN-30

LA036: MC&A Techniques for Other Nuclear Materials
Status: New

This project will develop MC&A techniques that can be used for other nuclear materials that appear in the nuclear fuel cycle. Techniques for monitoring these materials in liquid, powder, and solid bulk materials will be investigated.

APPENDIX

APPENDIX A
CRITERIA FOR EVALUATING PROPOSALS

A number of criteria for evaluating nonproliferation and arms control proposals have been suggested. These can be grouped into five general categories, as described below. Many of the criteria will be recognized as relevant to any scientific proposal. Some considerations are, however, unique to the nonproliferation and arms control arena.

1.0 SIGNIFICANCE

Proposals should address the potential significance of the end product should the project be successful. This should include the following considerations:

- ***Relation to current capabilities:*** Any proposed new project should result in a significant enhancement to the country's current proliferation detection and/or assessment capabilities. This could include improvements in the ability to detect treaty violations, resolve current false alarms, deter treaty violations, or perform a current covert operation in an overt fashion (i.e., development of "gray" assets). It is recognized that current security levels attached to assets and analytical techniques associated with proliferation monitoring are very high. As a result, it will be extremely difficult for individual researchers, especially those not currently involved in the nonproliferation and arms control arena, to effectively relate the proposed concept to current capabilities within the intelligence community. Review of proposals by a group of individuals with appropriate clearances will, therefore, be used to help avoid duplicative efforts wherever possible. Submitters should be aware that the reviewers may not be able to provide a detailed explanation for rejection of a proposal due to security constraints.
- ***Value of information:*** Particular emphasis will be given to the development of technologies and analytical techniques capable of providing definitive information on a country's capabilities and current activities. Unambiguous identification of facilities/countries engaged in proliferation activities may well require the "fusion" of a number of complementary sources of information. Proposals should address how the information collected/created by the proposed technology/technique relates to current requirements and analysis and how the information would augment and be integrated with that obtained from existing or other proposed systems.
- ***Flexibility:*** The relative value of proposals aimed at a specific country or facility versus those with wider application will be balanced against the immediate importance of the proposed target, the estimated time for project completion, and the likelihood of project success. Additional factors to be considered include the applicability of the proposed technology or analysis technique to other treaties (both existing and anticipated) and any potential spin-offs to other technical arenas.

2.0 OPERATIONAL CONSIDERATIONS

Although the majority of NAC programs are not involved in the development of operational systems, some of the operational requirements of an eventual system utilizing the proposed technology or analytical technique must be considered during the review. These requirements are somewhat different for instrument technologies as opposed to analytical techniques. The necessary areas to be addressed in a proposal shall, therefore, be described for each of these two areas.

2.1 Instrumentation Systems

Particular care will be given during the review process to ensure that any instrumentation system derived from the proposed technology can be utilized in an operational form that is consistent with known field limitations. Areas to be addressed include the following:

- ***"Fieldability" under proposed operating conditions:*** Proposals should address the

issues surrounding the feasibility of fielding an operational device incorporating the technology to be developed. For example, proposals for technologies requiring cooling for proper operation should discuss potential methods for meeting this requirement in a field system.

- *Access:* What type of access (e.g., airplane, human operative, etc.) would be required for deployment of an operational version of the technology should the program be successful? Requirements for soft placement or operator setup are especially important to note.
- *Coverage:* The ability of the proposed technology to monitor broad geographic areas must be weighed against any loss of definition in the information to be obtained, the relative cost of a narrow versus broad coverage system, etc.
- *Ease of use:* Proposals should discuss the required training and expertise of personnel anticipated for proper installation, maintenance, and operation of an eventual system based on the proposed technology. For example, technologies requiring frequent calibration by human operators would not be considered practical for use in the unattended ground sensor arena.
- *Vulnerability to countermeasures:* Although it is not expected that a full countermeasures study will be performed prior to submitting a proposal, some attempt to identify and discuss the implications of the more obvious countermeasures should be made.
- *Overt/Covert:* Proposals should address any operational requirements for covert versus overt data collection. No emphasis is intended to be placed on one mode as opposed to the other.
- *Speed/Responsiveness:* Can the project be completed within a time of value to the problem being addressed? This is especially important for proposals intended to develop technologies aimed at a specific country or facility.

2.2 Analysis Techniques

Particular care will be given during the review process to evaluate the proposed technique in light of current operational constraints on the availability of information and on the source sensitivity of the resulting output. Areas to be addressed in the proposal include the following:

- *Availability of information:* Under current operational procedures, it frequently can be difficult (if not impossible) to assemble all relevant information into a single database. Each segment of the information comes into the intelligence community through many different channels, each of which may be independently secured. Proposals should identify required sources of information and indicate plans for obtaining access to the required data. Any previous negotiations with controlling agencies should be detailed.
- *Security considerations:* Information which cannot be released or utilized in international negotiations has limited value in the international community. NAC would like to encourage the development of analysis techniques that use less source-sensitive intelligence collection systems and/or whose output can be effectively decoupled from the input data. Proposals should address the anticipated security considerations of an operational system in these terms.

3.0 LIKELIHOOD OF PROJECT SUCCESS

The likelihood for successful completion of the stated programmatic goals should be assessed. Factors to be considered include the following:

- *Relation to current state of technology:* Proposals will be evaluated to determine whether the proposed work represents an evolutionary or revolutionary change to the current state of the art in that particular technical arena. Attempts at revolutionary change are encouraged but will be carefully considered in terms of the potential gain versus the associated technical risk.

- ***Technical risk:*** Some discussion of the anticipated major technical hurdles to be overcome during execution of the proposed program should be presented. The discussion should include at least a general outline of any ideas currently under consideration for overcoming these hurdles.
- ***Qualifications of principal investigator and technical team:*** The ability of the principal investigator and technical team to effectively carry out the project can be difficult to determine. Factors include technical background/experience, past record of achievement in the specific area under consideration, and available institutional resources. In order to avoid the loss of innovative ideas from persons/teams new to a given area, the reviewers are encouraged to suggest and promote appropriate collaborations between relevant organizations on such projects.

4.0 SCIENTIFIC AND TECHNOLOGICAL SOUNDNESS

A major element of the review process will focus on determining the scientific and technological soundness of the proposed concept. Proposals should carefully address the following issues:

- ***Detail of supporting technical work:*** Supporting background work performed by the proposing team should be detailed in the proposal. Of particular importance are details of any calculations supporting numbers (e.g., estimated performance parameters) quoted in the proposal, preliminary instrument designs, etc. Any material which may convey to a reviewer the level of technical preparation embodied in the proposal should be included.
- ***Knowledge of previous work:*** Previous related work by the proposing team should be described and/or referenced in the proposal. In addition, related work either previously or currently being done by other organizations should be noted and referenced and its relation to the proposed effort explained.

5.0 CONSISTENCY WITH NAC CHARTER AND GOALS

The relation of a proposed project to the stated charter and goals of the NAC program should be clearly delineated. The proposal should also address the following points:

- ***Identified user:*** It is very important that any proposed technology or analysis technique to be developed for nonproliferation and arms control have an identified user. Preferably, the identified user should have had some prior contact with the proposed project to ensure that it will meet an existing need. Any such contacts should be detailed in the proposal.
- ***Uniqueness of contribution:*** The proposal needs to address the issue of why the project should be conducted at a DOE laboratory as opposed to within industry, universities, etc.
- ***Industrial involvement/planned partnerships:*** Any planned or potential collaborations with industry or other organizations should be detailed. Industrial participation, in the form of either collaborative research and development agreements (CRADAs) or other agreements, is greatly encouraged and will be factored into the review process.

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