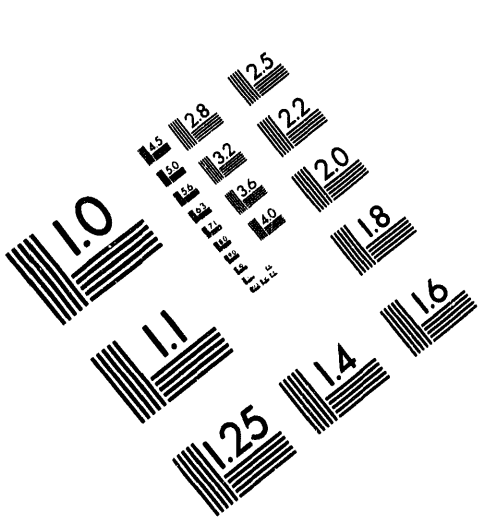

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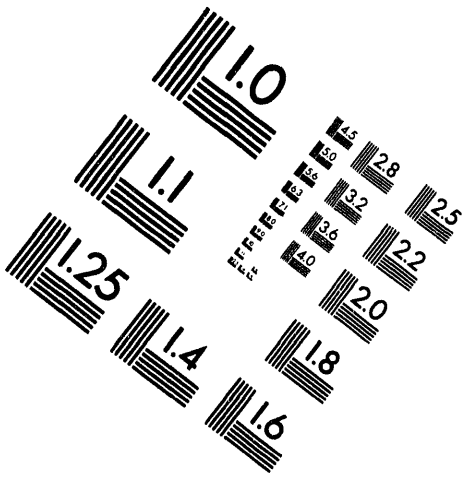
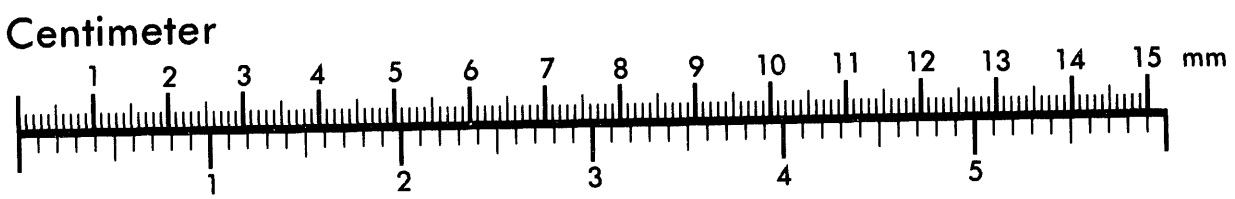
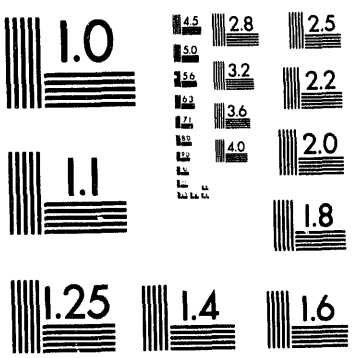
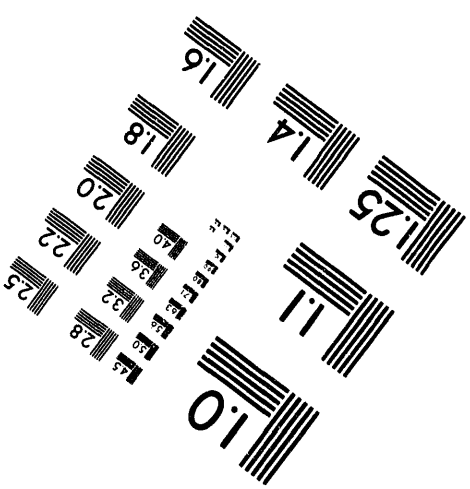
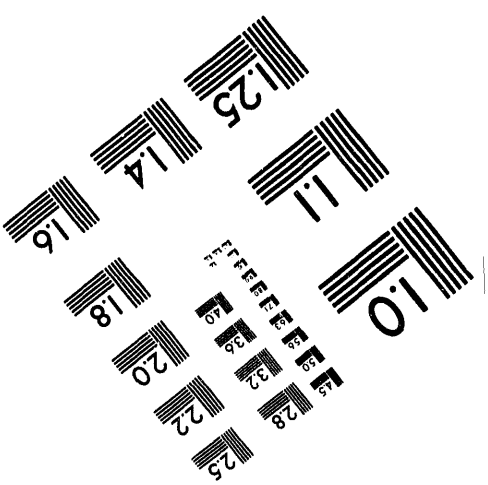
301/587-8202











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Physical Security Technologies for Weapons Complex Reconfiguration Facilities

Calvin D. Jaeger
Surety/Dismantlement Department 5821
Sandia National Laboratories
Albuquerque, NM 87185-0765
505-844-4986

Abstract

Sandia National Laboratories was a member of the Weapons Complex Reconfiguration (WCR) Safeguards and Security (S&S) team providing assistance to the Department of Energy's (DOE) Office of Weapons Complex Reconfiguration. This support started approximately two years ago and continued until May 1994 when DOE reorganized its reconfiguration and nuclear materials disposition programs. The physical security systems in the new and upgraded facilities being considered for the WCR had to meet DOE orders and other requirements set forth in the WCR Programmatic Design Criteria (PDC), incorporate the latest physical security technologies using proven state-of-the-art systems and meet fundamental security principles. The outcome was to avoid costly retrofits and provide effective and comprehensive protection against current and projected threats with minimal impact on operations, costs and schedule.

WCR facilities need to meet the highest S&S standards. Physical security requirements for WCR facilities include: (1) reducing S&S life-cycle costs, (2) where feasible automating S&S functions to minimize operational costs, access to critical assets and exposure of people to hazardous environments, (3) increasing the amount of delay to outsider adversary attack, (4) compartmentalizing the facility to minimize the number of personnel requiring access to critical areas and (5) having reliable and maintainable systems. Past experience has shown that S&S measures implemented during early design stages and integrated into the facility operations are more effective, more economical and less intrusive on operations. To be most effective against threats physical security must be integrated with facility operations, safety and other S&S activities, such as material control and accountability, nuclear measurements and computer and information security. New and improved S&S approaches and technologies were considered for WCR facilities.

This paper will discuss the S&S issues, requirements, technology opportunities and needs. Physical security technologies and systems considered in the design effort of the Weapons Complex Reconfiguration facilities will be reviewed.

Background

The Department of Energy's Office of Weapons Complex Reconfiguration (WCR) was formed in early 1992 to establish a nuclear weapons manufacturing capability that was consistent with national security requirements for the 21st century (Complex 21). Sandia National Laboratories, along with Los Alamos National Laboratories, became involved with this program

in the Spring of 1992. A safeguards and security (S&S) team was formed which provided S&S assistance to the DOE, the architect and engineering firm and the Lead Laboratories for the various functions within the program. This support was provided in parallel with the primary design activities.

In early 1994 there was a major reorganization of reconfiguration activities and two organizations were formed. The DOE Office of Reconfiguration's primary areas of concern are tritium activities and the DOE Office of Nuclear Materials Disposition is concerned with disposition options for excess plutonium and highly enriched uranium. Safeguards and security support is to be provided for both of these efforts.

Objectives

The support given to the WCR program involved S&S assistance in parallel with the primary design activities. Support was given to the DOE, the architect and engineer and the Lead Laboratories for the respective WCR areas (e.g. storage, processing, assembly/disassembly). The effort involved both high and low-level approaches. At the high level, guidance on protection systems and strategies was provided, S&S issues and concerns identified, and technological opportunities identified. At the low level, S&S requirements and criteria were developed and facility operations and designs were evaluated.

The objectives of this paper are to discuss the S&S issues, requirements, technology opportunities and needs, and physical security technologies and systems considered in such areas as image processing, intrusion detection and assessment, access control, contraband detection, alarm communications and display, access delay, insider threat, automation and robotics and material monitoring and tracking for the design effort of WCR facilities. The efforts in support of the WCR facilities identified S&S needs and requirements but more work is needed to identify specific S&S approaches and technologies. Ways to increase technical exchange and team with industry and government, particularly in the areas of technical transfer and cooperative agreements, are being sought.

Issues

There are many S&S issues which were considered during the support to the WCR facility design activities:

- Every effort was made to reduce the costs for S&S. In particular, life-cycle costs were considered when evaluating particular S&S options. Because S&S personnel represent such a large percentage of the typical operating S&S costs for facilities, ways to reduce the S&S personnel requirements by using technology were given serious consideration.
- Risks to both outsider and insider adversary threats were minimized consistent with the cost/benefits and the possible consequences of the adversary act. Preliminary vulnerability assessments were performed not only to identify facility weaknesses but also to analyze possible design alternatives.
- Automation and robotics (A&R) was to be used quite extensively in many of the WCR facilities. Although the use of A&R provided definite advantages such as reducing personnel access to nuclear materials and to hazardous environments, many new S&S issues which had not previously been fully addressed.

- The S&S functions of physical protection, material control and accountability, nuclear measurements and information security were to be integrated along with other non-S&S activities such as safety, environmental monitoring and emergency preparedness.
- In addition to meeting domestic S&S requirements, some facility designs needed to also consider the possibility of third party/international inspections. These inspections might possibly be required as part of bilateral or International Atomic Energy Association (IAEA) agreements.
- Finally, there are considerable efforts within DOE to extend the inventory requirements for special nuclear material (SNM). Consideration was given to using technologies and approaches which supported this effort.

Requirements

In addition to the requirements identified in the different DOE orders and other regulations, criteria was provided to the designers to help develop the most effective protective system which met the anticipated threat and had minimal impact on cost, schedule and operations. The following requirements were identified in the Programmatic Design Criteria (PDC) document:

- Reduce the cost of S&S personnel operations using technology.
- Where feasible automate S&S measures and functions.
- Integrate S&S into the A&R architecture and operations.
- Use on-line S&S measures so that nuclear material can be kept on the process line when the facility is not in operation.
- Compartmentalize the facility to minimize the number of personnel requiring access to critical assets.
- Reduce the inventory requirements for SNM.
- Increase the amount of delay to outsider adversary attack.

There were other requirements which were "implied" (e.g. not necessarily specified in any orders, regulations or the PDC). They included:

- Reduce the risks identified in vulnerability assessments of existing facilities.
- Analyze the S&S effectiveness at each phase of the design process.
- Consider the fundamental security principles in the security design (e.g. protection in depth, balanced protection, protection against single point failure).
- Ensure physical security systems are reliable and maintainable.
- Utilize technology-based protection systems versus people-based systems.
- Ensure physical security systems are compatible and functionally integrated with other S&S systems and other facility operations (e.g. safety, environment, emergency operations).
- Consider physical security systems to ensure affordability of life-cycle costs.
- Evaluate technology and manpower trade-offs.
- Consider standardization of S&S systems and components.
- Support as-low-as-reasonably-achievable (ALARA) criteria.

Technology opportunities and needs

Many opportunities and needs were identified for S&S technology areas. State-of-the-art proven S&S systems and components were to be considered for the various WCR facilities. Basic approaches, concepts and types of S&S systems and components were identified for some

facilities. Specific technologies, to include manufacturers, were not identified. Consideration was to be given to any S&S technologies, commercial or governmental, with demonstrated performance in either the laboratory or at a facility. Automation and robotic (A&R) systems were to be used to meet specific S&S applications and facility processing and operational requirements. Through the use of A&R systems personnel access to nuclear materials and hazardous environments can be reduced. Real payoffs can be realized if the intervals between SNM inventories can be extended. Personnel access to SNM and also radiation exposure can be reduced which means fewer personnel would be required to perform these functions. A number of different technologies have been developed which provide real-time continuous monitoring and remote inventory of SNM. These measures along with other S&S systems can enhance the assurance that SNM is adequately protected. Technology-based systems were being considered to reduce the threat of both the outsider and insider threat. Improved intrusion detection, image processing, personnel and material tracking are just a few of the systems considered to provide greater protection to WCR facilities.

The operational costs of S&S personnel represent a very significant percentage of most facilities' S&S budget. Every attempt was made to reduce the S&S personnel requirements, particularly for protective forces involved in access control, security checks of facility locations and response activities. For facilities with nuclear material which was considered very attractive to adversary theft, underground or bermed construction was considered. Such facilities with "enhanced delay characteristics" provide opportunities for new S&S approaches and technologies. For example, traditionally around certain security areas an isolation zone containing intrusion detection and assessment systems is constructed. These systems provide a very high level of detection probability but are quite expensive to install and operate. If a facility has significant passive delay in its design it may be feasible to utilize other detection alternatives which provide an acceptable level of detection but at a lower cost. Finally, every effort was made to integrate physical security with other S&S activities (e.g. material control and accountability, nuclear measurements, computer/information security) as well as non-S&S activities such as safety, environmental monitoring, health physics, emergency preparedness. Part of this integration effort includes a command and control system which helps bring together all of the various pieces of information (e.g. from S&S, ES&H, emergency preparedness) for the facility operator.

S&S Technologies

Image processing

A number of different image processing technologies were being considered. They include integration of image processing with other intrusion detection systems, video motion detection, object recognition and sensor fusion algorithms. Ways of "looking beyond" the perimeter were being considered and included a number of range imaging technologies such as laser and synthetic aperture radar. In addition to ground-based warning systems, airborne early warning systems were considered. Image processing was to be integrated into a number of different S&S measures such as alarm assessment, surveillance, biometrics, contraband detection and access control.

Intrusion detection and assessment

Alternatives to a perimeter intrusion detection and assessment system were being considered as part of an integrated total system. Ways to more completely evaluate events which occur very quickly such as pre alarm video assessment were being considered. Fiber optic sensors were being evaluated for possible use in both external and internal applications. A number of different technologies were being considered which reduced life-cycle costs and risks to DOE facilities.

Access control and contraband detection

Consideration was given to a number of existing systems, especially systems which integrate a number of operations, such as ARGUS (Argonne Unified System) and E3S (at Savannah River Site). A number of biometric devices were being considered, with hand geometry the technology currently selected by DOE as the standard device. The DOE standard badge was to be used with possible enhancements. These included the use of smart card technology and the use of proximity badges for certain applications. Considerable efforts was expended in the area of both vapor and bulk explosives detection. This area is a critical technology for adequate contraband detection and must not only detect explosives entering a facility on personnel or vehicles but also in packages and mail.

Alarm communications and display

The major effort in alarm communications and display was to make existing systems more robust and intelligent with respect to data processing and analysis. In addition, the concept of having an integrated command and control (C2) system for a facility was being developed. This C2 system would integrate a number of different functions to include intrusion detection and assessment; nuclear material control and accountability; critical equipment monitoring; environmental, health physics and safety areas and also emergency response operations.

Access delay

Increased delay can result in reduced life-cycle S&S costs and an enhancement in security. Consideration for some WCR facilities was being given to underground or bermed construction. This would provide enhance delay features for the protection from certain adversary attack scenarios. Although this type of construction is not a technology area, it can have a significant impact on a facility's protection strategy and systems. In particular, alternatives to traditional perimeter intrusion, detection and assessment systems were being considered. Another area which deserves attention, particularly for facilities which need temporary storage capability, is modular vaults. These vaults can be constructed in a variety of configurations and be tailored to meet the needs of the particular facility.

Insider threat

A number of different technologies were being considered to help mitigate the insider threat. They include an integrated personnel and material tracking systems, such as PAMTRAK (Personnel and Material Tracking System) or AIMS (authenticated item monitoring system), which includes entry control, personnel tracking and material monitoring. Use of these systems would have many benefits to include enforcement of two-person control, compartmentalization, radiation exposure monitoring and personnel accountability during emergency situations. Although not necessarily design impacting, a number of information security systems were being

considered to include paperless systems for classified information. Tamper protection, including such areas as seals, enclosures and line supervision, were to be incorporated into the security system.

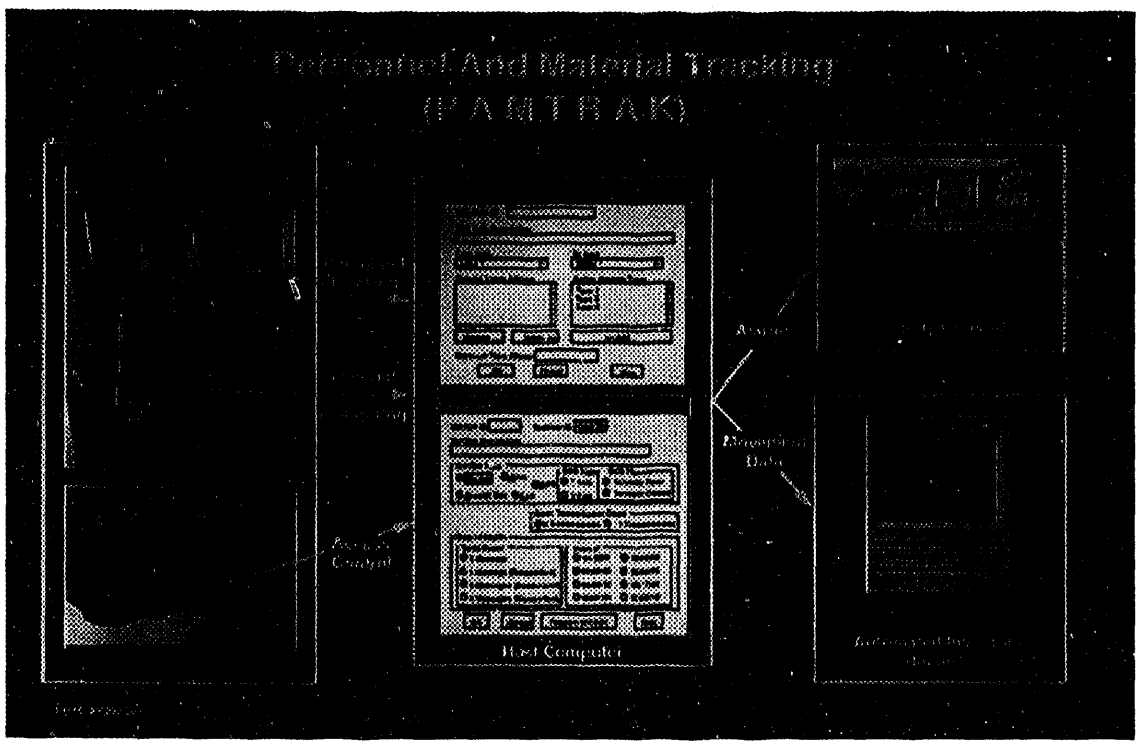

Figure 1. PAMTRAK

Automation and robotics

There were two basic areas where automation and robotics (A&R) were to be used in a facility. The first included A&R systems for specific security and nuclear material accountability purposes. Consideration was given to using A&R technologies to perform such functions as sensor testing, remote assessment, inventories and also as part of a response force to a security or ES&H event. These systems would reduce personnel involvement, reduce operating costs and minimize personnel radiation exposure. In addition to mobile systems, permanently mounted devices which can give an external stimuli for volumetric sensor testing were being considered. Many of the WCR facilities planned to use considerable A&R in support of their operations. Many of these operations involved special nuclear material and/or classified operations. The S&S ramifications of these activities needed to be carefully analyzed to include such areas as software control, data communications, computer system architecture and the use of on-line S&S measures.

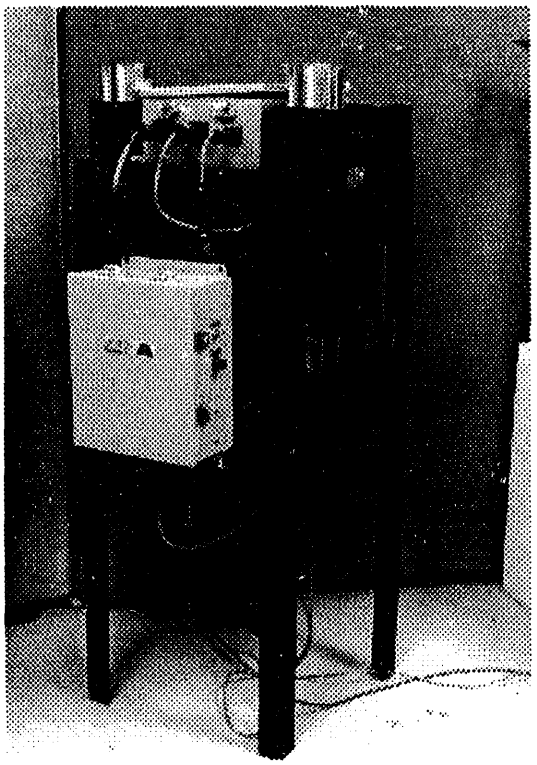

Figure 2. Material monitoring system.

Material monitoring and item tracking

The purpose of material monitoring and item tracking is to provide increased assurance that nuclear materials are accounted for and adequately protected. The combination of various measures may result in an extension of the SNM inventory interval. A number of different technologies have been develop to provide real-time, continuous monitoring. The attributes measured vary depending upon their purpose. They could help confirm material presence, enhance security and provide a state-of-health indication of materials being stored.

Summary

The S&S support given to the Weapons Complex Reconfiguration design effort helped ensure that S&S issues and concerns were identified early in the design, helped identify measures which would result in savings in life-cycle S&S costs and identified technological approaches which reduced S&S personnel requirements. Specific technology opportunities were identified based on the requirements and needs of the identified based on the requirements and needs of the WCR facilities. Integration of physical security systems with other S&S and non-S&S measures helped provide a more effective and less costly command and control system for the facilities.

Much of the S&S efforts in support of the WCR design effort were very high level and considerable opportunities exist for the development of new security technologies. Increased technical exchanges among industry, operators and other government agencies and organizations would be very beneficial. Teaming of industry and government in S&S development would allow us to take advantage of available proven commercial and government systems and components and reduce research and development costs.

Acknowledgments

The success of this program would not have been possible without the considerable support of a large number of people who provided their technical skills and vision to this program.

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robotics), Marv Plugge (access delay), Ellen Lemen (vulnerability assessments), Roxy Jansma and Tan Thai (information surety).

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