CMC

COOPERATIVE MONITORING CENTER

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Achieving Cooperative Security Objectives through Technical Collaborations

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Mission Statement

The Cooperative Monitoring Center assists political and technical experts from around the world to acquire the technology-based tools they need to assess, design, analyze, and implement nonproliferation, arms control, and other security cooperative measures.

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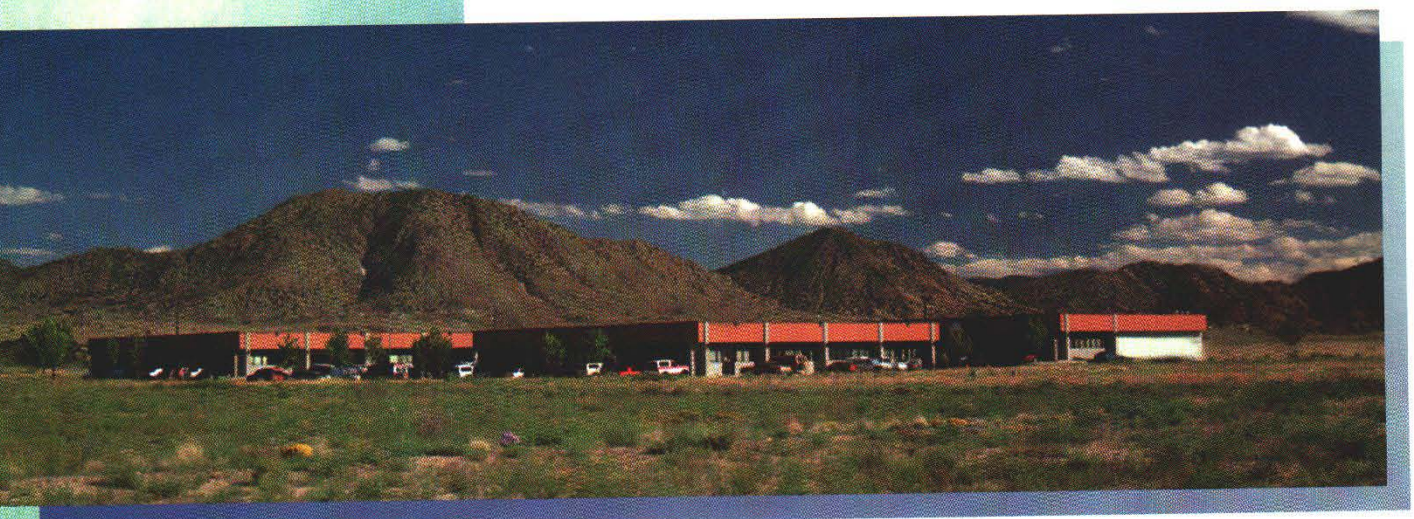

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INTRODUCTION TO THE CMC

The end of the cold war has reduced the probability of global war but has increased the likelihood of regional conflict. Without the stability provided by a system of states dominated by two super-powers, local disputes over resources, territory, immigration, and ethnic and political antagonisms can escalate into regional conflicts. Regional wars can have global consequences, particularly if the countries involved possess weapons of mass destruction (WMD).

Achieving regional security is a critical nonproliferation objective for at least three reasons. First, regional tensions and threat perceptions can be the fundamental motivation for countries to acquire WMD. Addressing these motivations is increasingly important since the spread of advanced technologies and expertise makes WMD acquisition easier. Second, regional concerns have a crucial impact on the negotiation and implementation of global arms control and nonproliferation regimes, such as the Nuclear Nonproliferation Treaty or the Comprehensive Test Ban Treaty. Third, global progress in nonproliferation will require progress in regional arms control and the establishment of regional regimes tailored to unique geographic and historical circumstances.

The next twenty years will bring unprecedented demands and opportunities for international and regional cooperation on issues ranging from halting weapons proliferation to managing the environment and natural resources. A growing number of countries will be party to multilateral or regional cooperative agreements. Effective implementation of cooperative agreements will require acquisition, processing, analysis, and sharing of large quantities of information and data. Much of this can be done using technology available to all parties to an

agreement. Provisions for sharing data and resolving anomalies will be other requirements. Such "cooperative monitoring" will become a vital component of security for individual countries, regions, and international institutions. However, many countries lack the basic experience and technical infrastructure necessary for full participation in cooperative regimes. Even technically sophisticated countries will require enhancement of existing information acquisition and management capabilities. A successful transition into a more cooperative world will present a complex technical and political challenge.

The Cooperative Monitoring Center (CMC) at Sandia National Laboratories in Albuquerque, New Mexico, was established by the US Department of Energy in July 1994 to help meet this challenge. Sandia's history includes extensive involvement with US treaty verification and leadership of US nuclear weapon stewardship activities. In combination with complementary expertise at other DOE national laboratories, these activities have resulted in a unique systems-level approach to problem solving and a broad spectrum of technology-based tools applicable to the challenges of cooperative monitoring.

The CMC promotes the development of the technical and scientific infrastructure for arms control around the world through a visiting scholars program, by conducting workshops to explore how technology can facilitate solutions to specific problems, and by providing assistance to on-going international negotiations and discussions. The CMC also supports international experiments on the use of technology in enhancing the effectiveness of transparency and confidence building measures.

Workshop participants receive hands-on experience with monitoring hardware, software, and data processing capabilities for a wide range of applications. For example, the CMC collects monitoring data from nuclear facilities worldwide as part of an experiment to demonstrate the role remote monitoring can play in providing transparency. Numerous monitoring technologies are demonstrated at the CMC, including ground sensors for detection and assessment, satellite and aerial image analysis, and data security and access control technologies. Simulations are used to educate participants about the way such sensors can be used effectively in applications of interest to them.

India Workshop, 6/95

The CMC leverages long-standing DOE technology programs into new cooperative applications. As a center for the development of sharable monitoring systems for use by regional and international organizations, the CMC promotes worldwide development of the technical infrastructure necessary for implementing security agreements. It makes these technologies, and the technical expertise of the DOE national laboratories accessible to a wide spectrum of US and international organizations.

The 22,000 square foot CMC facility includes laboratory space, technology training and demonstration rooms, meeting and conference facilities, and office space for CMC personnel and visiting scholars. For more information, please visit the CMC home page on the World Wide Web:

http://www.cmc.sandia.gov.

DOE and National Laboratory History in Arms Control

Nuclear Burst Detection Satellite Sensor Systems

Since the late 1940's, the US Department of Energy (DOE) and its predecessors, the US Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), have had primary responsibility for the design, development, manufacture, stockpile and maintenance of US nuclear weapons. Much of this work has been carried out at the DOE national laboratories. Collectively, the various national laboratories have maintained expertise in nuclear materials, nuclear weapon components, testing requirements, and all other aspects of safely and reliably developing and maintaining the nuclear weapon stockpile of the United States. With this experience, the national laboratories were among those most heavily involved in the early and ongoing efforts to monitor other nuclear programs and to place limits on the development, deployment and testing of nuclear weapons. Since the early 1960s Sandia and its sister laboratories have developed and deployed systems to monitor nuclear testing and to provide security associated with protection and accounting of nuclear materials. They have also developed technologies to monitor other arms control agreements concerning chemical and biological weapons, conventional military forces and tactical and strategic missile systems. Currently, the laboratories play a major role in developing transparency measures for weapon dismantlement under nuclear arms control agreements. Joint efforts with the former Soviet Union to provide protection, accounting and control for nuclear material at defense and civilian facilities is another major activity.

Much of the experience and many of the technologies that have been developed by the national laboratories over the past forty years can be applied to other cooperative applications, including regional confidence building and arms control. Developing a framework to apply existing technical capabilities to new applications is a key objective of the CMC.

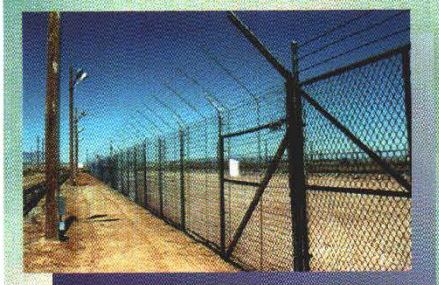
Monitoring Technologies and Systems at the CMC

The CMC displays individual technologies, complete monitoring systems and data from operational monitoring systems. Many of these technologies and systems are described in this section. Expanding the number of technologies and systems demonstrated at the CMC is a project objective. In particular, the CMC seeks to increase the number of technical demonstrations representative of work from other foreign and US laboratories.

Missile Monitoring System at Votkinsk Russia

Physical Security

Physical security sensor systems are used to control, monitor, and record movements of vehicles, people, or other objects. These systems may be designed for exterior or interior application and are used extensively to monitor and protect both government and private facilities. Displays at the CMC include alarmed fences to control entrance or exit from a protected facility or area, video systems that record images periodically or when triggered by other sensors, and ground sensors that measure seismic, magnetic, infrared, or other indicators of objects or people. The Intermediate Range Nuclear Forces Treaty (INF) between the US and the former Soviet Union is an example of an agreement which makes use of such systems. This agreement requires monitoring systems and on-site inspectors at missile assembly facilities to monitor treaty compliance. US and Russian versions of these missile monitoring systems are displayed at the CMC.

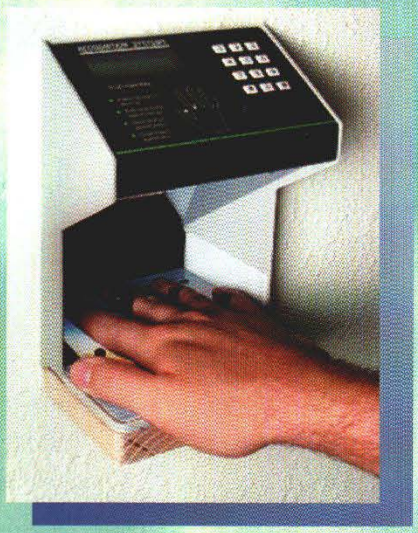


Instrumented Security Fence

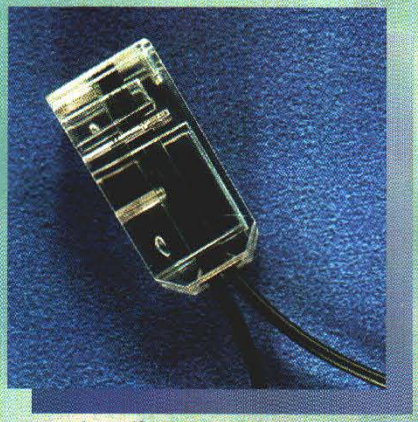
Access Control and Delay

Access control technologies limit access to secure or controlled facilities. Delay technologies impede the progress of unauthorized persons seeking entry or performing tasks in a controlled area. A simple example of access control is a locked door to an off-limits area. With increasing sophistication, access control can include locking mechanisms that require codes, cards, or unique identifiers to gain entry. CMC displays of these technologies include a "man-trap" access control booth and a simulated facility entrance system which includes magnetically locking doors with keypad, card reader and hand geometry access control devices.

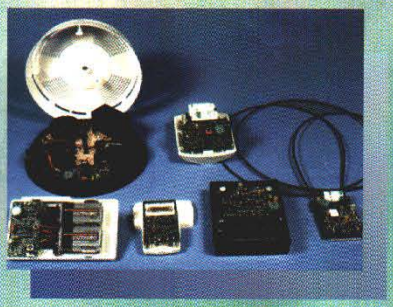
Mini Intrusion Detection Sensors



Hand Geometry Reader



Passive Fiber Optic Seal



Authenticated Item Monitoring System Sensors

Shrink Wrap Seal

A computer model for evaluating weaknesses of access control systems is displayed. Also represented are examples of delay technologies, including the use of barriers and smoke obscurants.

Tags and Seals

Tags provide unique identifiers for objects controlled by an agreement. A tag may be a characteristic feature of the item, such as its ultrasonic response, or may be a device attached to the object. Seals assure closure of facilities or other objects and can be used to determine whether an item previously inspected has been opened or altered. Passive tags and seals are inspected periodically to assess changes. Active tags and seals transmit data about the condition of the device to allow continuous monitoring. Ultrasonic, electronic, and optical tagging technologies are displayed at the CMC. Seal technologies include fiber-optics, electronics, and special wrapping materials. Seals are designed to fit a wide range of applications that include doors, valves and canisters.

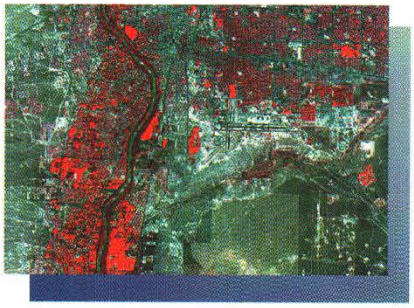
Data Security

Ensuring the integrity of the data collected, transmitted and received is an important element of a monitoring system. This can be accomplished through different algorithms and technologies including data encryption and data authentication. Encryption algorithms use a computer code to scramble data or messages so that only those knowing the code can read the information. Data authentication is a cryptographic technique that does not change the data but appends an authentication tag that accompanies the message. Public key data authentication as demonstrated at the CMC allows multiple recipients of data to validate data integrity while denying them the ability to modify the data or impersonate the sender of the data.

Data authentication concepts can be integrated with sensor hardware and systems to provide authentication of monitoring information. One example of such hardware is the Authenticated Item Monitoring System (AIMS). Systems such as this have potential safeguards applications in the areas of arms control and treaty verification, military asset control, International Atomic Energy Agency (IAEA) and other nonproliferation verification activities, as well as domestic nuclear safeguards activities. Commercial applications could include high value inventory control and security systems.

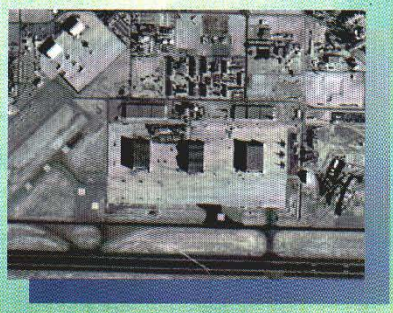
Satellite and Aerial Imagery

Commercial satellite imagery provides opportunities for wide-area monitoring. Both the resolution and the spectral characteristics of satellite imagery are distinguishing features among different commercial satellite systems.

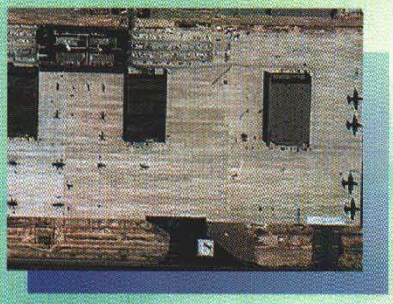


US Landsat Image of Albuquerque

French SPOT Image of Albuquerque Airport



Russian Commercial Satellite Image of Albuquerque Airport



Aircraft Image of Airport Hangers

The CMC has examples of imagery from several commercial satellites and software for analyzing and comparing images. The US Landsat produces images with a resolution of 30 meters, which means that objects with a size of about 30 meters are identifiable. Landsat images are multi-spectral with different images in each of seven spectral bands. The French SPOT satellite produces either 10-meter resolution images that lack the spectral information available from Landsat, or 20-meter resolution multi-spectral images. Panchromatic imagery from the Russian KVR-1000 satellite, with 2-meter resolution, is also available.

Optical and radar imagery from aircraft also can be used for monitoring. Airborne sensor systems can be quickly dispatched and, because of their lower altitude, can achieve much higher resolution than is available from space-based systems. However, aircraft require access to the airspace over areas of interest, which may not be permitted. Image resolution is a function of the optics of the sensor system and the altitude of the aircraft, and can be specified in particular applications. For example, the Open Skies Treaty permits no better than 30-cm resolution for its optical systems. The treaty also allows the use of a Synthetic Aperture Radar (SAR). Radar systems permit gathering images at night and under clouds, when visual imaging is not possible. Under Open Skies, SAR imagery with 3-meter resolution is permitted.

The CMC maintains examples of aerial images from different sensor systems. These can be compared with one another as well as with the available satellite imagery, using commercially available image analysis software.

Seismic Monitoring

Large-scale seismic systems have been used for decades to measure underground nuclear testing and earthquakes. Seismic sensors placed in the ground record the patterns of earth motion created by explosions or earthquakes. The CMC has examples of seismometers, seismic data displays and models of remotely deployable seismic stations. Data processing and analysis software, as well as data from

US Open Skies Aircraft

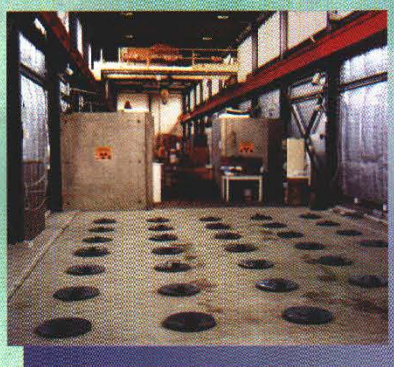
international seismic monitoring stations like those proposed for use in monitoring the Comprehensive Test Ban Treaty, are available at the CMC.

On a smaller scale, seismic sensors can also be used to measure localized ground motion caused by vehicles on roads or people walking along paths. These smaller scale systems are displayed as part of the physical security applications described earlier.

Experimental Monitoring Systems

The CMC also demonstrates experimental monitoring systems. The purpose of the Remote Monitoring System (RMS) project is to demonstrate efficient data collection and analysis in the monitoring of civilian nuclear facilities worldwide. Under an international collaborative project, the CMC currently receives data from sensors deployed in nuclear facilities in Russia, the US, Australia, Japan, Sweden, and Argentina. More sites are planned. The system consists of authenticated sensors to monitor activity, a communication system to transmit data to remote monitoring sites, and decision support software. Sensors collect and store data on-site and then send the data, including photographic images, over phone lines to monitoring stations like the one at the CMC. Workstations display the data in an intuitive manner to facilitate analysis and decision-making. Current data includes sensor alarms and triggered video images. Data review requirements are greatly reduced by collecting data only when sensors are triggered.

A similar experimental system is also used to monitor dismantled nuclear weapon components at the PANTEX facility in Amarillo, Texas. Simulated storage casks, sensors and the actual data from PANTEX can be viewed at the CMC. Multilevel security features permit appropriate data to be



Monitored Nuclear Spent Fuel Storage in Australia

made available to such varied users as the US government, site engineers, foreign governments, state agencies, and the general public. This project demonstrates the ability to provide transparency to sensitive activities while protecting national security and proprietary information.

On-Site-Inspection Technologies

On-site-inspection is a common element of cooperative monitoring. The On-Site-Inspection System (OSIS) demonstrated at the CMC uses a geographical information system to assist inspectors (and hosts at inspected facilities) to manage information associated with inspections. Examples of information relevant to inspections include: treaty text, maps, facility diagrams, results of previous inspections, and routes for inspectors to follow. The OSIS can be used both to plan inspections and to manage and track inspections as they occur. A version of this system was used by the inspection teams in Iraq under the UN Special Commission.

Environmental Monitoring

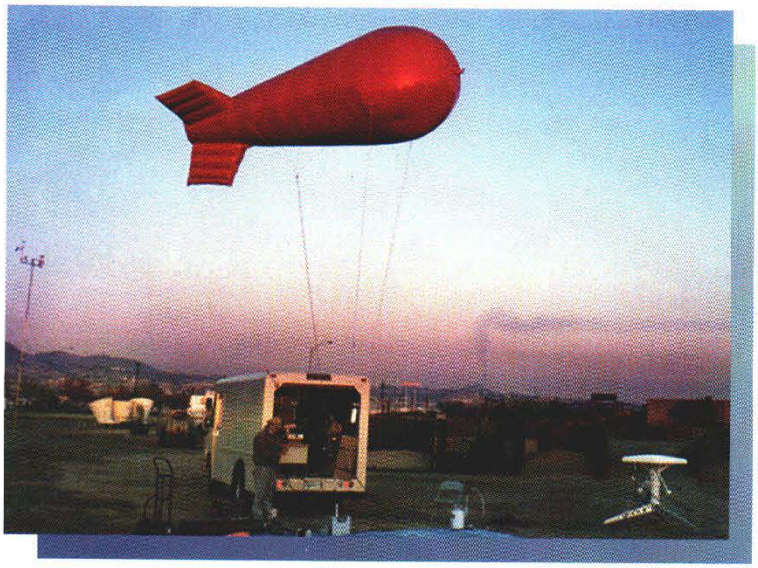
Selected technologies for monitoring the environment and natural resources are also demonstrated at the CMC. These include computer software to model particulate dispersion over complex terrain, airborne sensors to measure pollutant concentrations, and computer data bases that match environmental problems, such as toxic waste sites, with remediation technologies. The number of environmental technologies at the CMC will increase in the future.

Portable CMC

To allow the CMC to conduct workshops in other regions, a portable CMC capability is being developed. The portable CMC will include sensor hardware, analysis software, project displays and videos.

Monitoring of simulated nuclear weapon component storage

Information for On-Site Inspection



Air sampling Instrumentation

Services Provided by the Cooperative Monitoring Center

The mission of the Cooperative Monitoring Center is to assist political and technical experts from around the world to acquire the technology-based tools they need to design, evaluate, and implement nonproliferation, arms control and other cooperative security measures. The CMC provides three types of services to accomplish this mission:

1. analysis of the role of technology in facilitating resolution of security problems;
2. workshops and training classes on monitoring and verification technologies and procedures; and
3. technical experiments using monitoring technology.

In all cases, the CMC helps participants think through options for using monitoring technology for specific applications. Because of the complexity of individual situations, there is never a single "right" answer for any given problem.

Technical Analysis

The CMC provides a neutral forum in which political and technical experts can meet to establish a dialogue on the role of technology in facilitating regional security. The CMC focuses on the evaluation of technical options for monitoring potential agreements, rather than on advocating particular policies. Short seminars at the CMC, long-term visits under the Visiting Scholars Program, and collaborative projects with researchers from other countries are part of this program.

The CMC has developed an analytical framework to evaluate monitoring options for potential cooperative security arrangements. This framework helps analysts think through the broad set of contextual issues that surround any proposal for technical monitoring. It emphasizes the relationship between the detailed provisions of an agreement and monitoring or verification measures. It also stresses the need to analyze issues such as intrusiveness and cost in recommending technical monitoring options.

Analysts at the CMC have applied this framework to develop monitoring options for a wide spectrum of proliferation-relevant topics, noted in *Table 1*. Also listed in *Table 2* are several "nontraditional" topics for confidence building measures. Some of these nontraditional topics, such as environmental degradation and resource scarcity, can be major sources of tension and thus contribute to regional instability. Many involve issues that affect more than one country and whose solution will require cooperation. In some cases,

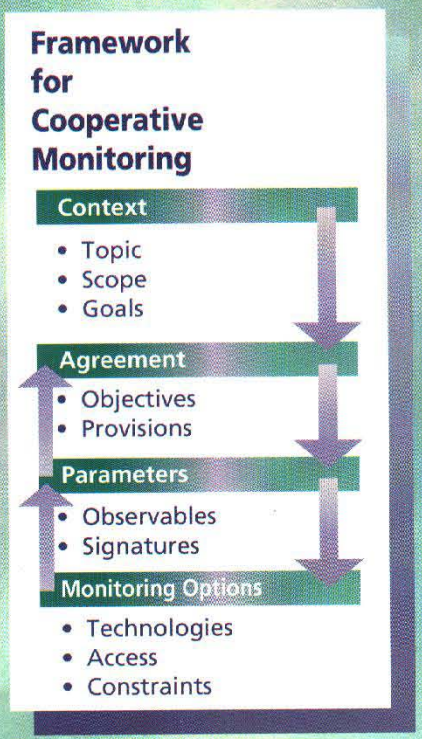


Table 1

Proliferation-Relevant Topics for Confidence Building Measures or Arms Control

Nuclear

- Fissile material production cutoff
- Reactor closure
- Nuclear weapon free zones
- Material disposition and safeguards
- Test limitations

Conventional

- Demilitarized zones
- Arms reductions or limitations
- Pre-notification of military exercises
- Incidents at sea agreements
- Arms transfer registers

Delivery Systems

- Missile non-deployment
- Missile destruction
- Missile production limitations
- Missile test limitations
- Missile bans

Chemical and Biological

- Production controls
- Facility closure
- Disease reporting
- Weapons destruction

Table 2

Nontraditional Topics for Confidence Building Measures

Environment

- Water, air and soil pollution
- Nuclear reactor safety
- Hazardous waste disposal

Resources

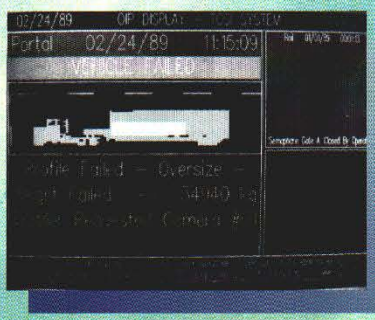
- Water quantity, quality and distribution
- Soil degradation and deforestation
- Wildlife depletion

Commerce / Trade

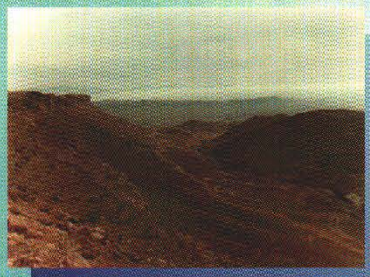
- Border control
- Drug interdiction
- Smuggling and piracy

Emergency Response

- Hurricanes
- Epidemics
- Oil spills



Vehicle Profile Image from INF monitoring Systems



Giddi Pass monitoring location in Sinai desert

Table 3

Workshops Conducted by the Cooperative Monitoring Center

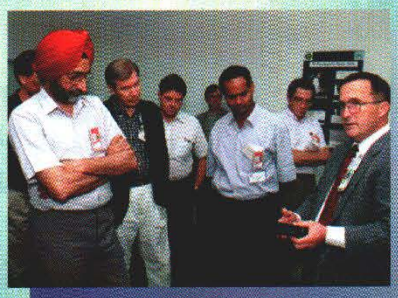
July 1994 through May 1996

Region	Date	Participants	Subject	Sponsors/Partners
Middle East	7/94	Egypt, Israel, Kuwait, Oman, Qatar	border & missile monitoring	DOE, IGCC
	5/95	Egypt, Israel, Jordan	security & the environment	DOE
	7/95	Qatar	regional security centers	DOE, State
	1/96	Israel	verification technology training	DOE, ACDA
	2/96	Egypt, Israel, Jordan	weapons of mass destruction free zones	DOE, DePaul University
	4/96	Algeria, Jordan, Kuwait, Morocco, Saudi Arabia, Palestinian Authority	cooperative monitoring & regional security	USIA, DOE
Northeast Asia	8/94	South Korea	verification technologies	DOE, State
	2/95	China, Japan, South Korea, Russia	limited weapons of mass destruction free zones	DOE, Georgia Tech
	11/95	South Korea	demilitarized zone monitoring	DOE
	4/96	South Korea, Canada	nontraditional security challenges	DOE
South Asia	10/94	Pakistan	border & missile monitoring	DOE, ACDA
	6/95	India	border & missile monitoring	DOE, ACDA
	2/96	India, Pakistan	South Asian security	DOE
China	3/96	Chinese nuclear labs	verification technologies	DOE
Middle East South Asia China & Europe	5/96	Journalists from 11 countries	verification technologies	DOE
Former Soviet Union	8/95	Russian nuclear labs	nonproliferation	DOE

(see organizational acronyms in *appendix C*)

countries may be more willing to engage in discussions of confidence building measures on "nontraditional" issues than on military matters.

Analytical efforts have also examined the use of monitoring technologies in historical agreements. Two prominent examples were the use of ground sensors to monitor the Sinai disengagement agreement between Israel and Egypt in the mid-1970s and the use of portal monitoring systems as part of the Intermediate Range Nuclear Forces (INF) treaty between the US and the USSR in the 1980s. Further information on these analyses can be found in the referenced publications and briefings listed in the appendices.



South Asian Workshop

Workshops and Training Classes

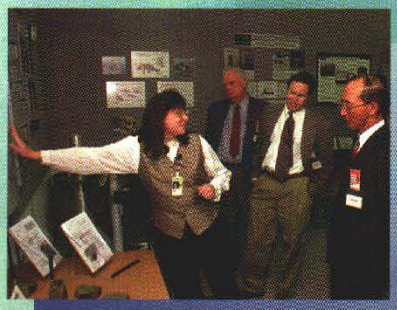
The CMC has conducted cooperative monitoring workshops for groups from the Middle East, Northeast Asia, South Asia, China and the Former Soviet Union. Workshop participants have included members of the academic, military, and government communities from the various countries. In addition to sponsorship from the DOE, many of these workshops were conducted with assistance from research organizations or other government agencies. The agenda for each workshop was determined through close coordination with participants from individual countries or with the partner or sponsoring organization. *Table 3* lists workshops through May 1996.

Middle East Workshop

Workshops include presentations on technical analyses of monitoring options for specific applications, briefings and demonstrations of monitoring technologies and systems, and presentations on the basic elements of system design and evaluation. For example, in the Weapons of Mass Destruction Free Zone(WMDFZ) workshop in February 1996, the CMC staff briefed the group on potential monitoring options for a Fissile Material Cutoff Treaty, and demonstrated relevant monitoring technologies, including a system that monitors dismantled nuclear weapons components at DOE's PANTEX facility in Amarillo, Texas. *Appendix A* lists examples of workshop presentations developed over the last two years.

Korean Workshop

For longer workshops, the CMC has developed a "simulation exercise" in which participants are divided into groups and given the opportunity to design a monitoring regime for a specific application. For example, for the Israeli Verification Training Course in January 1996, a "model text" agreement establishing a demilitarized zone between two hypothetical



Collaborations with Korean Arms Control Officials

countries was developed. Participants were divided into two groups, each representing one of the hypothetical countries, and assigned the task of developing monitoring options for elements of the agreement. Exercises such as this require participants to utilize information learned during the workshop. They consistently have been one of the more popular workshop activities.

In most cases, time is provided throughout the workshop to hear participants' views on regional security issues. Such discussions provide a critical context to the briefings and presentations on technical monitoring.

In addition, members of the CMC team have participated in numerous international conferences on security and the use of monitoring technologies. These have included meetings in the US, Canada, United Kingdom, Greece, Jordan, Cyprus, Japan, and the Republic of Korea. Other interactions have also been held in Israel and Egypt.

Plans for the future include conducting monitoring workshops in other regions, working with ACDA to offer verification training courses to groups from other countries, and developing joint training programs with institutes such as US defense universities. Suggestions for additional workshop topics are welcome.

TECHNICAL COLLABORATIONS

CMC workshops, coupled with regional travel and participation in activities sponsored by other organizations, have led to a number of collaborative projects between the CMC team and regional researchers. Increasing the number of collaborative projects is a major project objective. Examples of existing and potential collaborative projects are summarized below.

Monitoring Options for Korean Demilitarized Zone

This collaboration, between the CMC and researchers at the Korean Institute for Defense Analysis (KIDA) will analyze cooperative monitoring options for the Korean demilitarized zone. Funding for the Korean participation is provided by the Korean Ministry of National Defense.

Sensor Test Bed for Monitoring Conventional Arms Limitations

The Korean Arms Verification Agency (KAVA) has expressed interest in working with the CMC to design and deploy an experimental system in South Korea for monitoring tank

garrisons. The experimental system could be used to prepare for monitoring potential agreements with North Korea on conventional force limitations. The CMC staff would welcome similar experiments with researchers in other regions.

Region Specific Scenarios for Simulation Exercise

Another regional researcher, under a contractual arrangement with the CMC, has developed region-specific scenarios for the cooperative monitoring simulation exercise. The project focuses on monitoring demilitarized zones brought about by the withdrawal of forces under disengagement agreements. Developing additional scenarios in collaboration with other regional experts is a priority for the future.

Role of Technology in Furthering Cooperation Among Neighboring Countries

In collaboration with the S. Neaman Institute of Israel, the CMC is planning a workshop for the technical communities of Egypt, Israel, Jordan, the Palestinian Authority and possibly other Middle Eastern countries on how technology can further cooperation on common problems such as environmental degradation, resource scarcity and border monitoring. The objective of the workshop will be to generate proposals for technical projects involving two or more countries.

Future Monitoring Experiments

A top priority for the future is to increase the number of experimental collaborations with technical experts from other countries. Monitoring experiments can be useful tools for exploring a range of monitoring options for specific applications. They can also be useful to train regional experts on the basic elements of cooperative monitoring. For example, to learn more about the technical issues involved in collecting, sharing and analyzing data, two or more countries could install monitoring technology, such as motion sensors, video cameras, and temperature or radiation sensors, at a "non-sensitive" facility. Collected data could be shared with experimental partners using information security technology, such as data encryption and authentication. Experiments such as this provide training on the use of monitoring technologies and data security. The same facility could also be used to practice techniques used during on-site inspections.

Visiting Scholars Program

To expand the number of collaborative projects, the CMC plans to structure a more active visiting scholars program. During extended stays, regional experts can collaborate with technical experts from the CMC on analytical or experimental projects.

Looking to the Future

Regional interactions at the CMC have led to a few key observations that will guide future activities. First, regional problems require regional solutions. Although the US/USSR experience can provide valuable lessons, each region is unique and will need to develop its own logic for confidence building and arms control. In some cases, regional verification may be needed to supplement international or global monitoring regimes to reflect region-specific concerns.

Second, education and training are critical for constructive regional participation. Many countries lack the institutional framework to train experts for participation in international negotiations. Experts from all participating countries need sufficient knowledge to feel confident in a negotiating forum. Asymmetries in regional technical expertise may be as important as geographical asymmetries.

Third, agreements on weapons of mass destruction may be the last step in a regional security process. Issues such as conventional arms and delivery systems, which also pose a threat, are of great interest. Discussions on nontraditional security challenges, such as resources and the environment, may also offer opportunities to engage parties constructively.

Fourth, collaborative technical experiments provide opportunities to investigate a range of monitoring options in non-threatening environments. Such experiments prepare the technical communities to evaluate and implement agreements in a timely manner when they become a reality. Collaborations also help establish a regional constituency for arms control and nonproliferation.

In the future, the CMC will endeavor to expand ties with regional and US organizations to assist in the effort to develop an infrastructure for implementing security agreements worldwide.

Appendix A: Representative List of CMC Briefing Topics

The titles listed below are representative of the range of briefings and presentations given during the many workshops held at the CMC. Most are being continually reviewed and updated. Many of these presentations are also associated with technology demonstrations or displays. The list includes materials from Sandia as well as other agencies, and laboratories, such as Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), and Pacific Northwest Laboratory (PNL) who participate in workshops held at the CMC.

Tutorials

- Overview, Goals and Activities of the CMC
- Principles of Cooperative Monitoring
- Fundamentals of Cooperative Monitoring System Design and Development
- Monitoring Nuclear Materials
- Principles and Implementation of On-Site Inspections
- Multilevel Security at Sensitive Facilities
- Infrastructure Needs for Regional Cooperation
- Overview of Physical Protection Systems
- Introduction to Missile Issues
- National Means and Cooperative Monitoring

Technologies

- Remote Monitoring Systems
- Transparency at Civilian Nuclear Facilities
- Vehicle and Cargo Tracking and Monitoring
- Commercial Satellite Imagery
- Computer-Assisted Inspection Planning
- Survey of Seismic Monitoring Technologies
- Radiation Sensors in Arms Control, Verification and Monitoring
- Tags and Seals
- Data Authentication Technology
- Vulnerability Assessment of Monitoring Systems
- Access Control and Delay Technologies

Precedents for Cooperative Monitoring

- Sensors in the Sinai
- Regional Monitoring System for Argentina and Brazil (ABACC)
- The Biological Weapons Convention: Monitoring Opportunities

Monitoring a Missile Assembly Facility for the INF Treaty
INF Inspection Exercise at a Production Facility
UNSCOM and IAEA Remote Monitoring and Sampling in Iraq
Monitoring of Iraqi Missile Test Facilities by the United Nations
Cooperative Environmental Monitoring Between the US and Mexico (Air Quality Monitoring)

APPLICATIONS

Design of Border Monitoring Systems
Monitoring Exercise for Limited Force Zone Monitoring
Border Monitoring for South Asia: India/Pakistan, India/China
Technical Options for Enhancing Existing South Asia Confidence Building Measures: Notification of Military Land Exercise
Border Monitoring for Non-Security Purposes
Monitoring and Modeling Water Resources in the Middle East
Using Seismology for Regional Confidence Building
Applications of Airborne Sensors
Application of Aerial Sensors in the Open Skies Treaty
Options for Missile Monitoring
Monitoring Options for India/China Missile Nondeployment
Nuclear Material Protection Control and Accountancy
Monitoring Options for Fissile Material Cutoff Agreement
Comprehensive Test Ban Treaty (CTBT) Monitoring
Monitoring Options for Weapons of Mass Destruction Free Zones
Multi-Level Security for Weapons Dismantlement Transparency

APPENDIX B: LIST OF CMC PUBLICATIONS

Pregenzer, Arian L. et. al., *Cooperative Monitoring Workshop: Focus on the Middle East,* SAND95-1067, Sandia National Laboratories, Albuquerque, NM, May 1995.

Herron, Kerry, *Cooperative Monitoring Workshop: Limited Nuclear Weapons Free Zones in Northeast Asia,* VST-061, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque, NM, February, 1995.

Pregenzer, Arian L., *Crisis Prevention Centers as Confidence Building Measures, Suggestions for the Middle East,* SAND94-0919, Sandia National Laboratories, Albuquerque, NM, May 1995.

Pregenzer, Arian L., *Crisis Prevention Centers as Confidence Building Measures, Suggestions for North East Asia,* SAND94-1527, Sandia National Laboratories, Albuquerque, NM, May 1995.

Pregenzer, Arian L., *Enhancing Regional Security Agreements Through Cooperative Monitoring,* SAND94-3250, Sandia National Laboratories, Albuquerque, NM, May 1995.

Herron, Kerry, *Consultative Meetings on Cooperative Monitoring Initiatives in the Middle East, May 8-15, 1995,* VST-079, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque, NM, June, 1995.

Pregenzer, Arian L., Michael Vannoni, and Kent Biringer, *Cooperative Monitoring of Regional Security Agreements,* VST-076, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque, NM, June, 1995.
(to be published as SAND96-1121)

Vannoni, Michael G., *Institute for Defense Studies and Analyses (IDSA) Cooperative Monitoring Workshop,* June 26-28, 1995, VST-073, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque, NM, April, 1996.

Vannoni, Michael G., *A Precedent for Regional Cooperative Monitoring: Sensors in the Sinai,* VST-074, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque, NM, May, 1996.

Biringer, Kent L., *Cooperative Monitoring: A Framework for Issues Analyses and the Role of Technology,* VST-075, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque, NM, May, 1996.

Lincoln, Richard, *Cooperative Nuclear Agreements and Monitoring,* VST-078, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque NM, May, 1996.

Trost, Larry, *Ballistic Missile Control and Monitoring Options,* VST-077, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque NM, May, 1996.

Biringer, Kent L., *Republic of Korea/Canada/CMC Workshop: Exploring Collaborations and Regional Cooperative Monitoring,* VST-080, Cooperative Monitoring Center, Sandia National Laboratories, Albuquerque NM, May, 1996.

Available Technology Fact Sheets

Continuous Monitoring Systems for the INF Treaty
Video Surveillance
AIMS: Authenticated Item Monitoring System
ATMS: Authenticated Tracking and Monitoring System
Network Technology for Remote Monitoring Applications
IRMP: International Remote Monitoring Project
Straight-Line: A Nuclear Material Storage Information Management System
OSIS: On-Site Inspection System
ACE-IT: Augmented Computer Exercise for Inspection Training
UNM-LTER: University of New Mexico Long Term Ecological Research
MIDS: Mini Intrusion Detection System
Taut Wire Intrusion Detection Systems
BIM: Barrier Integrity Monitor
Active Infrared Intrusion Detection Systems
Bistatic Microwave Intrusion Detection System
Fiber Optic Intrusion Detection Systems
Monostatic Microwave Intrusion Detection Systems
Special Nuclear Material (SNM) Monitors for Material Control at Nuclear Facilities
Radiation Detection Equipment for Monitoring the Intermediate-Range Nuclear Forces Treaty

Asphalt: A Low-Profile Neutron Sensor
CMC Workstation Demonstration Capability
Seismic Monitoring
Image Processing of Remotely Sensed Data
SAROS: Synthetic Aperture Radar for Open Skies
RAMP: Remote Atmospheric Monitoring Project
Two-Dimensional Data Visualization
MACCS: MELCOR Accident Consequence Code System
Air Flow Over Complex Terrain
EnviroTRADE Information System
Cobra Seal
Bolt and Loop Electronic Identification Devices
PNL Tamper Tapes
Tamper-Evident Shrink-Wrap Seal
SVSC: Sample Vial Secure Container
RPT-2: Second-Generation Reflective Particle Tag
Public-Key Data Authentication System
Access Delay Technology
Vulnerability Assessment
Demonstration: Monitoring the Gate of the "Nuclear Research Reactor Facility"
Demonstration: Monitoring the Route of the Spent Fuel Cask Shipment
Demonstration: Tracking the Spent Fuel Cask Shipment
Demonstration: Monitoring the "Spent Fuel Handling Building"
On-Site Chemical Sampling Equipment for the Chemical Weapons Convention

Appendix C: Acronyms

ACDA	United States Arms Control and Disarmament Agency
ACRS	Arms Control and Regional Security process (Middle East)
AEC	United States Atomic Energy Commission
AIMS	Authenticated Item Monitoring System
CMC	Cooperative Monitoring Center
CTBT	Comprehensive Test Ban Treaty
DOE	US Department of Energy
ERDA	US Energy Research and Development Administration
FMCT	Fissile Material Cutoff Treaty
IGCC	Institute on Global Conflict and Cooperation, University of California
INF	Intermediate Range Nuclear Forces Treaty
IAEA	International Atomic Energy Agency
KAVA	Korean Arms Verification Agency
KIDA	Korean Institute for Defense Analysis
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
NPT	Nuclear Nonproliferation Treaty
OSIS	On-Site Inspection System
PNL	Pacific Northwest Laboratory
RMS	Remote Monitoring System
ROK	Republic of Korea
SAR	Synthetic Aperture Radar
SNL	Sandia National Laboratories
UN	United Nations
UNSCOM	United Nations Special Commission
US	United States
USIA	United States Information Agency
USSR	Union of Soviet Socialist Republics
WMD	Weapons of Mass Destruction (nuclear, chemical, biological)
WMDFZ	Weapons of Mass Destruction Free Zone

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SAND 96-1379
UC-900
June 1996

This work was supported by the
US Department of Energy under
contract DE-AC04-94AL85000

Sandia National Laboratories

US Department of Energy multiprogram laboratory