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THE APPLICATION OF COOPERATIVE MONITORING TECHNIQUES TO A CONCEPTUAL LIMITED DEPLOYMENT ZONE IN THE KOREAN PENINSULA

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ABSTRACT
The Korean peninsula is the site of a tense military confrontation. Relations between North and South Korea improved during the early 1990's but the process is now frozen. Confidence building measures, particularly military ones, that address the security needs of both countries would decrease the danger of conflict and help create an environment for direct negotiations. The Korean Institute for Defense Analysis (KIDA) analyzed current security conditions and options. Their scenario includes a conceptual agreement to establish Limited Force Deployment Zones (LDZ) along the current demilitarized zone (DMZ) to increase mutual security. The Cooperative Monitoring Center (CMC) of Sandia National Laboratories, in collaboration with KIDA, developed a strategy, with examples, for cooperatively monitoring the agreement. A cooperative monitoring regime requires consideration of the agreement's terms, the geographic, logistic, military, and political factors of the Korean environment, and the capability of technology to monitor the terms. This paper assesses the applicability of cooperative monitoring to Korea, describes the monitoring strategy for the Korean enhanced DMZ scenario, and describes the applicable technologies and procedures.

INTRODUCTION

Origin of the Project
The U.S. Department of Energy (DOE) established the Cooperative Monitoring Center (CMC) at Sandia National Laboratories in 1994 to assist political and technical experts from around the world acquire the technical tools needed to assess, design, and implement cooperative monitoring agreements. The Korea Institute for Defense Analyses (KIDA) specializes in political analysis and security policy development to help the Republic of Korea (ROK) government develop strategic options and solutions. KIDA proposed that the two organizations collaborate to apply the principles of cooperative monitoring to the problem of Korean security.

The joint analysis focuses on reducing the risk of attack by conventional forces. KIDA developed a scenario to strengthen the existing Armistice Agreement by establishing Limited Force Deployment Zones (LDZs) along the border with the Democratic People's Republic of Korea (DPRK). Based on this scenario, the CMC developed a strategy for

monitoring the agreement.[1] The project is a conceptual analysis of political and technical options for confidence building that might be feasible in Korea at some future time and is not a proposal to any government or organization. Neither KIDA nor the CMC are representatives of the ROK or U.S. governments.

The Concept of Cooperative Monitoring

Cooperative monitoring is the collecting, analyzing and sharing of agreed information among parties to an agreement. Cooperative monitoring typically relies on the use of commercially available technology. Examples include technologies for detection and assessment, such as unattended ground sensor systems, aerial overflight systems and commercial satellite systems; technologies for data security, such as data authentication and tamper indication; and technologies for access control. When combined with data management, analysis and integration capabilities, these technologies provide powerful tools for implementing security-related agreements. The technologies incorporated into a cooperative monitoring regime must be sharable among all parties. Furthermore, there must be equal access to information acquired by the system. A cooperative monitoring regime also should include procedures for dealing with anomalous data and false positives. Such procedures are necessary for constructively resolving problems and are likely to involve human presence and activity.

Cooperative monitoring can strengthen existing agreements and set the stage for continued progress in improved relations. An agreement on security between two or more countries may bring about a temporary equilibrium in their relations, but time and resources must be invested to make the equilibrium a lasting one. An investment in cooperative monitoring signals that the parties regard the agreement as important and are committed to its success. The availability of standardized monitoring systems to all parties to an agreement can remove personal bias, minimize suspicion, and balance the ability to detect and analyze relevant information. This is particularly important when parties to an agreement have differing indigenous technical capabilities. Cooperative monitoring provides a method of openly documenting compliance with the terms of an agreement and makes any act of noncompliance difficult to ignore. Although an external party can assume partial responsibility for monitoring the terms of an agreement, participation of regional parties is essential to the strength of the regime.

Cooperative monitoring can also support the process of confidence building. When two or more parties begin the process of confidence building, no permanent agreements are assumed. Specific actions to increase mutual confidence are defined which may be as simple as the exchange of military budgets or as complex as the unattended remote monitoring of a nuclear research facility. Such confidence building measures (CBMs) are intended to permit the parties to gain experience by working together. The experience hopefully leads to more substantive actions and formal agreements. The 1991 quadripartite agreement[2] for monitoring Argentine and Brazilian nuclear facilities was the culmination of

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[1] This work was supported by the U.S. Department of Energy under Contract DE-AC04-94AL85000.

[2] Brazil, Argentina, The Argentine-Brazilian Agency for Accounting and Control of Nuclear Materials (ABACC) and the International Atomic Energy Agency (IAEA) were signatories.

over a decade of CBMs beginning with simple visits and evolving to a comprehensive, technically-based monitoring regime. The Egyptian-Israeli Peace Accord of 1979 occurred after six years of increasingly complex and significant interim agreements for disengagement in the Sinai. Cooperative monitoring is not limited to arms control or military applications, but also may be applied to a wide range of other regional concerns including natural resources, commerce and trade, the environment, and emergency response.

Shared information collected by cooperative monitoring can have great utility in discussions of compliance, but additional information also may be important. Countries that participate in cooperative monitoring arrangements usually retain the sovereign right to make compliance decisions, using all available information, including that collected from purely national means. Cooperative monitoring complements, but does not replace, a country's national technical means (NTM) and intelligence activities. NTM can, in fact, play a direct role in a cooperative monitoring regime. Such a role occurred in the 1975 Sinai Agreement where unilaterally operated electronic signal collection stations were permitted to operate in the cooperatively monitored buffer zone between Egyptian and Israeli forces.

THE ENVIRONMENT FOR COOPERATIVE MONITORING IN KOREA

The Current Security Situation

Korea is the site of the world's largest current military confrontation. 1.9 million North Korean, South Korean, and U.S. troops face each other along the 255 km long military demarcation line (MDL) established by the armistice agreement of 1953. A demilitarized zone (DMZ) extends 2 km into each country from the MDL. Most troops are within 100 km of the DMZ. Significant international concern exists about North Korea's efforts to acquire nuclear, chemical, and biological weapons of mass destruction (WMD). The nuclear weapon question has been the focus of the security debate over North Korea since 1992. The October 1994 Framework Agreement between the U.S. and the DPRK, with the support of the International Atomic Energy Agency (IAEA) and Japan, has stabilized this security problem.

Nuclear proliferation, significant as it is, is not the only security problem in Korea. Richard Armitage, former U.S. Ambassador to the ROK, made several key points in a speech given to the Council on U.S.-Korean Security Studies on October 27, 1995[3]:

- "... it is a grave mistake to define Pyongyang's nuclear ambitions as the issue rather than part of the larger Korea problem."
- "This (conventional force threat) must be the center of U.S. - DPRK dialogue, and on a well-coordinated and parallel track, of North-South reconciliation."
- "If the nuclear deal was wildly successful, DPRK conventional, missile, and chemical weapon threat would not necessarily be diminished one iota."

Confidence Building Measures and the Goal of Reunification

[3] *Playing the Winning Hand: The U.S.-ROK Alliance from Confrontation to Unification*, presented Oct. 27, 1995, 10th Annual Conference, The Council on U.S.-Korean Security Studies, Arlington, VA.

In spite of the political conflict with the North, South Korea has looked ahead to issues associated with reunification. ROK President Kim Young-Sam, in a speech on Aug. 15, 1994, defined the first step in future North-South relations as "reconciliation and cooperation." Dr. Baek Jong-Chun listed several security goals that would have to be achieved during reconciliation and cooperation:[4]

- Military confidence building measures
- Transforming armistice regime into peace
- Denuclearization of the Korean peninsula
- Multilateral regional security dialog
- Adjust U.S. - Korea relationships

Military CBMs are thus a very important topic for improving relations between the DPRK and ROK. There is a general consensus that they need to precede initiatives directed at WMD. Some positive precedents for CBMs occurred during ROK/DPRK ministerial-level meetings during the late 1980s and early 1990s. In 1992, the "Agreement on Reconciliation, Nonaggression, and Exchange and Cooperation" was signed. The Agreement called for the peaceful resolution of disputes between the DPRK and ROK, recognition of the existing boundary, establishment of a hot line for crisis management, and establishment of a South-North Joint Military Committee. The Military Committee was to negotiate CBMs and arms reduction, provide notification of large military exercises, exchange information on military deployments, and conduct mutual inspections associated with verification. Unfortunately, the terms were never implemented because of the general degradation in bilateral relations but they remain a framework for the future.

The primary threat to stability in Korea is the constant threat of conventional attack. The huge forces arrayed along the MDL are capable of launching a short-notice attack at any time. Consequently, forces in the ROK remain on some elevated level of alert constantly. The need for prompt response to threats is reinforced by the lack of strategic depth in the South. Given the current lack of communication between North and South, minor events run the risk of escalating into an undesired conflict. A crossing of the MDL by a few DPRK soldiers might be caused by an unintentional error, the direction of a local commander, or the calculated decision to cause a provocation for political purposes by the national leaders. This dangerous and unstable state of affairs was demonstrated by DPRK incursions along the MDL during April and May of 1996. South Korea raised the alert status of its forces to the highest level in a decade.

The 1974 Israel-Syria Disengagement Agreement as a Precedent

The Middle East may offer insights into the potential for reducing military threats in the absence of a formal peace. The Golan Heights between Israel and Syria has a number of strategic similarities to the Korean Demilitarized Zone: a thin buffer zone, little strategic depth, a short distance to national capitals and population centers, and a high state of readiness by mobile armored forces. A general cease-fire agreement was negotiated on

[4] *The Korean Peninsula; Security Issues While Moving into the Twenty-First Century*, Baek Jong-Chun, published by the Sejong Institute, presented Oct. 27, 1995, 10th Annual Conference, The Council on U.S.-Korean Security Studies, Arlington, VA.

October 25, 1973, ending the Yom Kippur War. Egypt and Israel signed a military disengagement agreement on January 15, 1974 and officially acknowledged that they viewed it as the first step in a long-term peace process. Syria and Israel displayed far greater hostility. Periodic combat flared along the Golan front. Only on May 31, 1974, with heavy U.S. support, was a disengagement agreement signed. Even then, the text of the agreement contains the icy sentence, "This agreement is not a peace agreement."

In spite of such hostility and the lack of a formal peace agreement, the Golan Disengagement Agreement has worked well for 22 years. There has been no conflict on the Golan Heights since the Agreement was signed. The structure of the Golan agreement consists of a neutral and completely demilitarized buffer zone (1 to 6 km in width) supported by two limited force zones (10 km width each). The United Nations Disengagement and Observer Force performs monitoring including on-site inspection. Reports from monitoring are shared with both parties. A joint committee resolves disputes. At the same time, Israel and Syria continue to use their NTM to monitor conditions.

SUMMARY OF THE KIDA SCENARIO FOR MILITARY CBMs

KIDA developed a scenario to decrease the risk of conflict and increase mutual confidence including an agreement to establish limited force deployment zones along the current DMZ.[5] The key parts of the KIDA scenario are summarized in this section.

The conceptual agreement has both short-term and long-term goals:

<u>Short-term</u>

- Improve the current dangerous military situation
- Increase overall Korean security

<u>Long-term</u>

- Rejuvenate the peace process between the DPRK and the ROK
- Begin conventional arms reduction
- Begin arms control of WMD

The agreement defines a number of specific actions which do not depend on a formal state of peace between the DPRK and the ROK. The strategy of thinning the existing forces along the DMZ would significantly reduce the risk of a crushing surprise attack. At the same time, each country retains a credible defensive capability. This combination permits the alert status and overall level on tension along the MDL to be reduced. Given that the two Koreas have little experience in arms control, such a system, which does not depend on arms reduction, is more likely to be accepted politically. The scenario assumes the re-establishment of the Joint Military Committee (from the 1992 Agreement) which acts as the negotiation and implementation organization. Problems related to compliance with the agreement would be managed by a newly formed "Joint Verification Committee."

[5] *Scenario For Limited Force Deployment Zones in Korea: A Conceptual Development*; Nam Man-Kwon, Moon Kwang-Keun, Kim Myung-Jin; presented at the Korea/Canada North Pacific Arms Control Workshop; June 10, 1996, Victoria, B.C., Canada.

Successful implementation of the scenario and its associated monitoring could provide momentum for subsequent initiatives dealing with reconciliation and cooperation. With the absence of the constant threat of conflict, North and South could then begin to pursue realistic options for arms reductions of all kinds and/or transforming the armistice regime into a permanent and formal peace agreement. Subsequent initiatives could include reducing the level of conventional weapons and troops, assuring that production or stockpiling of WMD is not occurring, and establishing a framework for reunification.

The Agreement would be implemented in two phases. The first phase would remove all personnel and facilities from the existing 4 km wide strip along the MDL and make it a true demilitarized zone. The second phase, to be implemented as soon as possible after the first, would establish two limited deployment zones in both the DPRK and the ROK. The limited deployment zones are based on the current defensive lines in each country. Consequently, the zones are not equal in width.

Phase 1

The current DMZ, established by the 1953 armistice agreement, is retained and enhanced. The DMZ is not literally demilitarized. Up to 1,000 "military police" from each side are permitted by the 1953 Agreement inside the DMZ. Both the North and South maintain observation posts and perform patrols within their respective sides of the DMZ. There is at least one civilian town on each side within the DMZ. The scenario calls for the removal of all troops and equipment, all military facilities (including buildings, tunnels, obstacles and weapon emplacements), and all civilian facilities.

Phase 2

The first LDZ would be restricted to a small number (2,500) of light infantry and civilian police equipped with small arms. Emplacements for heavy offensive weapons must be removed although defensive positions may remain. Civilian activities and facilities are not restricted. LDZ-1 is defined to run from the edge of the DMZ to the existing first defensive line within each country. The width of this zone averages 4 km in the South and 25 km in the North.

The second LDZ would limit military forces to no more than five mechanized infantry divisions. Artillery with the capability of firing across the DMZ from any location in LDZ-2 would be removed. Civilian activities and facilities are not restricted. LDZ-2 is defined to run from the edge the existing first defensive line to the second defensive line within each country. The width of this zone averages 15 km in the South and 20 km in the North.

THE FRAMEWORK FOR COOPERATIVE MONITORING REGIMES

The establishment of a cooperative monitoring regime is a process. There is no single monitoring solution. To evaluate monitoring options it is first necessary to establish a framework. For every cooperative monitoring regime, the 1) context of the agreement, 2) agreement itself, 3) parameters affecting the monitoring function, and 4) options for monitoring technologies must be defined.

Context
The context of the agreement includes the historical, political, geographic, and economic factors which affect the negotiation of the agreement.

> ***Topic***–This is the subject of interest. It may be an arms control agreement on missiles, conventional forces, or WMD. It may also be an environmental, resource, or commerce-related topic of agreement.
>
> *Within the KIDA scenario, the topic is the separation and redeployment of conventional ground forces with offensive capability.*
>
> ***Scope***–The scope of the agreement addresses the region, the number of parties involved, the time frame, and the extent to which the agreement will apply. The scope could be a bilateral agreement or a global regime with many signatories (e.g., the Nuclear Nonproliferation Treaty).
>
> *The KIDA scenario is focused on the region of the Korean peninsula between Pyongyang and Seoul. The conceptual agreement is intended to be bilateral between the DPRK and ROK with the option for supporting participation from third parties.*
>
> ***Goals***–These are the high-level purposes for which an agreement is being considered. It may include eliminating weapons or initiating a regional dialogue on issues of concern. These goals will become more specific when incorporated into the specific agreement.
>
> *The overarching goal of the ROK is to improve relations with the DPRK to create an environment where substantive negotiations can occur to solve security problems and develop a framework for reunification. The specific goal is to reduce the danger of surprise conventional attack and create a more stable relationship.*

Agreement
Agreements, whether formal treaties or less formal CBMs, have certain objectives and provisions intended to achieve the goals established in the **Context** phase. The agreement documents the specific objectives and contains the provisions of the monitoring regime. Agreements normally contain:

> ***Objectives***–All agreements, treaties, and CBMs have a stated purpose or objective. These objectives may:
>
> - set limits or restrictions on objects or activities.
> - provide mechanisms for transfer of information, thereby reducing uncertainties or perceived threats.
> - promote or enhance relationships among the parties to the agreement.

Provisions–The objectives of the agreement are expanded in the provisions. The provisions define the operational aspects of implementation. For example:

- the types of control proposed,
- the objects controlled by the agreement, and
- the condition, time, or location when the objects become subject to the agreement.

Agreements providing information may specify provisions for:

- format and frequency of communications,
- quantity, location and operational doctrine,
- characteristics such as performance and physical dimensions,
- confirmation of storage or destruction.

The KIDA scenario, summarized in the previous section, defined the objectives and major provisions of the LDZ agreement.

Parameters For Monitoring

The parties identify specific parameters of the agreement that are measurable. Parameters define the function of the monitoring regime.

Observables–Observables are those items or activities in the agreement that lend themselves to being monitored and observed. They define what the monitoring system is intended to detect and characterize. These may include objects, activities, processes, or movements. For example, missile testing observables include launch equipment movement, launch vehicle deployment, fueling, closures of missile ranges or target areas, rocket ignition, rocket plume, radar track, vehicle telemetry, impact craters, and recovery operations.

Signatures– Signatures are the physical phenomena associated with the observables that can be measured. These signatures allow sensor systems to detect and classify differences between the items observed.

In the KIDA scenario, the parameters are associated with the monitoring of conventional troops, their weapons, and their facilities. Examples of what specifically will be monitored are troops or vehicles moving across the DMZ, the reintroduction of artillery to hardened positions, and placement of troops and weapons in excess of the maximum permitted in the LDZs, and the reactivation or construction of a banned facility. Figure 1 lists applicable observables and signatures.

- **Observables**
  - Vehicles
  - People
  - Buildings
  - Facility Construction
  - Facility Dismantlement
- **Signatures**
  - Weight
  - Magnetic characteristics
  - Radar reflection
  - Seismic signal
  - Infrared radiation
  - Physical dimensions
  - Physical deformation

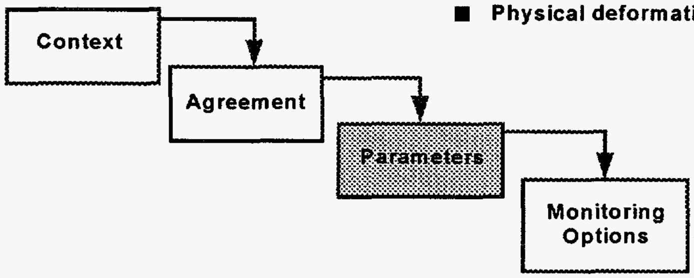

Figure 1. Parameters For Monitoring

Cooperative monitoring systems are designed to build trust. It is assumed that both parties may test the detection capability of the monitoring system, but will not deliberately violate the agreement. Cooperative monitoring is intended to provide information that prevents or helps resolve disputes. It is not inherently a security system or another form of intelligence collection. Since an event may be considered a violation of the agreement, it is important to define the nature of observables that constitute a reportable event. Event definition, detection, characterization, and communication must be carefully structured to ensure that a timely diplomatic resolution is possible.

Monitoring Options

Once the objectives and provisions of an agreement have been defined and the parameters identified, technical options for the monitoring system must be evaluated. Monitoring options for an agreement range from no monitoring to extensive technical monitoring. The capability of available technology may constrain which activities or features can be monitored. Factors such as cost, personnel, redundancy, timeliness of reporting, data and hardware security, power requirements, utility and communications infrastructure, sensor function and display, environmental conditions of operation, and vulnerability need to be assessed. In addition, the level of access or intrusiveness permitted under the terms of the agreement will affect the types of acceptable monitoring technology.

Figure 2 lists technologies and constraints applicable to the KIDA scenario.

- Coordinate cooperative monitoring with existing security and NTM activities
- Blend technical and non-technical types of monitoring

Phase 1: Monitoring the Demilitarized Zone

The offensive doctrine of the DPRK Korean People's Army calls for a fast-moving assault supported by artillery and armored vehicles. Strategic movement by offensive forces would be forced by time and logistic requirements to move through major crossings. Figure 3 shows ten primary land crossings of the DMZ identified by KIDA. Infantry can move through the intervening hills but, without significant vehicle support, their offensive capability (both in mobility and firepower) will be much lower than mechanized forces. Infiltration by special operations troops is also a threat.

Two levels of simultaneous monitoring are proposed for the DMZ in order to best adapt to the physical and military environment. The terrain along the MDL is rugged, particularly in the eastern half. The strategic crossings are to be monitored intensively for the movement of vehicles and personnel. The area along DMZ between the strategic crossings poses a lesser security threat because the terrain restricts movement to relatively small, non-mechanized forces. A less complex system will monitor these areas primarily for people carrying weapons.

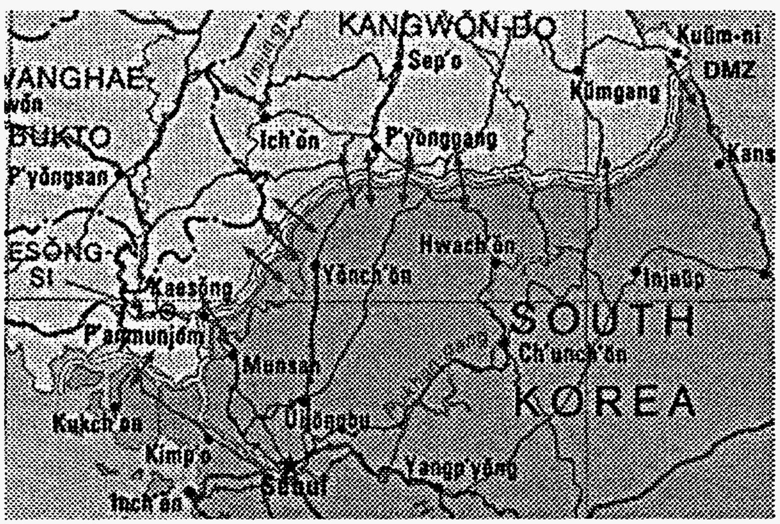

Figure 3. Strategic Crossings of the DMZ

Techniques for Monitoring the DMZ

The DMZ crossings require a system that can operate reliably during weather extremes. The tense confrontation along the DMZ will not be reduced by a system that frequently reports events that are non-existent upon investigation. Neither party will gain confidence in either the monitoring system or each other's actions under these conditions. For maximum flexibility and reliability, the monitoring system uses a combination of ground and aerial sensors supplemented by human observers. A system composed of sensors with different detection phenomenologies results in significant synergies. (Descriptions of sensor characteristics are in Appendix A.)

Watch stations, operated by the monitoring organization, will be placed at strategic locations at each crossing point. DPRK and ROK liaison officers may be present at the station. To minimize the background activity, the observers will not normally enter the DMZ except to perform maintenance and to resolve sensor activations that cannot be confirmed from the watch station itself.

The areas of the DMZ between the strategic crossing points will be monitored by both cooperative and unilateral means. A limited number of unattended sensors will be placed along paths or other natural features. These sensors will report to the nearest watch station for evaluation. Broad area monitoring of the DMZ will be achieved by the cooperative use of an aircraft mounted with optical, radar, and infrared sensors. The capability of the monitoring system (photographic/video, synthetic aperture radar, and imaging infrared) will be the same as the Open Skies Treaty. The all-weather aircraft will be operated by the third-party monitoring organization and have DPRK and ROK liaison officers aboard. Flights will be performed on a weekly basis and be restricted to the 4 km wide DMZ. Both sides of the DMZ will be marked with radio beacons as navigation aids.

Existing military patrols along the DMZ boundaries will continue using the permitted 2,500 light infantry based within the first LDZ. Information collection by NTM conducted from the LDZs or from aircraft outside the DMZ will continue.

The Role of Central Monitoring Center

A "Korean Monitoring Center" should be established to evaluate reports from the cooperative monitoring system. The monitoring center will provide centralized data collection for subsequent analysis, assessment, communication, and the resolution of disputes. The location most likely to be acceptable for such a center is the current Joint Security Area (JSA) at Panmunjom. The JSA is a circular area, approximately 1 km in diameter, straddling the MDL at the site of the former village of Panmunjom. It was established in 1951 as the site for negotiation of the Armistice. After the Armistice was signed, the site was maintained for meetings of the Military Armistice Commission (MAC) and other negotiations. Consequently, an infrastructure of buildings, roads, utilities, and communications exists in the JSA. Figure 4 shows a schematic representation of the conceptual Korean cooperative monitoring system.

Diagram of Korean Cooperative Monitoring System

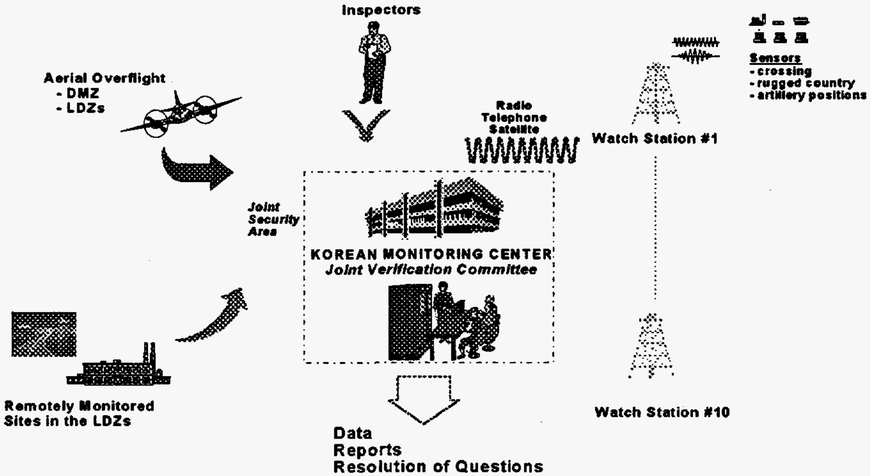

Figure 4

Example of the Sami-Ch'on Valley Crossing

The Sami-Ch'on Valley crossing (Figure 5), located about 22 km northeast of Panmunjom, was chosen as an example for the design process. The valley is shaped like the letter "Y" and surrounds the Sami-Ch'on River. The elevation of the river is about 25 m above sea level. The surrounding ridges typically rise about 100 m elevation with occasional peaks rising as high as 185 m. Although the area is not what is traditionally considered as mountainous, the steep hills serve as natural barriers to tracked and wheeled vehicles. There are no roads through the valley, but major roads in both the DPRK (Highway 1025) and ROK (Highway 322) are within 5 km of the northern and southern entrances.

Commercial satellite imagery shows sand bars located at the major turns of the Sami-Ch'on river which indicates that it periodically floods during the summer rainy season. Siberian winds blow during the winter and the area also has periodic fog. Snowfall normally occurs between December and February. Smoke from burning fields outside the DMZ, dust from China, and spring haze may limit visibility.

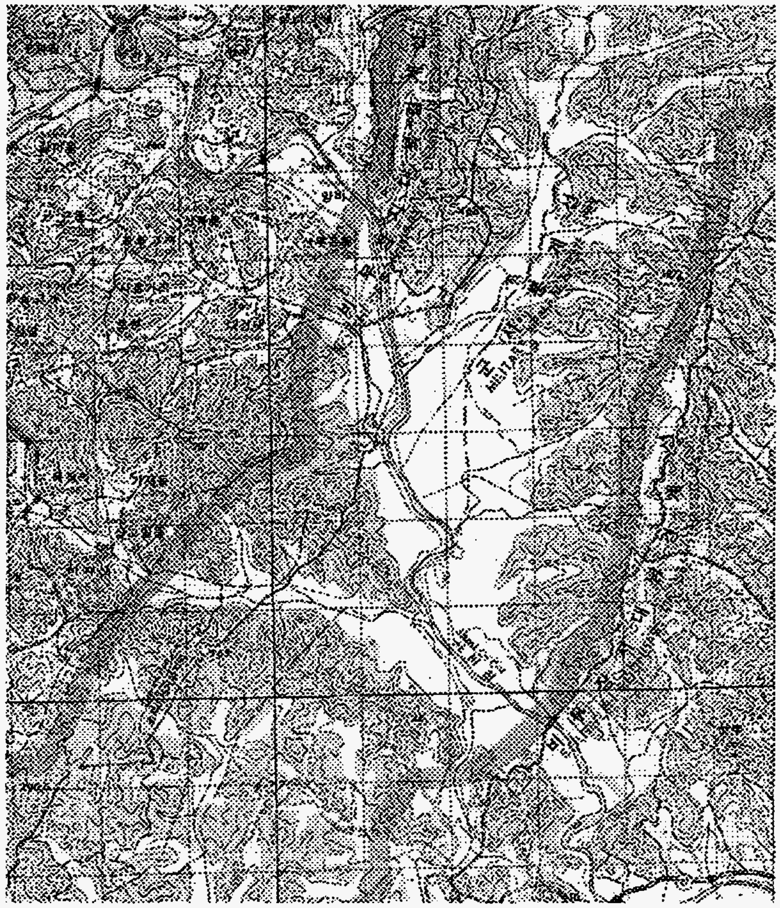

Figure 5. Topography of the Sami-Ch'on Valley Crossing

The monitoring strategy uses layers of sensors. Layering consists of using different detection phenomenologies as well as sensor positions. Sensors generally function in either a detection or assessment mode. Careful design of a monitoring system may permit some sensors to contribute to both goals. A summary of the sensor strategy for the Sami-Ch'on Valley is in Table 1.

Primary Detection Sensors	Secondary Detection Sensors	Assessment Sensors
fence-type	magnetic video motion (future) human observers	magnetic video camera human observers

Table 1. Monitoring Strategy for the Sami-Ch'on Valley Crossing Point

Primary Detection Sensors

Fence-type sensors will be used for first detection because there are designated boundaries along the DMZ. They can take advantage of existing fencing and serve as a highly visible symbol of the agreement as well as a deterrent to violations. Although the systems have low rates of false alarms, a conventional fence will be placed a short distance away to prevent accidental alarms caused by civilians or animals.

Fence sensors will be placed as close to the DMZ boundary as possible given the terrain conditions. To reduce costs, the more capable, but more expensive, taut-wire fence system will be placed across the chokepoints to vehicular travel in the valley. Cheaper fiber-optic fence sensors will be used along the hilly terrain flanking the likely vehicle routes. They would also extend for some nominal distance east and west of the crossing to deter infiltrators or single vehicles. Fence sensors report the movement of both people and vehicles, but do not distinguish between them. The exact location of the alarm within a fence segment cannot be reported.

Secondary Detection Sensors

Magnetic sensors detecting the metallic mass associated with vehicles and infantry weapons monitor within the DMZ. Magnetic sensors are unaffected by background activity and weather (including snow).[6] Their role is to provide confirmation of movement given an activation of a fence sensor. The presence of a magnetic signature is a relatively unambiguous indicator of a violation of the agreement. The strength of the magnetic field is a function of both the mass of the object and its range. Consequently, a single sensor cannot distinguish between an infiltrator at close range (5 m) and a vehicle at long range (25 m). Groups of magnetic sensors will be buried in a linear array across the north-south line of movement through chokepoints. In contrast to a fence sensor, their presence is virtually undetectable.

Manned watch stations will be positioned so that primary routes are within view. Each watch station will be used for collection of data from the monitoring sensors. Observers at the watch stations will use optical and night-vision devices to supplement the field sensors and confirm activations. In effect, the observers function as visual sensors.

There are two options for placing watch stations: a) a pair of stations along the DMZ placed such that one station overlooks each end of a crossing point, and b) a single station placed within the DMZ itself. Given that liaison officers may be present, the single station approach would require a higher degree of cooperation between North and South Korea. Each of the watch stations would be linked to the Korean Monitoring Center. Digital terrain data and commercial satellite imagery can be combined by computer software to generate simulated fields of view. This technique permits watch stations to be positioned at the most favorable position without doing extensive field surveys first. However, on-site surveys must still be conducted to verify that such positions are obstacle-free. In the case of the Sami-Ch'on valley, it is possible to achieve full visual coverage with either a pair of watch stations along the north and south entrances or a single station within the DMZ. Not coincidentally, the best site for the single station is currently a ROK military observation post. Figure 6 shows the computer generated view from the this position looking west.

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[6] Seismic sensors were rejected because of their varying detection ranges due to soil moisture and snowfall as well as the likelihood of an unacceptable number of false alarms.

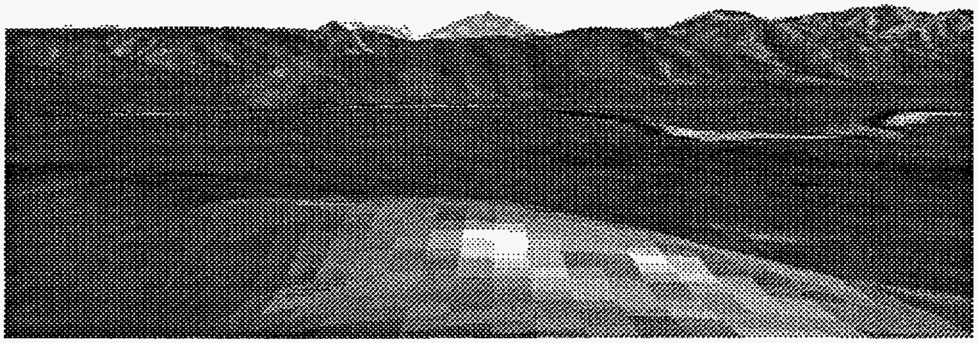

Figure 6. Computer-Generated View West From the ROK Observation Post

Assessment Sensors
Although magnetic sensors have the limitation described above, it is possible to configure the sensors to provide information about the size and direction of movement of the intrusion. When a linear array of sensors is deployed, the mass of an object may be estimated by noting which units register an activation. A large object can activate several simultaneously while a person with a weapon would only activate one. A moving object would activate sensors sequentially, so that the direction and speed of movement through the sensor array can be estimated.

Video cameras are an unambiguous means of assessment. In the Sami-Ch'on system, an activation by a fence or magnetic sensor will command the secondary activation of a video camera positioned to view the area around the detecting sensor. Two images are transmitted to the watch station for interpretation by the observers. The video camera can also be directly activated by the observers. Commercial cameras are available which have visual capability under conditions of low light. Imaging infrared cameras that function in conditions of total darkness are available, but are much more expensive. Even with careful positioning, there will be occasional times when conditions such as darkness combined with heavy fog degrade the camera's ability to assess alarms. Future improvements may also permit the cameras to serve simultaneously as detection sensors. Movement is detected by a signal processing unit that detects changes in the stationary field of view. Current motion detection technology is not reliable because of the potential for background movement (e.g., trees moving in the wind) to cause an alarm.

A key role of the observers at the watch stations is to assess what caused the sensor activation, determine whether it is a reportable event, and transmit the report to the central monitoring center. This is done both by direct observation and interpretation of sensor reports. The observers will also initiate a patrol if they cannot determine the cause of the activation from the watch station.

The proposed system will rely primarily on radio communications from the magnetic and video sensors to the watch station, direct connections from the fence systems, and telephone (landline or satellite) communications between the watch station and the Korean Monitoring Center.

Phase 2: Monitoring the Limited Deployment Zones
Cooperatively monitoring of LDZs is technically and procedurally more complicated than monitoring the DMZ. In the agreement, the DMZ is a clear zone where there is very little natural background activity. The LDZs, in contrast, have high levels of background activity caused by permitted military and civilian activities. Consequently, the system must distinguish relevant activities from background noise and permitted activities from banned ones. The problem of reliable discrimination limits the application of remote monitoring to points rather than zones. Applications for remote monitoring are artillery positions and possibly some roadways and military garrisons.

The most widely applicable tool for monitoring the LDZs is on-site inspection. In the cooperative monitoring regime, on-site inspection would be performed by the third-party organization. There would be host DPRK or ROK liaison officers present during the inspections. As confidence increased, liaison officers from the non-host Korea might accompany the monitoring organization during inspections. The purpose of on-site inspections is to verify closure of facilities, observe troop movements and exercises, and verify removal of limited equipment from military bases. The procedures for inspection are to be based on the successful Conventional Armed Forces in Europe (CFE) treaty.

Hardened Artillery Positions
There are hardened firing positions for heavy artillery all along the DMZ. The DPRK has developed a large system of concrete bunkers and tunnels in hillsides to shelter its artillery. Under Phase 2, all artillery would be removed from these positions within LDZ-1. The monitoring regime will rely on on-site inspection by the monitoring organization to verify that removal has occurred on schedule. Continuous remote monitoring by ground sensors will then be performed to detect if artillery has been reintroduced. Given the potential number of sites, remote monitoring of deactivated positions could be limited to those associated with heavy artillery (defined as 155 mm or greater and including rockets).

The system of monitoring artillery positions will include balanced magnetic switches and/or radio frequency fiber optic seals placed on those positions with doors. After installation during the initial on-site inspection, these sensors will detect if an artillery position has been opened. For locations without doors, magnetic or induction loop sensors placed at the entrance or under the floor will be used to detect when artillery equipment has been repositioned. These sensors are battery powered and transmit their signal by radio to the nearest watch station. Periodic status reports (including tampering) are transmitted. Radio signal repeaters or direct satellite transmission could be used if the distance to a watch station is too great. The sensors could also be linked to a video image system that transmits images (as in the Sami-Ch'on system). This option would permit rapid assessment of alarms but may be more intrusive than is currently acceptable. Passive seals such as a fiber-optic loop could also be used but would require periodic on-site inspection to verify their condition.

Aerial Monitoring
The aerial monitoring regime established during Phase 1 for monitoring the DMZ will be

expanded to include the two LDZs. The purpose of aerial monitoring is to detect facility construction, facility reactivation, and the re-entry of prohibited equipment into the LDZs. The sensors mounted on the aircraft would be unchanged. Commercial satellite imagery may also be incorporated when planned future enhancements in image resolution and data availability become available. Appendix A describes current and future capability in satellite imagery.

Point and Military Facility Monitoring

Continual remote monitoring of locations and facilities may be perceived as a significant encroachment on sovereignty and will require a political commitment by the parties. Remote monitoring might be performed at the gates of a closed military facility such as the gate to a garrison or storage facility. A more complex, but technically feasible, application would be to monitor the gate of a permitted facility in LDZ-1 to detect if prohibited heavy weapons are reintroduced. Monitoring of facilities is accomplished by a combination of detection and assessment sensors. Given the level of background activity, it is not feasible to selectively monitor a roadway with any acceptable level of confidence. The only option would be to install a video system at a key point which continually collects and transmits images to the Korean Monitoring Center. This is a quite intrusive and would probably not be politically acceptable.

FACTORS TO CONSIDER DURING IMPLEMENTATION

Individual components need to be integrated into an operational monitoring system. Factors in system design include communication between sensors, data transmission to a central monitoring site, and power for the system. Software to manage the sensors and data collection system is another important element in system integration. A complete system design and evaluation also must include an assessment of system vulnerabilities. Many analysis tools can assist in analyzing the weaknesses of monitoring system designs.

Intrusiveness

The intrusiveness of the system will be influenced by the transparency and reciprocity that is part of the agreement. A determination must be made as to whether each side will permit monitoring systems within their facilities or require them to be deployed outside in such a way as to not impact normal operations of the facility. The effect on normal operations is a significant determinant to the acceptability of a monitoring system. The continuous presence of on-site inspectors must be weighed against the value of periodic inspections. A determination must be made as to whether data from sensors be collected on-site or transmitted to a distant site.

Sovereignty is a key issue in any monitoring system implemented in Korea. The DPRK has historically rejected verification as an infringement on its sovereignty.

Communications Systems

The communication of data from a site-specific monitoring system to a monitoring station can be accomplished through several mechanisms:

- direct connections by copper wire or fiber optic cable
- radio frequency communications
- land-line or cellular telephone communications
- satellite communications

Combinations of these mechanisms are possible. The choice of which mechanisms to use depends on whether on-site communications or remote access to the monitoring system are permitted. All of these mechanisms have advantages and disadvantages relating to cost, complexity, reliability, and availability.

Data Integrity

There needs to be confidence that data sent from unattended monitoring systems has not been tampered with and that it is only received by authorized organizations. Limitations may be imposed in the agreement's provisions defining what type of data can be sent and under what circumstances. Between parties to an agreement, data authentication confirms that the host country has not altered the sensor reports. It adds a unique identifier to the transmitted data to assure that the information received is not false data. Sensitive information can be excluded from non-parties to the agreement by means of encryption. Additionally, access controls on the data can be employed at the monitoring stations.

In the Sami-Ch'on example, the majority of sensor communications are performed using radio communications. The system will use a beacon to generate state-of-health messages to ensure that the communications are not being jammed. Access to the watch stations should be limited to liaison personnel and third party monitoring organization.

Local Infrastructure

The availability and reliability of local power and communications infrastructures may support some system designs over others. If power is not readily accessible, some sensors can operate on battery power or solar power. Therefore, the maintenance program must plan for battery replacement or power backup during long periods of cloudy days. Countries operate on different electrical power standards, so equipment must be compatible with locally available power.

The monitoring plan for the KIDA scenario is constrained by the DPRK's relatively primitive telephone and electrical power systems. Telephone service is not generally available in rural areas and there is a shortage of electrical power. A specialized cellular telephone system might be installed if needed. Direct satellite communications, powered by batteries, is another option. The monitoring system in the Sami-Ch'on Valley assumes that AC power is available to operate the fence sensors, video cameras, and watch station. An alternative is to install small diesel generators to power the watch stations and associated sensors. It also may be possible to power all sensors except the fence sensors by batteries recharged by solar photoelectric panels.

Cost And Personnel

The cost of a monitoring regime can be significant and must be scaled to the available resources of the participating parties. Long-term costs must be estimated. For example, higher installation and capital costs may minimize later operation and maintenance costs. Conversely, systems with low installation costs may have higher operational and maintenance costs. The number of personnel and skill types needed to install, operate, and maintain the system must be defined.

In the KIDA scenario, the parties must direct whether military personnel, civilian contractors, or foreign third-party personnel will operate and manage the system. The poor financial condition of the DPRK means that it will probably only contribute material.

CONCLUSIONS

This paper presented the design process for a cooperative monitoring system to implement the conceptual confidence building agreement defined in the KIDA scenario. This analysis assesses the applicability of cooperative monitoring to security problems in Korea, presents a monitoring strategy for the conceptual agreement, and assesses candidate monitoring technologies.

KIDA recommended that a "third party" be engaged to perform monitoring. The DPRK and the ROK have not developed an extensive expertise in arms control nor is there an adequate level of confidence between them to rely on indigenous monitoring. United Nations peacekeepers are the most common third party, but regional organizations have been created in Central America and sub-Saharan Africa. Individual countries have also performed the role of a neutral third party, most notably the United States in the Sinai. KIDA concludes that the U.S. cannot perform a unilateral monitoring role in Korea.

Assuming that a third-party monitoring organization can be identified, KIDA and the CMC conclude that cooperative monitoring can play a key role in reducing tensions in Korea. Furthermore, the CMC conceptual system development demonstrates that a cooperative monitoring system could be installed in Korea. This system accommodates political concerns about sovereignty, the physical environment in Korea, the security problem associated with conventional forces, and the limitations of monitoring technology. Remote monitoring is best implemented in relatively inactive environments such as the DMZ. The conceptual system for the strategic crossing points includes human observers for redundancy and political confidence. Remote monitoring by unattended sensors in the LDZs has limitations because of the size of the monitored area and the high level of permitted background activity. Other forms of monitoring are needed. Aerial monitoring by manned aircraft enables the monitoring of facilities and forces over broad areas. Commercial satellite imagery may supplement and partially replace aerial monitoring when planned enhancements in resolution and data distribution occur. Commercial satellite imagery will probably never be able to monitor fast-moving situations. Non-technical forms of cooperative monitoring, primarily on-site inspection in the LDZs, are also needed.

An important conclusion is that the cooperative monitoring regime does not have to monitor all the security concerns affecting Korea. The regime is complementary with existing security and NTM activities performed by the national parties to the agreement.

Cooperative monitoring systems are designed to build trust by providing information that prevents or help resolve disputes. It is not simply a security system or another form of intelligence collection. These unilateral activities are expected to continue and the parties reserve the right to make compliance decisions based on all available information.

A "Korean Monitoring Center" should be established to evaluate reports from the cooperative monitoring system. The monitoring center would centralize data collection from all sensors, watch stations, aircraft, and inspectors for subsequent analysis, assessment, communication, and the resolution of disputes. The recommended location for such a center is the Joint Security Area (JSA) at Panmunjom.

The current level of tension between the DPRK and the ROK probably prevents such a conceptual agreement and monitoring system from being implemented in the near future. Such initiatives, however, should be evaluated by the parties in preparation of future improvements in relations. The recent proposal by Presidents Kim and Clinton for a four-way dialog between the U.S., China, ROK, and the DPRK indicates that the time may occur when such initiatives evolve from the conceptual to the practical.

APPENDIX A

TECHNOLOGIES FOR A COOPERATIVE MONITORING SYSTEM

Table 2 lists sensor technologies that can be used in cooperative monitoring systems. There are multiple manufacturers for most types of sensors. Consequently, different models of the same type of sensor may have different features and capability.

Terrain-Following	Area	Assessment Options	Communication Options	Monitoring Station Options
• Fence sensors Buried Line-type • Pressure • Magnetic Field • Ported Coax • Fiber Optic	• Active Infrared • Passive Infrared • Microwave Radar • Video Motion • Seismic	• Magnetic • Acoustic • Combinations of Sensors • Overflights • Video	• Direct Connection • Radio Frequency • Telephone • Cellular • Satellite	• Textual • Graphical • Archival

Table 2. Applicable Sensor Technologies

Fence Sensors

The taut-wire fence sensor uses the property that a steel wire will act as a spring. High-tensile strength wires are strung horizontally between posts and placed under tension. Each wire is connected to a sensor located in a post mid-way along the wires. Attempting to climb over the fence or to spread the wires activates the sensors and causes an alarm. Cutting the wire also causes tension in the wire to activate the sensor. The taut-wire fence has a very low false-alarm rate, is terrain-following, and is not generally affected by weather. The taut-wire fence is relatively expensive (approximately $154,000 per kilometer installed) and is thus primarily applicable to zones or facilities that are to be monitored intensely.

An alternative type of fence sensor uses fiber optic cables to detect intrusions. The fiber optic cables (typically three) are woven through a new or existing chain-link type fence. An optical communication unit continually transmits a coded signal through the cable. Disruptions to the signal, caused by cutting or movement, cause changes in the light pattern which are detected by a receiver. This system is somewhat more likely to generate false alarms than the taut-wire system but can be installed in more rugged terrain. The cost of this type of system, including the fence, is about $60,000 per kilometer.

Microwave Radar

Microwave radar units are available to monitor movement on the ground. A cigar-shaped detection zone (normally 6 to 12 m wide) is created up to 500 m in length. Intruders entering the zone cause a change in the received signal strength or phase and generate an alarm. When the radar unit(s) is carefully positioned, the detection zone can follow undulations in the local terrain. A system can be tuned to detect objects above a specified size and/or speed. Special consideration must be given to wildlife and vegetation where these sensors are used. Systems are available which use one or two transmitter/receiver units. A unit costs approximately $5000.

Unattended Ground Sensors
Sensors using infrared (passive), magnetic, break-wire, and seismic detection phenomenologies are buried in the ground or placed near the surface. The detectors sense activity in an area but cannot assess the nature of the activity. An antenna is normally attached to the sensor transmitter for radio communication up to 800 m away line-of-site. Signal repeaters can be used for more range. A beacon can be positioned among the sensors to indicate if the signal is being jammed. The sensors transmit their identification code to a receiver when operating as a system. A large number of sensors will require a computer to display sensor status on a map. Sensors are battery operated devices which will require regular maintenance about every three months. A typical unit price is $300 to $500 (not including the receiver).

Infrared Break Beams
Infrared break beam sensors detect changes in the signal power of a line-of-sight infrared beam created between a transmitter and a receiver. The typical separation of the transmitter and receiver is about 30 m but new systems can be as far as 150 m. The simplest version of a break beam system consists of a single sensor pair mounted on tripods. A more complex system of multiple transmitters and receivers can be installed on poles at each end of the detection zone. The detection zone becomes a vertical plane and can measure the profile of an object passing through it. If parallel sets of break beams are used, the system can determine if an object is greater than a specified length as well as its direction of travel. Break beam systems can be portable. A single set of sensors costs approximately $500 while a planar array system costs $10,000 (not including the communication equipment).

Weight Sensors
In well defined locations such as roads and paths, vehicles passing a point can be detected using a weigh-in-motion system (WIM). A WIM system consists of two magnetic sensors and a capacitance type sensor. A WIM can be calibrated to only report vehicles weighing greater than a specified weight. WIM systems cost approximately $15,000.

Video Cameras
Video cameras are primarily used to determine the cause of alarms and document events. They may also be used as part of a video motion detection system which detects changes within the field of view. In the assessment mode, an alarm transmitter interprets sensor signals, determines if an alarm condition exists, and instructs the video camera to operate. The camera takes video snapshots which it transmits to a remote receiving station. The receiver station displays the alarm information and provides the operator interface to the system. Cameras cost between $100 and $1000. Rugged containers permit operation in adverse climates. The motion detection unit costs about $500.

Facility Monitoring Systems
Sensors of different types can be combined into a system which performs a specific function such as monitoring activity at a facility. For example, a gate might be monitored by different sensors to detect and characterize traffic entering and exiting the facility by size and quantity or other specifications such as a radioactive signature. Information associated with vehicles that do not meet the monitoring specification is not transmitted. The system might also detect vehicles that try to bypass the system to avoid being monitored by exiting out of the sides of the system.

Commercial Satellite Imagery
Commercial satellites provide wide-area monitoring and can detect construction or changes in roads, large buildings or facilities, and vegetation patterns caused by human activity. Images can be digitally processed by commercial software for analysis of features. Combining different spectral bands permits viewing of the image in false color. For example, the near-infrared spectrum shows healthy vegetation in red. Table 3 summarizes currently available imagery. Cost per image varies from $2,000 to $5,000.

Significant improvements by 2000 in the coverage, timeliness, and variety of commercial satellite imagery are forecast by the satellite service companies. Digital images with resolution to 1 m will be available. Improved multispectral and radar images will also be available. Although useful for monitoring, commercial satellite images are not currently timely. Planned improvements may shorten the acquisition process to a few days. Commercial imagery could still not be used to track quickly changing events. In addition, all satellites are limited by the time to repeat the image of the same location (revisit time).

Satellite	Country	Resolution	Sensitivity	Revisit Time
LANDSAT	USA	30 m	color (7 bands)	16 days
SPOT	France	20 m/10 m	color (3 bands)/B&W	26 days
KVR-1000	Russia	2 m	black & white	N/A
ERS-1	EEC	8-30 m	radar (SAR)	35 days

Table 3. Commercial Satellite Characteristics

Aerial Sensors
Sensors mounted on aircraft can be quickly dispatched to monitor terms of an agreement and can achieve much higher resolution than is currently available from satellites. Monitoring must be cooperative because aircraft need permission to fly over national territory. The 1992 Open Skies Treaty applies to members of NATO and the former Warsaw Pact. The treaty imposes limitations on the operation of the aircraft and capability of sensors used. Four types of sensors with the associated resolutions are permitted:

Optical Camera	30 cm	Video Camera	30 cm
Infrared Line Scanner	50 cm	Synthetic Aperture Radar[7]	3 m

[7] Synthetic Aperture Radar (SAR) will create images of objects using radar signals that permit night and bad weather capabilities not possible with visual imaging systems.