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Strengthening the Chemical Weapons Convention Through Aerial Inspections

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Pragmatic steps toward ideal objectives

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The Multilateral Verification Project

This essay is a product of the Stimson Center's Multilateral Verification Project which is made possible by grant support from the Carnegie Corporation of New York and the Rockefeller Brothers Fund. The Multilateral Verification Project is designed to promote constructive approaches for international security problems and multilateral negotiations. Our work has focused primarily on useful applications for "Open Skies" and constructive ways to strengthen a prospective Chemical Weapons Convention. Our goals are to generate understanding and appreciation of problem-solving approaches that are practical, equitable, prompt, and as resistant to manipulation as possible. We also wish to call attention to multilateral verification proposals that are likely to cause more harm than good. Luncheon meetings are held in Washington where concept papers are presented and discussed by representatives of the executive and legislative branches, the diplomatic corps, non-governmental organizations, and the media. These papers and notes of the meetings are then distributed to government offices and research institutes.

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STRENGTHENING THE CHEMICAL WEAPONS CONVENTION THROUGH AERIAL INSPECTIONS

Strengthening the Chemical Weapons Convention Through Aerial Inspections

Amy Smithson and Michael Krepon

I. Introduction

Negotiations to ban the development, production, and stockpiling of chemical weapons (CW) have produced guidelines for monitoring the destruction of stocks and prohibiting CW production. At the same time, chemical industries will continue to manufacture pesticides, herbicides, pharmaceuticals, and other commercial products.[1] Much work remains for the thirty-nine delegations in Geneva to devise detailed verification procedures to provide a satisfactory degree of assurance that permitted chemical manufacturing processes are not diverted to proscribed ends, while protecting proprietary information.

As one analyst noted, "It was clear from the outset, that due to the very nature of the obligations of a Chemical Weapons Convention, an imaginative and novel approach was called for in order to provide for the necessary confidence in compliance with the treaty."[2] This paper examines one such innovative approach, the concept of using aerial inspections to increase the efficiency and effectiveness of on-site inspections (OSIs).

The idea of using aircraft in monitoring the Chemical Weapons Convention (CWC) has not been considered at any length in Geneva. Perhaps one reason is that attempts to negotiate aerial monitoring regimes have so far failed in the Open Skies negotiations and the Conventional Forces in Europe (CFE) Treaty. Consequently, aircraft may be perceived as either too difficult to negotiate or not worth the trouble, since the principle of challenge inspections on the ground has been accepted in the CWC negotiations.

Even if a rigorous challenge inspection regime can be negotiated, a strong case can be made for incorporating aerial inspections into the CWC monitoring regime. If a weakened form of challenge inspections is negotiated, the case for aerial inspections becomes more compelling. The Technical Secretariat will have limited resources, yet it will be charged with monitoring several thousand sites.[3] Overflights would allow inspectors to orient themselves and plan ground inspections more effectively and efficiently. Overflights that incorporate the use of sensors would permit the development of a data archive, an institutional memory essential for an international inspectorate with rotating personnel. Furthermore, use of aircraft would make overhead data available to the Secretariat and the CWC member states that may not have assured access to national technical means (NTM) of verification.[4] Though aerial operations would be expensive, member states in different regions could donate aircraft, sensors, and basing opportunities to offset those costs and to demonstrate their special interest in the Convention's proper implementation. In short, aerial inspections can increase the utility and rigor of OSIs while bolstering the authority of the Secretariat.

The next section of this paper discusses the standard objectives of verification, applies these objectives to the CWC, and briefly identifies several ways that aerial inspections can contribute to them. The following section discusses possible pitfalls of aerial inspections and suggests ways in which operational practices and safeguards could be employed to avoid these pitfalls. Technologies that would play a major role in CWC aerial inspection are reviewed in Section IV. Specific roles and missions are explored in more depth in Section V, followed by conclusions.

II. Verification Objectives

Arms control monitoring regimes are designed to collect data on treaty-related activities, to provide evidence about adherence to the agreement's terms, to provide indicators of troubling activities, and to support judgments by political officials about suspected violations. Relevant CWC activities include monitoring declared CW stocks, facilities, and the single small-scale production facility; transfers of permitted quantities of agent and movement of CW stocks to demilitarization sites; destruction of CW stocks, associated equipment, and facilities; and, commercial chemical production.[5] The large number of sites to be covered, the difficulty in pinpointing CW monitoring signatures, and the legitimacy of commercial operations that could subsequently be reoriented to military applications make the verification tasks facing the CWC inspectorate dwarf those of other treaties. The Technical Secretariat must therefore make the most of the monitoring tools at its disposal and also consider adding new ones to its inventory.

The three basic objectives of a verification regime are widely recognized to be detection, deterrence, and confidence-building.[6] These broad objectives are interconnected and can be refined in several ways. For instance, detection of violations is of critical importance, but detection of ambiguous activities can provide indication and warning of possible future trouble spots. A well-designed monitoring system can help deter prohibited activities because of its ability to detect them. The threat of punitive measures after detection and the extra cost that a violator must bear to hide illegal actions from a monitoring system serve as additional deterrents. The transparency resulting from a well-designed monitoring system can also build confidence in the treaty over time, as parties have less reason to fear the consequences of noncompliance by other participating states. A more in-depth discussion of these broad verification objectives can provide a useful base for evaluating the effectiveness of aerial inspections in a CWC monitoring regime.

Detection

The classical requirement for "adequate" or "effective" verification is the detection of militarily significant activities in time to take appropriate responses.[7] Early warning of a militarily significant violation allows other parties to take appropriate countermeasures, including the imposition of sanctions, if requests made through the Convention's consultative mechanism to stop or adequately explain the troubling activity are unsuccessful. The higher the probability of detection, the less uncertainty parties will have about the true adherence of other states to the agreement's terms and the more time they will have to respond appropriately if adherence is in doubt.

Aerial overflights used in conjunction with routine, ad hoc, or challenge inspections can increase detection probabilities both directly and indirectly, particularly if appropriate sensors can be carried onboard. Flight tests of several remote detection sensors show a tangible and direct ability to detect CW-related activities from aircraft.[8] Aerial overflights may also directly enhance detection capabilities by enabling inspectors to choose the most appropriate places within sites to be inspected while being more informed about what to look for when they arrive on site. Broad area search by means of aircraft could also provide indirect benefits, becoming the basis for later factfinding missions by the Secretariat, or preliminary inquiries about facilities not subject to routine OSIs.

Ideally, monitoring systems should not only detect and indicate the nature of ambiguous activities, but also provide "smoking guns" — concrete evidence of treaty violations. In theory, the more incriminating the evidence a monitoring system uncovers, the easier it will be to take decisive punitive actions against the violator. In reality, however, "smoking guns" are rarely found. Increasing the probability of detecting violations usually requires highly intrusive and expensive monitoring systems, costs that few nations are willing to bear. Aircraft may increase detection probabilities without undue increases in intrusiveness or expense, especially if appropriate safeguards are used and donations in kind are provided.

Deterrence

The second broad objective of verification is deterrence of violations or circumventions of a treaty. As the Canadian government has noted, "When adequate verification increases the risk of detection that a violator would face, the temptation to seek advantage by violating an agreement is reduced and deterrence is enhanced."[9] Aircraft overflights could marginally increase deterrence if approved flight plans and sensors increase the likelihood of detection or the possibility of follow-up investigations by the Secretariat's inspectors in the field. The disapproval of proposed flight plans or sensors could also suggest the need for further investigation. Deterrence of noncompliance would be heightened the more participating states are willing to accept sophisticated monitoring equipment, although the approval of sensor suites will be a complicated matter, given the legitimate requirement to protect proprietary information. Deterrence (as well as concerns over the protection of proprietary information) would also be heightened the less aware states are of the capabilities of the sensors carried aboard. Broad area searches by aircraft could be particularly effective in deterring potential treaty violators or forcing them to bear the higher costs and associated tip-offs of more elaborate evasion schemes.

Confidence-Building

The third broad objective of verification is to build confidence among parties to an agreement. When governments have confidence that the verification system will detect and deter activities that threaten their national security, they are more likely to rely on arms control to enhance their security and to engage in further steps in a long-term process of arms limitation and disarmament. With appropriate political conditions and procedures, cooperative aerial inspections can increase the transparency of military operations and lessen the likelihood that intentions will be misinterpreted, decreasing tensions and improving chances to resolve conflicts peacefully. Aerial inspections in a CWC could give most participating states that lack assured access to data from satellites a new means to evaluate whether neighboring states that are parties to the Convention are abiding by its terms.[10]

The authority to conduct aerial inspections could strengthen a CWC in may ways. The Secretariat, acting at the behest of individual states, could use information gathered through aerial inspections to target OSIs more effectively, an important consideration given the limited quota of OSIs that are likely to be allowed. The Technical Secretariat and inspection teams could analyze aerial sensor data and also retrieve data from on-site sensors before going on site. Increased use of remote capabilities could enable inspectors to finish their jobs more quickly and, possibly, to forgo more extensive inspections on the ground if the overflight can be conducted with appropriate sensors. Use of aircraft would complement rather than substitute for ground inspections, permitting the Secretariat to use its limited resources in the most efficient and effective way. Given the large number of sites that could be inspected, aircraft can assist the Secretariat in focusing its limited assets in areas where they are needed most. While not a cure-all for the verification challenges faced by the CWC, aerial inspections can offer increases in monitoring confidence by increasing the ability of inspectors to detect anamolous activity or other signs of trouble.

III. Drawbacks and Ameliorative Measures

Adding aerial inspection to the monitoring tools available to the Secretariat makes sense only if its advantages outweigh potential drawbacks. This section of the paper examines these drawbacks and suggests ameliorative measures and safeguards.

Cost

The costs of conducting the proposed inspections would vary according to the number of aircraft, the type of sensors placed aboard, manning and maintenance requirements, the number of flights conducted, and the extent of donations in kind and in services. Cost estimates for the CFE Treaty aerial inspections and Open Skies missions can serve as rough guidelines for the expenses associated with the CWC. One study estimates the initial U.S. costs to establish Open Skies and CFE aerial surveillance at forty to 180 million dollars, with annual costs for flights over Warsaw Pact territory ranging from five to fifteen million.[11] A Canadian study concludes that the costs to operate a Dash 8-series 300 turboprop aircraft for *twenty* years come to $42,469,728; thus a fleet of eight aircraft would cost roughly $330 million.[12]

Additional costs would be incurred from the purchase and operation of detection equipment. Table 1 lists the costs of some

Table 1. Estimated Costs of a Notional CWC Aerial Sensor Suite.

Sensor Type	Description	Cost (U.S. dollars)
Large format aerial camera	Jena LMK 2000	$296,000[a]
Multispectral camera	VEB Carl Zeiss MSK-4	$765,000[c]
Video camera	Sony DXC-750	$12,000[b]
Low light level TV camera	Cohu 5162/4410	$6,000[b]
Thermal imager	Barr & Stroud IR18	$150,000[b]
Forward-looking infrared system	Honeywell	$450,000[d]
Fourier transform infrared system	U.S. Army model XM21	$125,000[e]
Air sampler	Tailored to specific purposes	$50,000 to $300,000[b]
Laser infrared radar system	SRI DIAL systems	$100,000 to $300,000[f]

[a] Includes forward image motion compensation, 3-axis gyrostabilized mount, two film magazines; four different focal lengths, ranging from 3 1/2 to 12 inches, available. Telephone interview with Marilyn O'Cuilinn of E. Coyote Enterprises, April 4, 1991.
[b] Equipment used on the U.S. Department of Energy's ARGUS aircraft, a Convair-580T platform to evaluate sensors, the integration of sensors, and the fusion of multisensor data for use in Open Skies, CFE, or a CWC. Cost information provided in a telephone interview by Steve Herrick of DOE's Office of Arms Control, November 8, 1990.
[c] Hartwig Spitzer, "Aerial Observation and Overflights," in *Verification of Conventional Arms Control in Europe: Technological Constraints and Opportunities*, Richard Kokoski and Sergey Koulik, eds. (Westview Press, Boulder: 1990), p. 101.
[d] "Open Skies: Sensors and Platforms," Allen Banner, in Michael Slack and Heather Chestnutt, eds., *Open Skies: Technical, Organizational, Operational, Legal, and Political Aspects*, Center for International and Strategic Studies (York University, Toronto: 1990), p. 10.
[e] Kirkman Phelps of the U.S. Army's Chemical Research and Development Engineering Center estimated that the next generation of this sensor should be available in two to three years, weigh about ten lbs., and cost approximately $10,000. Interview, November 1, 1990.
[f] Cost estimates for production quantities of ten or more systems from Joseph Leonelli, SRI International. Personal communication, November 29, 1990.

off-the-shelf sensors that might be considered for the sensor suite. The Secretariat would also have to absorb the manpower costs associated with operating the equipment, establishing and operating laboratory facilities to analyze aerial data, and providing proper training for the aerial inspectors.[13] The intent of this data presentation is not to suggest the exact sensors to be placed upon whatever platform is chosen, but rather to impart a general understanding of costs for CWC aerial sensors. These illustrative costs are a small fraction of the expenditures that some states devote to treaty verification. Nevertheless, an international inspectorate might find such costs burdensome.

Donations of aircraft and sensor equipment from participating states would alleviate much of this burden. The expectation that aircraft, sensors, facility, and manpower would be donated for the purpose of CWC aerial inspections draws on the example of United Nations (UN) peacekeeping operations. Beginning with the establishment of the UN Truce Supervision Organization in 1948 and continuing up to its current operations in Central America, nations have given a variety of resources to the UN for peacekeeping. The UN has conducted seventeen peacekeeping operations to date in the Middle East, Africa, Southeast Asia, and Central America. The UN reimburses most expenses for these multinational contingents from the regular UN budget or from special accounts, but donations have also been made to a majority (ten) of the missions. These donations include aircraft and crew, airlift, various ground vehicles and support equipment, sealift, medical facilities and staff, communications supplies, civilian police and military personnel, assorted goods and services, and cash. Aircraft were donated in eight cases, airlift in seven. These donations originated from twenty-two nations.[14]

Protecting Sources and Methods of Intelligence Collection

Another potential drawback associated with aerial inspections relates to sharing sensitive reconnaissance technologies with other nations. Since U.S. technologies that gather information about military activities are highly sophisticated and sensitive in nature, sharing them with all nations participating in the CWC would not be feasible, even if it were desirable. Advanced data analysis and equipment could also be required to make sense of the data collected from the various sensors.

Concerns over protecting sources and methods are likely to be overdrawn. This problem need not arise because sufficiently sophisticated CW sensors are commercially available. Participating states would not be required to share sensitive sources and methods of intelligence-gathering. Nor is it likely that these states would be called upon to divulge their most sophisticated analytical techniques for the analysis of air, ground, and soil samples. Cost factors as well as the requirement to protect proprietary information also militate against the use of state-of-the-art sensors and processing techniques. As a result, dedicated research programs have focused on testing techniques and devices that will serve the interests of the Secretariat without undesirable technology transfer side-effects.[15]

Protection of Sensitive and Proprietary Information

As alluded to above, aerial inspections in a CWC may heighten concerns about the discovery of sensitive military or proprietary commercial information.[16] Observers in aircraft flying over military and commercial facilities would be able to see all manner of equipment and make a variety of assessments about the nature of the activity taking place below. Data from sensors would give these inspectors an even more complete picture with which to work. The difficulty lies in allowing inspectors access to information that is relevant to the CWC monitoring mission while simultaneously protecting sensitive and proprietary information.

This potential problem must be placed in the proper context: the potential for uncovering sensitive military or proprietary information is far more pronounced for ground inspections and thus would exist whether or not the Secretariat has the right to conduct aerial inspections. Concerns about the loss of proprietary information from aerial monitoring practices could be relieved by the adoption of the appropriate safeguards. Table 2 identifies several safeguards of the type that might be considered for CWC aerial monitoring. This listing is illustrative and is not intended to be comprehensive. These procedures are similar to those employed in the Threshold Test Ban Treaty, the Nuclear Non-Proliferation Treaty, the Stockholm Accord, and UN peacekeeping operations. Safeguards are specifically designed to protect the rights of the host nation to ensure that the procedures and sensors used are focused on the desired monitoring tasks, not for purposes unrelated to the inspection. To the extent that aerial inspections enable the Secretariat to refrain from conducting ground OSIs, concerns over the loss of proprietary information might be alleviated.

Moreover, the U.S. chemical industry is already subject to aerial monitoring. Overflights to monitor compliance with environmental standards are conducted by the Environmental Protection Agency. A Supreme Court ruling has set the precedent that manufacturers expose themselves voluntarily to overhead reconnaissance when they take no countermeasures to block observation by airborne cameras.[17] Despite this precedent, the reaction of some industry representatives to the CWC aerial concept has been mixed. Although manufacturers would probably not find photographic records of their facilities problematic, some may see no need for other aerial sensor operations.[18] With appropriate procedures, concerns voiced by industry representatives about aerial inspections could be satisfactorily addressed. Upon reflection, manufacturers may conclude that aerial inspections pose less of a risk of revealing sensitive or proprietary information than ground OSIs.

Table 2. Potential Safeguards for Aerial Monitoring of a CWC.

Possible Safeguard	Explanation
Preflight inspection of aircraft and/or reserved aircraft stored at guarded facility	Limited time period to ensure no sensors other than those approved onboard aircraft, even if aircraft stored in a restricted area, used only for inspections.
Flight plan approval	Allows host to review for safety reasons, and, if needed, to suggest modifications of altitude, distance from sensitive facilities.
Flight notification, windows	Gives host a projected timeline for flight, with specific windows over areas along path.
Restricted, "blinded" sensors	Range of sensor sensitivity approved by Secretariat, restricting data collection to information pertinent to CWC verification.
Common sensor platform	Palletized platform of approved sensors could be installed on host aircraft. Choice of one of two pallets brought by inspection team assures provides randomization.
Host observers onboard all flights	Allows host to validate monitoring as opposed to intelligence gathering.
Copy of data given to host country	Ensures Secretariat and host are working with the same data.
Prohibition of data enhancement	No data enhancement (e.g., photo enlargement) other that agreed upon by CWC.
Secured data storage, no unauthorized data loans	Secured data storage with access granted only for analysis by Secretariat's personnel.
Confidentiality rule	Explicit measures, similar to those already in Article VII(3), Article VIII(5), and Annex on the Protection of Confidential Information.

Complexity

Another potential drawback against implementing aerial monitoring might be the complexity of negotiating and conducting aerial inspection provisions. Given the press to conclude a Convention, some may not wish to delay the negotiations by introducing new agenda items at this time. Other countries might be reluctant to take on additional organizational and logistical issues that might accompany the operation of a fleet of aircraft.

Aerial inspection procedures need not be that complex, however, especially in comparison with other dilemmas facing the negotiators. The operation of a fleet of aircraft by the Secretariat will be a complicated matter, but no more so than the management of ground inspections. Furthermore, the Secretariat and participating states need not start from scratch in developing appropriate procedures for aerial monitoring. They could draw upon the procedures and concepts already developed for the aerial inspections used in the Conference and Security Building Measures and Disarmament in Europe (CDE) and in UN-related peacekeeping operations.[19] The following paragraphs briefly describe terms of reference that could be used in negotiation and implementation of CWC aerial inspections.

Aerial inspections to confirm the number of troops participating in major military exercises in accordance with the terms of the Stockholm CDE agreement have been taking place since August 1987.[20] The format for CDE inspections involves a notification and response period, a four-member inspection team, and a minimum of restrictions. Inspectors are allowed to use simple equipment as they cover the specified exercise area on the ground, in the air, or both. The inspecting state has to specify whether fixed wing aircraft, helicopters, or both will be needed during the inspection, and the host nation must provide the team with appropriate aircraft that allow a continuous view of the ground during flight. Continuous communications are to be provided between team members on the ground and in the air. The inspecting team is allowed to specify the flight path, speed, and altitude for flights in the specified area. After a flight plan review by the host nation's air traffic authorities, the aircraft is allowed to enter the area without delay. The pilot of aircraft, provided by the host nation, takes instructions from the inspecting team throughout the flight. Deviations from the flight plan are permitted to make specific observations, as long as they are in line with safety and air traffic requirements. Aerial and ground inspectors are allowed to return to the area under inspection as often as needed during the forty-eight hour inspection period.[21] Aerial inspections following these provisions are now a routine matter for the thirty-five states of the CSCE.

Aerial inspections used in peacekeeping are much more varied. When the UN uses aircraft for patrolling, the terms of their use are negotiated by the local UN commander with the military representatives of the nations involved. The first UN flights for the purpose of inspection and surveillance took place with first UN Emergency Force, which was stationed in Cairo, the Port Said area, the Gaza Strip, and along the Egyptian-Israeli border in the Sinai from November 1956 until May 1967.[22] In the ongoing peacekeeping mission involving five Central American nations, helicopter patrols proceed after local air control authorities review the flight plan. These local air controllers might modify the direction or altitude of a proposed flight path to accommodate other air traffic in the area or safety concerns. On

Cyprus, UN helicopters can fly over the buffer zone established in August of 1974 and into certain Greek and Turkish areas south and north of the zone without advance notice, as often as needed. These UN patrol flights coordinate with local air traffic controllers once they are airborne. Aircraft patrols are also carried out several times a week in conjunction with and preparation for the ground inspections conducted by the Multinational Force and Observers (MFO), which assumed the Sinai peacekeeping mission from the UN in 1982.[23] The MFO's air and ground patrols cover the Sinai from the Mediterranean coast to the southern tip of the peninsula. Although the UN encountered different complications in its aerial operations, these missions have compiled a remarkable, but quiet, success story in a variety of very tense situations.[24]

As the preceding discussion demonstrates, aerial inspections have been used for more than three decades in various monitoring and peacekeeping missions. Many of the principles, safeguards, and operational details cited above could be adapted for the purposes of CWC aerial monitoring. The Secretariat might also consider prepositioning aircraft on each continent, at dedicated airfields where host countries would make hangar space and appropriate support services available. Forward deployment of CWC aircraft and sensors would ease the logistical burden of conducting flight operations within the regions while permitting some participating states to demonstrate their strong interest in successful implementation of CWC inspections. More than one state within a region may be inclined to donate approved aircraft and sensors, hangar space, or other services. Member states must, however, acknowledge the authority of the Secretariat to coordinate operations, to choose the aircraft and sensors for overflights from the pool available in the region, and to otherwise direct aerial overflights.[25] Undoubtedly, details such as these will require time and effort to settle. CWC negotiators might take heed of the fact that once the requisite political commitment was made, Egyptian and Israeli officials agreed upon the verification protocols for both air and ground inspections in just five days.

With or without the aerial component, CWC verification will be a elaborate endeavor. If aerial procedures can clearly add to the effectiveness of the Secretariat without large expense, then some additional complexity in negotiating might be wise. Finally, accelerating negotiations on a CWC to meet arbitrary deadlines would be injudicious if the final product is widely perceived as having woefully inadequate verification provisions. If some added time is required to produce a substantially stronger verification regime, that time will be well spent.

In sum, potential shortcomings associated with the aerial inspections concept exist. These drawbacks include the cost of funding aircraft and equipment, along with personnel and operational costs; the potential of sharing sensitive reconnaissance technologies and analysis techniques; the fear of compromising sensitive and proprietary information; the prospect of delaying a successful conclusion to the negotiations by adding complex aerial monitoring operations; and the potential complications of operating a fleet of aircraft for inspections around the globe. Each possible obstacle, however, can be greatly reduced by proper attention to design of the monitoring procedures and by donations of available equipment and resources. Together, these drawbacks do not appear to be insuperable. Furthermore, the potential payoffs of incorporating aerial inspections in the CWC monitoring regime appear to outweigh any anticipated complications.

IV. TECHNOLOGIES

If aerial inspection is incorporated into the CWC, the Secretariat will find no shortage of technologies available for the task. Many sensors have already been developed to detect CW use on the battlefield, to promote the safety of workers and the public near chemical facilities, or to monitor other arms control agreements. These devices would require some adaptation to work effectively against CWC monitoring requirements, which the U.S. government is still in the process of defining.[26] This section provides a brief overview of available sensor technologies.

Remote Air Monitoring

Air sampling, which involves sample collection, pretreatment, and analysis, is one of the most promising methods of remote detection. The reliability of air sampling for monitoring purposes derives from the fact that multiple high concentration samples can be collected and later analyzed by gas chromatography, mass spectrometry, and other techniques to greatly improve detection limits, usually by several orders of magnitude.

Sensor sensitivity requirements for CWC remote air monitoring equipment will be demanding because under ideal CW manufacturing circumstances, no agent will escape the facility. The lethality of the product necessitates production safety design features that inhibit emissions. If, however, agents, CW precursors, or the by-products of CW production are present, air sampling is an effective method of detection and identification.

The difficulties involved in air monitoring must be acknowledged. For instance, normal weather patterns complicate the efforts of scientists to pinpoint the origin of detected emissions. Scientists examine weather patterns before and during the overflight and use reverse engineering techniques to track down the point of origin. Ambient impurities in the air from pollution or the emissions of other manufacturing facilities complicate this task, but careful analysis can separate out much of this extraneous information. Highly sensitive detection devices and processing techniques are available that can reap reams of data from air samples. However, devices and techniques of reasonable sensitivity for monitoring purposes will have to be selected to avoid concerns about intelligence-gathering and to protect proprietary information.

Air Samplers[27]

Preserving the integrity of the sample for later laboratory analysis is one challenge that has been overcome by technical innovations. Particle collection allows low, medium, and high volume samples to be taken by drawing particles through a filter using diffusion, interception, inertial impaction, gravitational settling, or electrostatic attraction. Volatile CW agents adsorbed onto aerosol particles pass through the filter into the resin behind it. The most frequently used technique for sampling eliminates the filter and allows volatile agents to adsorb directly onto the resins.

Another method, precipitation scavenging, uses hydrometers to collect the particles transported by cloud droplets, raindrops, snowflakes, and fog droplets. Recent technical advances have also improved the condensation sampling technique known as cryogenic trapping. Tests of a new passive cryogenic whole air sampler with a volume capacity greater than 100 liters and a sampling lifetime greater than two hours have reliably proven that whole air samples can be taken without significant loss or concentration of any atmospheric constituents.[28] These samplers have been field tested in aircraft and on mobile ground units.

Air Sample Analysis Techniques[29]

After the samples are pretreated, cleaned-up, and concentrated, several methods are available to analyze their content.[30] Gas chromatography (GC) can separate samples according to molecular weight, purify sample components, locate suspected agents by a chromatogram, detect agents by identifying specific ion masses, and quantify the various components in a mixture with the use of standards. An electron capture, flame ionization, flame photometric, or ion trap detector used in conjunction with the gas chromatograph can detect agents down to the picogram level. For mass spectrometry, detection limits vary from nanogram down to femtogram level. Low and high resolution mass spectrometry identify the agents and their elemental composition, respectively, by comparing the contents of the sample with the mass spectra of known agents that have been incorporated into a database. Mass spectrometers can be used in tandem or combined with gas or liquid chromatography for excellent results.[31]

Other methodologies useful in air sample analysis are high performance liquid chromatography (HPLC), enzyme-linked immunosorbent assay (ELISA), and anti-cholinesterase testing. HPLC can identify agent precursors, hydrolysates, and degradation products, but not the agent, if the chemical compounds are water soluble. The results of HPLC, which can be used in conjunction with ultraviolet and electrochemical detectors, are confirmed against other methods. If an antibody is available for an agent, ELISA immunochemical testing can be very specific — down to the nanogram level. ELISA can identify soman, sarin, and T2 (Yellow Rain), among other agents. All organophosphate nerve agents inhibit the enzyme cholinesterase. Therefore, anti-cholinesterase tests have proven to be a reliable method of detecting the agents sarin, soman, tabun, and VX, but may not be able to identify precursor chemicals that do not strongly inhibit cholinesterase enzymes.[32]

Optical Cameras

Camera technology owes much of its refinement to photography's status as one of the oldest surveillance techniques. To provide a photographic record of a facility's layout, the options for vertical and oblique photography range from the Vinten Type 1360 on the low (but still sufficient) end of the technology scale to specialized Linhof aero Technica 45 EL and long-range oblique photography systems on the high end of the scale. Standard aerial cameras can be fitted with different lenses (sizes, multilens, and panoramic systems) and use either color or panchromatic film.[33]

Multispectral cameras enable a concurrent scanning of the reflectance and emittance properties of terrain surfaces. Similar to infrared sensors, they use electronic energy detectors focused simultaneously on several narrow spectral bands, ranging from ultraviolet wavelengths to the visible and thermal segments of the spectrum (0.3 um to about 14 um). Each channel, or discrete bandwidth being scanned, can be analyzed separately using a color additive viewer for visual enhancement or simultaneously through electronic digital techniques.[34] Multispectral systems can be configured with different groups of channels for application against specific targets. These cameras can detect changes in foliage on the battlefield and around production plants due to chemical emissions, as well as equipment or storage drums that might be camouflaged.[35]

Video and television (TV) cameras can provide a photographic record of the events in an aerial inspection to guide inspectors during the overflight or to be correlated later with the output of other sensors. Vibration resistant cameras with high shutter speeds, adjustable video levels, and timing clock circuitry will allow inspectors to play back certain frames in synchronization with other sensor data. While standard video cameras are limited to daylight operations, low-light TV cameras can produce real-time black and white imagery under extremely poor lighting conditions.[36]

Infrared Sensors

Infrared (IR) scanners would assist CWC monitoring by recording a facility's operational status and initially detecting chemical vapors.[37] IR sensors detect a form of light energy, radiant heat, on the electromagnetic spectrum from about 0.7 microns to about 1,000 microns wavelength. This portion of the spectrum is not visible to the eye, so an IR image is digitally manufactured, with colors arbitrarily assigned to emphasize different bands of the spectrum. An IR sensor is usually focused in either the near-infrared (geologic data), thermal infrared (hot targets), or far-infrared (cold targets) band.[38] Heat emitting manufacturing operations make thermal IR the band of interest for CWC monitoring.

IR sensor data can be reprocessed several times to look at different temperature ranges to categorize the status of a plant at lower and higher operational levels. IR images of oil refineries, which shares many common features with chemical facilities, clearly show the pipelines connecting different buildings and storage tanks. Also, cool and hot buildings, pipelines, and tanks can be readily identified, indicating where on the facility's grounds there is less or more activity, respectively — information that can be of help to inspection teams.[39]

Infrared linescanners (IRLS) that produce hard copy imagery are ideal for mapping purposes, although an operator cannot really adjust the direction of the wide field-of-view scanning track. A forward-looking infrared (FLIR) sensor produces real-time imagery from a narrow field-of-view over which the operator has full control. Unlike the IRLS, no image mensuration or analysis is required, nor does FLIR operation impose velocity or height restrictions upon the aircraft. FLIR images resemble those produced by a video camera and can be used for mapping and assistance in the direction of other sensors.[40]

Formerly restricted to stationary monitoring applications, the recent creation of digital filters and the development of a moving platform algorithm have made mobile Fourier transform infrared (FTIR) scanning from aircraft or ground vehicles possible. A Michelson-based spectrometer first collects emissions in the two to fifteen micron wavelength, the band of interest for CWC verifica-tion. The extremely high processing rate (thirty million instructions per second) of advanced digital signal processors enables essentially simultaneous scanning and spectral analysis for known target elements. Background signatures, generally of a wider bandwidth than the CW-related targets of interest, can then be screened out to permit higher scan rates that produce a clear and instantaneous interferogram, not the smeared ones that result from slower scanning.[41] The FTIR, which is capable of thirty-seven scans per second, can focus more effectively when a FLIR is used to initially detect the presence of vapors.[42]

Radar Sensors

Active radar sensors, known as lidars, use lasers to gather ranging, scattering, and absorption information to detect the unique spectral backscatter patterns for chemical vapors, aerosols, and liquids on surfaces.[43] A differential absorption laser radar detects particulate matter in vapor clouds because they selectively absorb some of the IR frequencies emitted by the carbon dioxide laser. A differential backscatter laser works in a similar manner by transmitting IR frequencies and interpreting the signals reflected back from ambient atmospheric aerosols, rains, soil, foliage, or equipment surfaces. Light reflected back to the sensor is converted to an electrical signal by a photovoltaic detector for measurement and comparison against the topography, naturally occurring aerosols, and other interferents. Computer processing yields quantitative, not qualitative, information about chemical species in the atmosphere. In short, lidars can detect particulate matter but not identify any agents or components therein, requiring their use in conjunction with sample analysis techniques such as mass spectrometry and enzymatic assay.[44] However, tests of airborne systems have detected chemical clouds seven kilometers downwind from the vapor source.[45]

Synthetic aperture radars (SARs) create a detailed map of the terrain below by capturing the reflection of a series of carefully timed microwave pulses of pre-set length emitted by the sensor. The forward movement of the aircraft creates a synthetic antenna of approximately a kilometer in length to focus the radar image. Real-time data processing enables the operator to see an image that corresponds directly to the amount of microwave energy that objects on the ground reflect back to the sensor. Smooth objects like pavement appear very dark, while objects with more surface roughness look brighter. SAR operations are not effected by the persistent cloud cover or adverse weather conditions that may severely hamper other sensors.[46]

A SAR image of a chemical production facility might reveal details that regular photography may not highlight as well, such as feed pipes, power lines, and vehicles parked around the facility. SAR images, like those from infrared sensors, may also permit the fullest utilization of aerial inspections because these sensors operate very effectively during the night hours when standard optical photography cannot be used. Very high resolutions of two meters or less, orientation of the sensor parallel with the feature to be imaged, and the use of the correct wavelength will heighten the potential for the SAR to image smaller objects. Closure of Schedule 1 facilities is likely to involve the severing of such lines and pipes, which might be confirmed in subsequent SAR imagery. The cost of commercial SAR systems, estimated at seven million dollars apiece,[47] may require donations by participating states if SARs are to be used in CWC monitoring.

Electronic Identifiers (EIDs)[48]

Advances in communications and microprocessing technologies can now create an electronic link between a sensor, tag, or seal and an inspector located miles (or inches) away. An EID is a small authentication device that responds with a unique, secure code or an open transmission when interrogated by an encrypted public/private key query. EIDs transmit only data provided by the sensor, telling inspectors whether a sensor is functioning as it should be, whether it has been tampered with, and whether the sensor has detected the objects or symptoms it was programmed to monitor. In short, by using electronic communications, the aerial inspectors can retrieve information about a facility's monitored operations without having to go on-site to actually read the output from different devices.[49]

Approximately one year would be needed to marry EID technologies to the sensors and seals being designed for CWC monitoring. The technology is now on the shelf, but adaptation and testing would be needed to couple an EID with each sensor. On-site equipment that could use the EID as a communications device include temperature and pressure sensors, flow and pH monitors, seals, and a variety of microsensors.[50] Since suspicions would undoubtedly arise about the misuse of EIDs for intelligence purposes, a dedicated effort would be required to familiarize states likely to join the CWC with EIDs and public/private key encryption.[51] Demonstration exercises would appear to be warranted as soon as possible.

V. Roles & Missions

As envisaged, aerial inspection in the CWC would support the verification objectives of detection, deterrence, and confidence-building while increasing the effectiveness and efficiency of ground inspections. Aerial inspection could also build greater redundancy into the CWC monitoring regime. Successful monitoring regimes are purposefully designed to exploit the information gained through one technique to cue other monitoring methods. Redundant monitoring approaches also tend to strengthen each other, while permitting the most effective use of individual monitoring tools. The addition of aerial inspections can have useful synergistic effects, strengthening the Secretariat's ability to analyze data, conduct ground inspections of various kinds, and deal with questions concerning compliance. Aerial inspections will also enable some tasks to be handled remotely, permitting more cost-effective and perhaps less intrusive operations.

The more tools the Secretariat has at its disposal, the better it will be able to do its job: the prospect of aerial as well as ground inspections can force potential evaders to incur higher costs in trying to hide prohibited activities while producing additional tell-tale signs of troubling behavior. Aerial over-flights might also lead to spin-offs in other areas, encouraging states in regions of tension to utilize this cooperative measure in other ways that enhance their mutual security. This section of the paper describes only those treaty-specific missions where aerial might appreciably assist CWC verification requirements. We have focused our analysis on inspections to validate data exchanges; to monitor facilities capable of producing Schedule 1, 2, or 3, chemicals; to confirm closure and monitor the destruction of Schedule 1 facilities; to detect any undeclared CW research, storage, production or transfer; and to support the 1925 Geneva Protocol.[52]

Baseline Site Confirmation

Verifying the data on the CW inventories, declared CW facilities, and commercial chemical production sites declared by treaty parties is one of the largest missions facing the Technical Secretariat. Large numbers of declared sites must have "initial" visits, while others may incur what is commonly referred to as a baseline OSI.[53] The utility of aerial inspections for baseline OSIs was evident in the experience of inspectors of the Intermediate-Range Nuclear Forces (INF) agreement. The United States and the USSR exchanged diagrams of declared facilities and photographs of missiles, launchers, and support equipment in December 1987. In some instances, these site diagrams, shown in Figure 1, complied with the letter of the Protocol requirements, but were quite sketchy in their depiction of the total number of structures on site capable of holding treaty-limited items (TLIs).[54] Inspection teams reportedly had to press their hosts to provide more information and access to all such structures. Assent to such requests varied, depending on the mindset of individuals hosting the inspections, and occasionally increased tensions during the inspection process.[55]

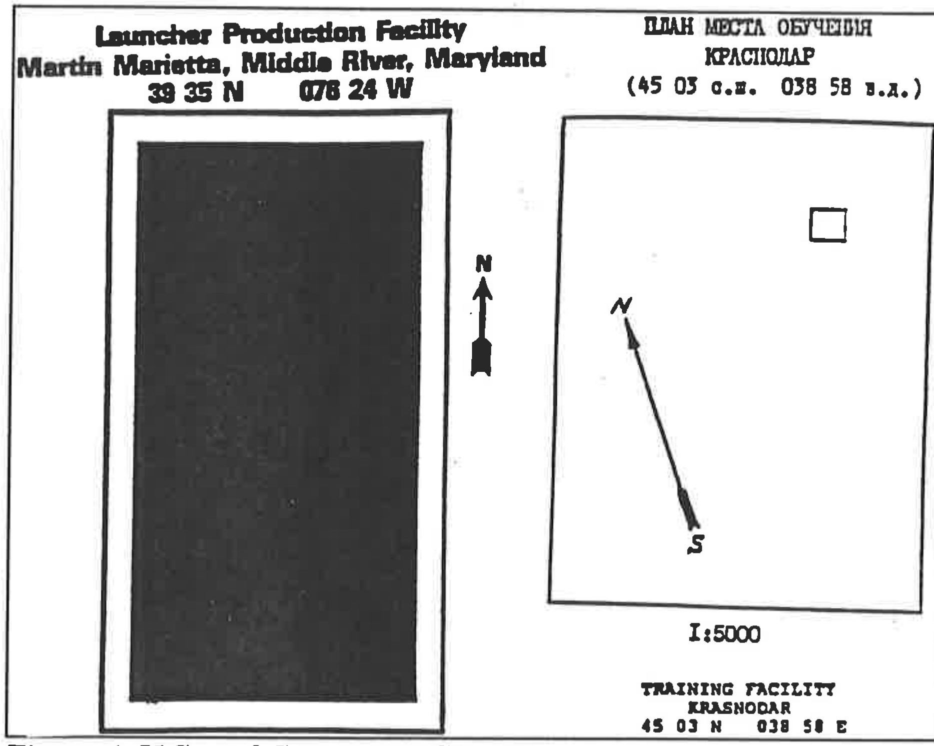

Figure 1. U.S. and Soviet INF Site Diagrams.

Most CWC inspectors could reasonably be expected to encounter greater difficulties than those confronted by INF inspectors since they will not have prior access to site diagrams of the facilities to be visited, except in the case of some Schedule 1 facilities.[56] U.S. and Soviet INF inspectors presumably use NTM assets that will be unavailable to the Secretariat to plan on-site visits. Without that advantage, CWC inspection teams would need assistance in determining where, amid large and complex chemical manufacturing facilities, they should concentrate their inspection efforts. Inspection teams would need to be as knowledgeable as possible, as host officials can be expected to be skillful in their control of physical and visual access on-site. An aerial photograph of each site, taken before baseline OSIs, would serve both to confirm the location of each facility and to assist the inspectors in site orientation. A data file of site photographs could be kept by the Secretariat and updated, especially when facilities give the required notice of major structural changes. Photographic records would be important for maintaining an institutional memory for an international organization with rotating professional staff. Access to these records need be given only to inspection team members prior to site visits.

Minimal Aerial Inspections for Declared Sites

In this concept, the aircraft could serve as a means of transport to the site and as a site familiarization platform. Especially if imagery from baseline confirmation aerial inspections is unavailable, an aerial tour of the site to be visited would serve at least two purposes: 1) to clarify which points within the facility would be most useful for the inspectors to request access, and 2) to suggest questions and points of clarification for host nation representa-tives.[57] If points for sampling and sensor placement can be identified from the air, even without sensors operating, then the OSI team would be able to complete their task more quickly, possibly with less interruption of facility operations.

An overflight might also allow inspectors to note possible abnormalities worthy of further investigation. Pre-inspection briefings during the INF baseline process focused mainly on safety and related procedures, not facility operations that might be of interest to inspectors.[58] If aerial inspections can precede pre-inspection briefings, the latter will be far more useful and substantive.

Fuller-Scope Declared Site Familiarization by Air

Additional data could be collected to confirm treaty compliance or raise questions requiring further investigation if aerial inspections for declared sites can employ a sensor suite aboard the aircraft. At a minimum, cameras can record the facility for the Secretariat's archives and to assist subsequent inspection teams. In addition, spectroscopic analysis of the emissions from a facility's smoke-stacks could be conducted. Sniffers could collect air samples for analysis by gas chromatography, mass spectrometry, or other appropriate procedures to ensure that proprietary information is not revealed. Other IR and radar sensors could also search for telltale signs of CW activity. Evidence of suspicious activity could come in the form of CW production by-products, precursors, or other chemical combinations that are incongruous with the data provided by the host state about the facility's operations. On-site data analysis would guide the inspection, but samples could also be taken back to the laboratories approved by the Secretariat for additional analysis. If participating states wish to resolve concerns over compliance directly, without utilizing the Secretariat and its laboratories, they could employ similar techniques, analyzing samples at national laboratories.

Site Familiarization for Ad Hoc Inspections

Several details remain unsettled on ad hoc inspections, but consensus is beginning to emerge on the general purposes and appropriate format for this type of inspection. Ad hoc inspections are meant to address relevant nondeclared chemical production facilities capable of manufacturing any chemical listed on the schedules. Not necessarily based on compliance doubts, ad hoc inspections should take hours rather than days and should permit sampling and on-site analysis.[59] By their very nature, ad hoc inspections will be conducted at unfamiliar facilities. No baseline data will be available for the sites chosen from national registers by the Secretariat for random inspections, unless broad area searches by aircraft are permitted at the outset of the Convention's entry into force.

If broad area searches by aircraft are not permitted, or if such searches have not been over sites being visited during ad hoc inspections, aerial inspections could enhance significantly the ad hoc verification regime. Imagery of these sites taken by NTM may well not be available to the Secretariat, and artist's drawings of the sites in question, if provided by states possessing high-resolution NTM, may not be an appropriate substitute. The only overhead data available to support ad hoc inspections may therefore come from lower resolution multinational or commercial observation satellites such as Landsat and SPOT, which may not have recent images available, or may not be able to provide new imagery on a timely basis. Even if such imagery were provided, it may not be of high enough resolution to assist in the ad hoc inspection.

Similar to its role in routine inspections of declared sites, an aerial tour of the facility, with or without sensors operating, would enable the inspection team to arrive at the gate with knowledge of the facility's overall operational configuration and of places of interest around the site. Agreed procedures that allow for the operation of sensors during ad hoc aerial inspections could help the inspection team to ascertain the nature of site operations. Depending on the sensors carried on the overflight, aerial inspections could help minimize the intrusiveness of the ground inspection, an element of considerable concern for those discussing the modalities of the ad hoc regime.

The Challenge Overflight

The use of aircraft and appropriate sensors could become useful tools in carrying out challenge inspections, either as a supplement or as an alternative to challenge inspections on the ground. An overflight could assist the inspection team to become familiar with a site about which the Technical Secretariat might hold very limited data. Instead of arriving at the gate "cold," the inspection team would have some site orientation, even if the flight were only conducted around the plant perimeter.[60] An overflight would allow the inspection team to ask appropriate questions during the pre-inspection briefing given by site officials, helping to make the subsequent ground inspection, if one is permitted, more purposeful. To be most effective, the challenge overflight should permit the use of appropriate sensors.

While aerial challenge inspections cannot fully substitute for OSIs in the facility in question, they could prove to be a satisfactory alternative if appropriate sensors are permitted and if other means to acquire data outside the plant gates are also allowed. A state that refuses to allow a challenge inspection inside plant gates might receive a sympathetic hearing, since many sites will be engaged in sensitive production unrelated to CW for which they may wish to deny access. In contrast, a state that denies aerial challenge inspections along with sampling above and beyond plant gates faces a far greater burden to justify its actions. Denial of inspections above and beyond plant gates would suggest the need for more intense scrutiny of the facility as well as the state in which it is located.

An aerial flyover or flyby could also provide an "above site" presence while the ground team is negotiating access to the facility at the national point of entry.[61] Appropriate procedures could be devised setting timelines for aerial observation and ground teams. Interval overflights might also be a way to monitor activity at the suspect site until the arrival of the ground team. Aircraft could replicate the "standdown" concept employed in nuclear arms control verification, where procedures prohibit the removal of treaty-limited items from a site before the arrival of inspectors. Major clean-up operations or other ambiguous activity may also be noticeable from the aircraft or other overhead systems.

The concept of a challenge flyover is likely to be controversial because some of the facilities challenged could be conducting sensitive research that is unrelated to CW production. Nonetheless, challenge overflights may well be more acceptable at some facilities than challenge inspections on the ground. Therefore, if participating states wish to give the Secretariat a greater ability to detect violations during inspections upon request, concepts such as the use of aircraft might usefully be entertained.

Challenge overflights could be arranged directly between the states involved in the compliance dispute, by a trusted third party, or by the Technical Secretariat. One of the apprehensions involved in inspections upon request is that the Secretariat's OSI teams will be multinational in character, and some of the nations represented may not be welcome by the state hosting the inspection. Nations directly involved might choose to resolve the dispute themselves to restrict outside access to such sites. If national equipment and facilities were not sufficient for the task, the resources of a third party could be called upon to help settle compliance issues. The good offices of the Secretariat, its aircraft, analytical techniques, and laboratory facilities would also be available.

Monitoring the Operational Status of Production Facilities

As discussed in Section IV of this paper, IR sensors are quite capable of indicating the operational status of a production facility by detecting heat emissions. Appendix I, Section VI of the rolling text describes OSI procedures to verify the closure of Schedule 1 production facilities not converted to destruction facilities. The inspection team may leave in place agreed tamperproof seals, markers, and other inventory control devices during the baseline and may return to inspect these devices and ensure that production operations have not resumed. Shifting the burden to aerial inspections following the baseline OSI is a logical and cost-effective way to utilize manpower and is well within the bounds of current technical capabilities.

Infrared sensors can detect very low levels of activity (e.g., operational heating pipes to account for permitted facility maintenance), allowing inspectors to follow up aerial inspections quickly with an OSI if the IR sensor picked up heat emissions from a reactor or supporting feedlines at a purportedly closed plant. In northern latitudes where such facilities are more likely to be bermed or embedded, a SAR might image feed and power lines into the plant to confirm that they were still disconnected. Furthermore, if agreed procedures permitted in situ monitors to be equipped with EID transponders, aerial inspectors could query these devices to receive state-of-health information. In this event, inspectors would only have to revisit the site when abnormalities were detected.

IR monitoring of commercial facilities could also prove useful for routine inspections. By cross-checking IR images of a facility's operational status with facility material flow records, the inspectors could have greater capabilities to uncover abnormalities. IR images showing activity out of synchronization with flow records or in an area of the facility that host officials pass over in their pre-inspection briefing might indicate a need for further investigation by the OSI team. The useful, but restricted information provided by IR scanning of declared sites suggests that these sensors deserve to be considered as routine accoutrements, along with film cameras, of aerial inspection teams. After all, IR sensors detect only the intensity of production activities, which does not reveal proprietary information.

More extensive monitoring of a facility's operational status could be accomplished during overflights by mating sensor and EID technologies. Current CWC provisions permit the inspectorate to place various sensors and seals throughout chemical production facilities. EID chips could be integrated into the flow, temperature, and pressure sensors, seals, and other devices installed during baseline OSIs. During subsequent overflights, whether combined with OSIs or not, these sensors can be queried to determine whether they have detected prohibited chemicals or other abnormalities. State-of-health information (e.g., operating according to programmed instructions, adequate power supply, tamperproof status) would also be available through the EID link.

Incorporating EID technology into on-site sensors would preserve reasonable monitoring confidence levels while conserving valuable resources. For example, if inspectors were satisfied with their record audit and the information received from the aerial inspection, they may opt not to conduct an OSI at that time.[62] On the other hand, any abnormalities reported by the EIDs would give the inspectors important clues about where to begin their work on the ground. The ultimate use of EIDs, however, would link the inspectorate to all facilities via satellite communications.[63] For instance, upon receiving a report that flow monitors seven and eight at plant 369 were sensing abnormal levels of activity, the inspectorate could ask for clarification from plant officials. An unsatisfactory response could prompt an OSI. Unless participating states are willing to make donations in kind, the cost of satellite links may outweigh the savings in human resources. The use of aircraft as an intermediate step may be the best way to collect the needed data and promote efficient use of inspection teams.

Monitoring the Destruction of Production Facilities

The destruction of CW production equipment and facilities is slated to take place over a nine year timeline, beginning not later than one year after entry into force. Treaty provisions allow for some production facilities to be temporarily converted into CW destruction facilities, but at some point, using the concept of "levelling out," the facilities themselves must be destroyed.[64] Just as mothballed plants can be monitored from the air, so can certain aspects of their destruction.

Six months before the wrecking ball swings, each state must file plans for the destruction process that include verification. Inspectors will undoubtedly want to be on-site to verify the destruction of standard and specialized CW production equipment, but progress on the tearing down of walls and final destruction of buildings can be readily observed from the air. Depending upon the size of the facility to be destroyed, the structural destruction process can take weeks, if not months to accomplish safely. Rather than leaving an inspection team on-site, intermittent aerial inspections could monitor the progress of the destruction effort, landing only if there were indications that something was amiss. In fact, the final inspection report could be filed from the air because the team flying over the site should see nothing more than a vacant lot.

Broad Area Search

One way to improve detection capabilities and thereby deterrence of noncompliance is to permit broad area aerial searches within participating states. Broad area searches at entry into force could allow the Secretariat to collect a library of imagery on facilities that may later become the object of baseline, routine, ad hoc, or challenge inspections.[65] This information would enable the inspectorate to carry out such inspections more professionally and purposefully. This library of data would also be useful for fact-finding investigations, as warranted and permitted. Even if monitoring signatures are not definitively agreed upon for all cheating scenarios, these overflights could help deter noncompliance by increasing concerns over discovery and raising the costs to pursue militarily signification violations. A quota formula in relation to the geographic size of each nation could determine the number of broad area flights for each country. Other modalities for broad area search might be patterned after the provisions under negotiation for CFE aerial inspection and Open Skies.[66]

The concept of broad area searches may be objectionable to some participating states, but concerns could be mollified by prior agreement on procedures governing components of sensor suites and other aspects of the overflight. The more participating states wish to be protected against prohibited activities taking place at undeclared or covert sites, the more they may be inclined to authorize broad area searches — as long as obligations are equitable and sufficient safeguards are in place so that the information gained cannot be misused by any participating state.

Supporting the Geneva Protocol and the Bacteriological (Biological) and Toxin Weapons Convention (BWC)

Upon entry into force, the CWC will reinforce the 1925 Geneva Protocol outlawing CW use by prohibiting all militarily significant pre-use activities. Words to this effect are contained in the CWC's preamble. The third of the General Provisions on Scope also specifically bans CW use. CWC monitoring might also pick up signs of illegal biological weapons development, production, or stockpiling — all activities banned by the 1972 BWC. Consequently, the CWC monitoring system could assume the burden of supporting two, or even three, treaties.

The ability of CWC aerial inspection to enhance the effectiveness of the OSI teams and to discourage covert activities would in all likelihood also improve detection and deterrence for noncompliance for the Geneva Protocol and the BWC. In the event of suspected CW use, aerial inspections using sniffers, FLIR, and FTIR could search for ambient agents. Multispectral data would also detect evidence of damage to nearby vegetation. Caution would have to be used in sending a manned aircraft into a potentially toxic area, so the use of remotely-piloted vehicles or drones with the appropriate sensors might be considered. Data collected during aerial inspections could be instrumental in confirming the violation.

VI. Conclusions

As the preceding discussion suggests, aerial inspections, while not the panacea for all of the CWC's verification ills, could make substantial contributions to the Convention's monitoring regime. Several of the missions described apply to monitoring of declared facilities. Some CWC observers have argued that cheating is least likely to take place in declared facilities, but the ability of manufacturers to change process flows quickly underlines what a difficult verification problem commercial monitoring will be.[67] The use of aerial inspections to strengthen the effectiveness and efficiency of human inspections and technical devices on the ground could help address difficult monitoring tasks while accommodating concerns about intrusiveness in the industrial sector. Other missions, like broad area searches, could enhance deterrence by increasing the likelihood — or at least the concern of potential cheaters — that prohibited activities will be detected. Aerial inspections could also promote more purposeful utilization of national and multinational technical means, especially for routine, ad hoc, and challenge OSIs.

We believe there are sound and substantive reasons to incorporate aerial inspections into the CWC. New initiatives are needed to move the CWC negotiations forward and to instill confidence in the Convention's monitoring regime. The acceptance of aerial inspections can help on both fronts. Because recent U.S. initiatives in Geneva have been received skeptically, if not negatively,[68] other states that are active in the CD may have to demonstrate their support for the use of aircraft and possibly take the lead in negotiations to include the appropriate provisions into the Convention.

The incorporation of aerial inspections into National Trial Inspections and agreement to work on technical issues through a series of multinational verification experiments might also be considered. To add aerial inspection to the tools available for CWC verification, sensors will have to be demonstrated and selected and negotiators will have to argue over details. Much work has already been done on sensor R&D, and precedents from the CDE Stockholm Agreement, peacekeeping missions, CFE, and Open Skies could aid negotiators in resolving operational provisions without extensive negotiations. General procedures could be contained in a separate aerial inspections annex or perhaps added to the Protocol on Inspection Procedures. Specific missions associated with each type of ground inspection could be added to the appropriate annexes for Articles III through VI. Attention to safeguards would enable aerial inspections to produce high quality data without undue concerns about misuse of the data collected.

Once these details are settled, the Secretariat would face yet another task, that of instituting aerial inspections. Donations of aircraft and approved sensors would be essential to limit costs. Participating states could also help with the provision of laboratory facilities for the analysis and storage of data collected. The responsibility to train inspectors and analysts and to support daily operations, however, is likely to remain with the Secretariat, which would require the active assistance of participating states with experience in aerial reconnaissance. Returns on this investment would be considerable, as they would enable the Secretariat to carry out its responsibilities more effectively and efficiently and, through the generation of a library of aerial data, enhance its institutional memory.

Policy makers and diplomats who will be reluctant to include aerial inspections in the CWC for fear of delaying negotiations must consider the consequences of agreeing to a Convention with far weaker verification provisions. This fear of delay may also be unjustified, given the groundwork that has already been laid in other agreements that use aircraft for monitoring. Furthermore, with roughly fifteen percent of the rolling text still in brackets, predictions of a quick conclusion of the Convention might be overly optimistic. The addition of aerial inspections may actually make settlement of tough problems over ad hoc and challenge inspections easier.

In our judgment, the benefits associated with CWC aerial inspections outweigh any complications that might arise in their negotiation. A versatile tool of significant utility to the Secretariat, aerial inspections will strengthen the links in the CWC monitoring chain. The closer the Geneva delegations come to closure on a CWC, the more scrutiny various parties, including the U.S. Senate, will give to the Convention's verification provisions. The contribution of aerial inspection to detection, deterrence, and confidence-building will fortify the Convention's verification regime for the trials of signature, ratification, and implementation yet to come.

NOTES

1. For monitoring purposes, chemicals have been divided into three schedules. Known nerve and blister agents comprise the super-toxic lethal chemicals listed under Schedule 1. Key precursors that may be the essential components of binary and/or multicomponent munitions and other supertoxic lethal chemicals are on Schedule 2, parts A and B. Schedule 3 lists dual purpose and precursor chemicals that would require more processing for conversion to munitions. Schedule 3 chemicals are usually produced in large commercial quantities for purposes not prohibited by the Convention. See the Annex on Chemicals, including definitions, schedules of chemicals, and guidelines for schedules of chemicals in the rolling text, UN document CD/1046, January 18, 1991, pp. 55-71.

2. Rudiger Ludeking, "Verifying a Chemical Weapons Convention," *Chemical Weapons Convention Bulletin*, no. 9 (September 1990), p. 1.

3. An estimated 10,000 facilities could fall under routine inspection. This benchmark figure, used for planning purposes, is derived by assuming approximately 1,000 known Schedule 1 and 2 producers worldwide will have at least ten customers each. Both manufacturers and consumers above the agreed quantity thresholds would be subject to monitoring. This figure of 10,000 could increase significantly if the final definition of ad hoc inspections includes *any* facility capable of some aspect of CW production. The need to detect clandestine production at undeclared sites is not factored into the estimate.

4. States with NTM, such as the Soviet Union the United States, will probably employ these assets as an additional means of monitoring the CWC. With the launch of the Helios surveillance satellite in 1994, Spain, France, and Italy will also have an NTM capability.

5. CWC monitoring tasks are described in greater detail by John Barrett in "Verification of a Chemical Weapons Ban: The On-Site Inspection Burden," in *Arms Control Verification & the New Role of On-Site Inspection*, Lewis A. Dunn and Amy E. Gordon, eds. (Lexington Books, Lexington, Massachusetts: 1990), pp. 139-158.

6. See *Verification: The Critical Element of Arms Control*, (U.S. Arms Control and Disarmament Agency, Washington: 1976), pp. 2-3.

7. According to former Secretary of State George Shultz, the United States would take several factors into account in determining the military significance of any given case of cheating: 1) the quantitative level of cheating and the overall threat it posed; 2) qualitative factors (e.g., kinds of weapons involved and their capabilities); 3) assessments of the military preparedness of the cheating force; 4) the extent to which the cheating force was redundant or was a force multiplier; 5) the extent to which the U.S. or its allies had forces or a surge capacity sufficient to counter the cheating force; and, 6) the overall environment surrounding the discovery of cheating. See Shultz' testimony in *Hearings before the Committee on Foreign Relations, U.S. Senate, Second Session on the Treaty between the United States of America and the Union of Soviet*

Socialist Republics on the Elimination of their Intermediate Range and Shorter Range Missiles, Senate Hearing 100-522, Part I, January 25-28, 1988, pp. 450-471. For the CWC, possible militarily significant violations have been identified as: 1) a threat from dual purpose agents; 2) a potential for significant undeclared production; and 3) a potential for significant undeclared stockpiles. See *Senate Hearings before the Committee on Appropriations: SALT II Violations*, Fiscal Year 1985, 98th Congress, Second Session, p. 33.

8. See *Air Monitoring as a Means for Verification of Chemical Disarmament: Field Tests, Part II*, The Ministry for Foreign Affairs of Finland (Helsinki: 1986). Also, air sampling equipment has reportedly been used aboard French aircraft overflying targets in Kuwait to determine the success of allied bombing in destroying Iraqi chemical weapon storage facilities. Air samples taken during these overflights reportedly found diluted poison gas residues, helping to confirm the destruction of CW targets. "Iraq's Chemical Weapons Still a Threat to Ground Troops, U.S. Says," R. Jeffrey Smith, *The Washington Post*, February 19, 1991, pp. A7-A8.

9. *Verification in All Its Aspects: A Comprehensive Study on Arms Control and Disarmament Verification Pursuant to UNGA Resolution 40/152(o)*, Government of Canada (Ottawa: April 1986), p.16.

10. Heinz Gaertner examines the difficulties of smaller nations trying to participate in arms control verification in "Challenges of Verification: Smaller States and Arms Control," Occasional Paper #12, (Institute for East-West Security Studies, New York: 1989).

11. *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, Congressional Budget Office, September 1990, pp. 31-33.

12. Annual direct operating costs included amortization for aircraft, aircrew, fuel and oil, and maintenance. John King, "Airborne Remote Sensing for Open Skies: The Platform" in Michael Slack and Heather Chestnutt, eds., *Open Skies: Technical, Organizational, Operational, Legal, and Political Aspects*, Center for International and Strategic Studies, (York University, Toronto: 1990), p. 33.

13. Research to date has not thoroughly addressed these costs. In 1984, Finnish scientists estimated that laboratory instrumentation would cost from one to three million dollars and suggested use of existing laboratories where international inspectors could work. *Technical Evaluation of Selected Scientific Methods for the Verification of Chemical Disarmament*, The Ministry for Foreign Affairs of Finland, ISBM 951-46-8093-6 (Helsinki: 1984), p. 38. Preliminary U.S. studies on the central laboratory issue are just getting underway.

14. Donating nations are the Netherlands, Switzerland, Canada, Italy, the United States, Australia, the Federal Republic of Germany, the Soviet Union, Japan, Norway, Poland, Sweden, Austria, the United Kingdom, Denmark, Finland, Ireland, New Zealand, Kuwait, Morocco, the Republic of Korea, and Greece. This information was abstracted from Appendix II: Facts and Figures in *The Blue Helmets: A Review of United Nations Peace-keeping*, document number DPI/1065-40500 (UN Department of Public Information, New York: August 1990) pp. 419-449.

15. Most notably, since 1973 Finland has sponsored an extensive research and development (R&D) program to meet CWC verification needs for sensors and analytical techniques.

16. A related concern is that although information gained during CWC monitoring activities is to be used only by the Technical Secretariat, some information might be released publicly in an attempt to focus attention on the party conducting questionable activities. This situation could occur with any type of data gathered, whether from ground or aerial inspection, if a treaty party ignores requests from the Executive Council to satisfactorily explain ambiguous or to stop prohibited activities. Nations sitting on the Council or most directly involved in the dispute might opt to make supporting documentation public in an effort to broaden pressures to reaffirm compliance or assist in the imposition of sanctions or assurances. Satisfactorily resolving compliance problems requires great tact, purposefulness, and the need to respect the rules of confidentiality associated with monitoring. At the same time, however, no state can be denied the right to disclose data regarding noncompliance when the mechanisms established under an agreement do not secure the desired response.

17. While manufacturers can have no expectation of privacy in the layout of plant facilities, sensors that record electronic signals or pick up other types of information not available to the naked eye are a separate issue, which has not been addressed by the U.S. courts. See the United States vs. Dow Chemical Corporation (536 F supplement 1355, E.D. Michigan, 1982); also see David A. Koplow, "Overflying the Country Without Overlooking the Constitution: Legal Implications of an 'Open Skies' Agreement," Paper prepared for The Henry L. Stimson Center (Washington: April 1990).

18. Michael Walls of the Chemical Manufacturers Association described sensors other than routine photography as "dangerous" in that they might reveal proprietary data. He suggested a 48-hour notification before an aerial inspection and also noted that such aerial sensor operations would unnecessarily duplicate information available elsewhere (e.g., through the EPA's records on aerial emissions) or procedures already agreed upon for ground inspections. Interview, October 23, 1990.

19. Additional guidance may come from procedures to be developed for aerial inspections in CFE and Open Skies.

20. The first CDE inspection was conducted by the United States of a Soviet military exercise conducted near Borisov in the USSR. Team members were allowed to use their own dictaphones, cameras, maps, binoculars, and aeronautical charts. The Soviets placed two Mi-8 Hip-C helicopters at the disposal of the U.S. inspection team, with two more held in reserve for the same purpose in case of equipment failure. For a first-hand account of the initial CDE inspections, see Don O. Stovall, "A Participant's View of On-Site Inspections," *Parameters*, U.S. Army War College, vol. XIX, no. 2 (June 1989), pp. 2-17. Stovall notes that the Soviets would not fly at night, nor were aerial inspections permitted for safety reasons when the air attack phase of the exercise involving low-flying Hind helicopters, Flogger, and Frogfoot aircraft, got underway. He also notes that inspector-to-pilot communications were done with hand signals at the Borisov site, and though the Soviets responded slowly to requests for flight path deviations in this initial inspection, in subsequent inspections, requests were initiated in a matter of seconds. In his concluding observations, Stovall notes that "From all indications, the inspections have not been used for the overt collection of intelligence." (p. 16).

21. Provisions of the Stockholm agreement dealing with the conduct of aerial inspections can be found in the Compliance and Verification section of the treaty, paragraphs 76-96. See the Document of the Stockholm Conference on Confidence- and Security-Building Measures and Disarmament in Europe Convened in Accordance with the Relevant Provisions of the Concluding Document of the Madrid Meeting of the Conference on Security and Co-operation in Europe in *Arms Control and*

Disarmament Agreements: Texts and Histories of the Negotiations, U.S. Arms Control and Disarmament Agency (Washington: 1990), pp. 319-335.

22. The 115th Air Transport Unit, provided by the Royal Canadian Air Force, made regular reconnaissance flights in conjunction with ground patrols using Otter single-engine aircraft painted with the UN's logo. United Nations Emergency Force, Background Paper #3, Public Information Office, (Gaza, Israel: 1962). For a complete description of UNEF I operations as well as those in other areas of the world see the appropriate chapters in *The Blue Helmets*, ibid.

23. Two disengagement agreements, monitored by the UN, preceded the formal peace treaty between Egypt and Israel, signed March 29, 1979. For a description of the MFO, see *The Multinational Force and Observers: Servants of Peace*, Office of Public Affairs (Rome: November 1990).

24. For instance, the UN needed twelve helicopters for its observer mission on the Iran-Iraq border, but Iran refused permission for UN controlled aircraft to operate in the region. The compromise reached by the local UN commander was to have Iran and Iraq each place six helicopters at the disposal of the UN observer mission. Unfortunately, these aircraft were sometimes slow to respond or entirely neglected to respond to UN requests for flights. Details about UN aerial operations were provided by Lt.Col. Dermot Earley of the UN Special Political Affairs Office. Personal interview, March 12, 1991.

25. Open Skies negotiators have found the origin of the aircraft, whether from an international pool, the inspecting country, or the host country, to be a difficult issue to resolve. The experience of UN peacekeeping missions indicates that this sensitive issue can be addressed flexibly, to the satisfaction of the concerned parties. The concept of regional basing follows the principles used by the U.S. On-Site Inspection Agency, which forward deploys some equipment and personnel to enable a more rapid response time for short-notice inspections.

26. The difficult task of defining CW monitoring signatures has been undertaken by the Office of the Assistant Secretary of Defense (Atomic Energy). Results are expected during 1991.

27. Except where noted, this discussion is drawn from "Evaluation of Sampling Techniques" in *Air Monitoring as a Means for Verification of Chemical Disarmament: C.2 Development and Evaluation of Basic Techniques*, The Ministry for Foreign Affairs of Finland, ISBN 951-46-806-2 (Helsinki: 1985), pp. 73-96.

28. Experiments are being conducted to miniaturize this sampler from less than 20 kg to less than 10 kg. "Advanced Concepts Report on the Detection of Xenon with a Miniature Whole Air Sampler Capable of Extended Operating Times," J.P. Dugan et al, Monitoring and Analysis Projects Group, Idaho National Engineering Laboratory, INEL-SP-274 (October 1990).

29. While the following discussion refers to methodologies for later analysis of air samples in the laboratory, some real-time analysis possible. These capabilities involve the use of infrared sensors set at specific wavelengths for the detection of agents or the use of miniaturized gas chromatographs, called minicams, that automatically direct the air sample into a briefcase-sized gas chromatograph for analysis.

30. Accounts of the latest advances made in these analytical methodologies can be found in the *Journal of Organic Chemistry*, the *Journal of Analytic Chemistry*, and the *Journal of Chromatography*.

31. *Technical Evaluation of Selected Scientific Methods for the Verification of Chemical Disarmament*, The Ministry for Foreign Affairs of Finland, ISBN 951-46-8093-6 (Helsinki: 1984), pp.37-63.

32. *Air Monitoring as a Means for Verification of Chemical Disarmament: C.4 Further Development and Testing of Methods, Part III*, The Ministry for Foreign Affairs, ISBN 951-47-0805-9 (Helsinki: 1987), pp.66-71.

33. "Open Skies: Sensors and Platforms," op cit, pp.4-8.

34. *Remote Sensing and Image Interpretation*, Thomas Lillesand and Ralph Kiefer (John Wiley & Sons, New York: 1979), pp. 442-443.

35. *Aerial Reconnaissance for Verification of Arms Limitation Agreements: An Introduction*, Allen V. Banner, Andrew J. Young, and Keith W. Hall, UNIDIR/90/83 (United Nations, New York: 1990), pp. 81-88.

36. "Argus: Remote Sensing System," Office of Arms Control, U.S. Department of Energy, mimeo, 1990.

37. The construction of dual band IR sensors might be considered to enable detection of chemical effluents. The standard open filter would comprise one band of the sensor, while the other band would have a series of special filters designed to detect target effluent signatures. This type of sensor could be fitted into the nose cone of the aircraft, but sensitivity of the sensor would have to be evaluated against CWC monitoring requirements during development. Telephone interview with Joseph Leonelli of SRI International, January 28, 1991.

38."Infrared Surveillance and Detectors," James C. Fraser, in *Arms Control Verification: The Technologies That Make It Possible*, Kosta Tsipis, David Hafemeister, and Penny Janeway, eds. (Pergamon-Brassey, Washington: 1986), pp. 166-169.

39. IR images and a more thorough explanation of IR technologies can be found in *Aerial Reconnaissance for Verification of Arms Limitation Agreements*, op cit, pp. 57-77.

40. "Open Skies: Sensors and Platforms," op cit, p. 10.

41. The breakthrough in FTIR technology has been accomplished by a team of scientists working in conjunction with the U.S. Army CRDEC. Their work is described in Gary W. Small et al, "Design of Optimized Finite Impulse Response Digital Filters for Use with Passive Fourier Transform Infrared Interferograms" *Analytical Chemistry*, vol. 62, no. 17 (1990), pp. 1768-1777, and Robert T. Kroutil et al, "Signal Processing Techniques for Remote Infrared Chemical Sensing" in *Computer-Enhanced Analytical Spectroscopy*, Vol. 2, Henk L.C. Meuzelaar, ed. (Plenum, New York: 1990), pp. 71-111.

42. CRDEC has been refining mobile FTIR operations in conjunction with FLIR and video recordings. The next generation of their XM21 FTIR is being specifically designed for international monitoring purposes. Interview, Kirkman Phelps, November 1, 1990.

43. Safety precautions would have to be taken if active sensors are used in monitoring. For instance, sensors that use lasers might damage the eyes of workers below not

equipped with protective goggles. This requirement for extra safety precautions makes active sensors a less attractive option for the sensor platform.

44. Compact mobile lidars that focus on spectral activity in the 3-5um and 9-11um spectral bands of interest and also detect several organic, inorganic, and chlorinated hydrocarbon compounds have been tested and are available for aerial monitoring. Information on these systems, created by SRI International, was provided by Joseph Leonelli. Personal communication, November 29, 1990.

45. "New Detection Approaches for Chemical and Biological Defense," Diane M. Kotras, *Army Research, Development & Acquisition Bulletin* (January-February 1989), pp. 3-4.

46. *Overhead Remote Sensing for United Nations Peacekeeping*, Verification Research Program, Department of External Affairs, Government of Canada (April 1990), pp. 9-14. Like other sensors, however, SARs can be spoofed; in this instance, with the use of radar reflectors.

47. Jeffrey Tracey, a Verification Research Officer with the Canadian External Affairs Department, points out that military SARs have a spotlight mode that enables a resolution of one meter or less. Such systems are not likely to be available for international monitoring missions and the commercial SARs would have to be tested against the identified targets to assess the sufficiency of their resolution for the task. Telephone interview, December 21, 1990.

48. Information about EID capabilities was provided by Thomas Prevender of Sandia National Laboratories. Interviews on December 6, 1990 and January 15, 1991.

49. The presence of metal roofs would interfere with transmissions, so a tamperproof antenna to the roof or on the side of the building would have to be provided. The EID would also require a small power source, such as a lithium battery.

50. Impressive advances are being made in the area of CW microsensors. For example, see "Fiber Optic Microsensor for Receptor-Based Assays," James J. Valdes, Myron J. Block, and Thomas R. Glass, U.S. Armament Munitions Chemical Command, CRDEC-TR-88071 (September 1988); and "Solubility Interactions and the Design of Chemically Selective Sorbent Coatings for Chemical Sensors and Arrays," Jay W. Grate and Michael H. Abraham, Naval Research Laboratory, Memorandum Report 6692 (July 27, 1990).

51. The concept of public/private key is, however, referred to in another manner in the rolling text. "Dual key" systems requiring both the inspector and host to be present to enable access are mentioned in Appendix I, UN CD/1033 (August 10, 1990), p. 157.

52. Aerial inspections are not expected to make a contribution to the verification of all monitoring requirements (e.g., monitoring CW storage facilities, the movement of CW to destruction sites, the destruction of CW stocks, and the permitted small-scale production facility).

53. Well over 1,000 baseline OSIs are likely to take place. This figure is derived from estimates of the number of declared facilities worldwide and from the requirements of the rolling text. Initial OSIs *must* be conducted at weapon production and storage facilities, single small-scale production facilities, and Schedule 1 production facilities. All Schedule 2 facilities are "liable" to receive baseline visits. Assuming that a percentage approach, similar to that used in the CFE baseline visits, is used for Schedule 2 facilities, an estimate of 1,000 to 2,000 baseline OSIs seems reasonable.

Schedule 3 facilities, which are covered by the ad hoc regime, will of course not receive baseline OSIs.

54. See *Photographs and Site Diagrams Appended to the Memorandum of Understanding for the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles* (ACDA, Washington: December 1987).

55. These difficulties were encountered mostly during the baseline process, when officials from both sides were becoming accustomed to the intrusiveness required by the Protocol. Both sides now know more about what to expect from each other and the inspection process itself.

56. Declaration requirements for Schedule 2 and 3 production facilities include the name, location, and production data, but not facility diagrams or maps. The declaration for Schedule 1 facilities not destroyed will include a layout of the facility and a process flow diagram. For more detail on the declaration requirements, see pp. 96-97, 118-119, and 123-124 of Appendix I UN CD/1046 (January 18, 1991).

57. Members of U.S. National Trial Inspection (NTI) teams noted that aircraft overflights have not been used in the four NTIs conducted to date. They found it difficult to judge the utility of the concept, but remarked that a helicopter platform would be more likely to allow the inspectors to select specific sampling and sensor placement points. Roundtable discussion, Multilateral Verification Project Meeting of the Henry L. Stimson Center, February 26, 1991.

58. Edward J. Lacey, "On-Site Inspection: The INF Experience," in *Arms Control Verification & the New Role of On-Site Inspection: Challenges, Issues and Realities*, Lewis A. Dunn and Amy E. Gordon, eds. (Lexington Books, Massachusetts: 1989), p. 7. According to the rolling text, the CWC pre-inspection briefing should include safety measures and administrative and logistic arrangements for the OSI, the facility's physical layout (using maps, *if needed*) and activities. UN CD/1046, Appendix I, Addendum (January 18, 1991), p. 143. During the pre-inspection briefing for a challenge inspection, the OSI team will be provided "a map or sketch drawn to scale showing all the structures and significant geographic features at the site." See p. 158 of UN CD/1046 (January 18, 1991).

59. For a more thorough description of the evolving ad hoc inspection concept, see Appendix II, Ad Hoc Verification, pp. 179-180 of UN CD/1046 (January 18, 1991) and "Verifying a Chemical Weapons Convention," op cit, pp. 6-8.

60. Access may be limited to the perimeter due to restrictions placed on the airspace over some sensitive facilities.

61. The rolling text acknowledges measures for "securing the site" upon arrival of the ground inspection team. The inspecting team is allowed perimeter patrol of the site, the stationing of personnel at exits, and the inspection of any transports leaving or entering the site to ensure there is no removal or destruction of relevant material. See Part III, Section II (C) for challenge inspection procedures, p. 158 of UN CD/1046 (January 18, 1991).

62. The observations of inspectorate personnel who have been on the premises to maintain in-situ monitoring devices would be factored into a decision to forgo an OSI. Maintenance personnel could be instructed to report any abnormalities they see as they go from point to point in a plant to maintain monitoring equipment.