Ad Hoc Group of Governmental Experts
to Identify and Examine Potential
Verification Measures from a
Scientific and Technical Standpoint

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CAPABILITIES AND LIMITATIONS OF OVERHEAD REMOTE SENSING FOR VERIFICATION WITHIN THE CONTEXT OF THE BIOLOGICAL AND TOXIN WEAPONS CONVENTION (BTWC)

DISCUSSION PAPER

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Introduction

Since the Biological and Toxin Weapons Convention (BTWC) was opened for signature some twenty years ago, there has been a significant evolution in the development of multilateral arms control agreements. The dramatic transformation which has taken place regionally in Europe within the last two years, and the re-emergence of the United Nations as a significant player in the global context, have served as catalysts in this process. They have served in the redefinition of the broader context within which the role of multilateral verification is destined to take on a higher profile.

To be successful, multilateral arms control and disarmament agreements must incorporate a package of effective, mutually supporting and well defined verification provisions. Verification, in this context, encompasses a wide spectrum of technologies and techniques. At one extreme, parties to a treaty might simply agree to a complaint and consult mechanism. Although this mechanism is useful, it is sometimes characterized as "token" rather than "real" verification. At the other end of the verification spectrum, a treaty might call for intrusive measures including the presence of inspectors on-site and in a variety of circumstances. Verification effectiveness is often seen in direct correlation to the degree of intrusiveness countenanced within a treaty mandate. In the longer term, however, it may be necessary to determine what is the minimum degree of intrusiveness in the verification process which will provide the level of confidence that all parties will require in terms of compliance with treaty obligations. To accomplish this, an understanding of synergistic effect brought to bear by a number of mutually interacting methods of verification will be essential.

This short paper is intended to initiate discussion of the potential utility of overhead imagery as one method of verifying compliance with the BTWC. In writing this paper, it is not our purpose to advocate the application of overhead imagery in verification. Rather, it is to put forward some of the discussion that has already taken place in other forums concerning this technology as part of a package with a view to reinforcing other verification methods. One objective is to establish a framework for further discussions of this topic, and to suggest criteria for evaluating future proposals.

The "Verification Package"

Although it can be argued that verification works best when there exists a specific, reliable technique that can be applied in a given situation, Canadian research has emphasized that, for purposes of multilateral verification, a package approach to verification, particularly in the longer term, offers the best guarantee of verification effectiveness and cost-effectiveness. Certain methods, for example on-site inspection (OSI), may be essential as United Nations Special Commission experience has proven. Nevertheless, if ambiguity, or outright cheating, might "defeat" a single method, then other methods within the package may compensate. Overhead imagery may be able, in some instances, to address the concern without requiring on-site inspections. In other instances, it might constitute a unique method of triggering or redirecting other methods for greater effect. In addition to the data collection and recording characteristics inherent in space-based or airborne data collection systems, the package might include information collection from a number of other sources, including human sources as well as low cost collateral analysis from open sources (literature surveillance). In the final analysis, the effectiveness of each measure will depend upon the nature of the specific treaty. Geographic features and natural occurrences and other general characteristics will have to be taken into consideration when deciding how to get the best from any package. An evaluation of the capabilities and limitations of each measure, and an understanding of their synergistic effects, will be absolutely essential.

Overhead Imagery

For the purpose of this paper, the discussion of Overhead Imagery is limited to commercially available space-based imagery and imagery obtained by the use of airborne platforms. It does not include the use of sophisticated methods such as high resolution imagery from satellites termed National Technical Means (NTMs) which are capable of resolving objects a few inches in size from a height of approximately 100 miles. It is useful to note, however, that today's commercial imagery satellites cannot provide this high resolution but do approximate the flight characteristics of such satellites. While not possessing the flight characteristics of NTM, airborne system do in fact possess the capability of producing high resolution images. A combination of the two could conceivably provide a capability approximating that of current NTM.

Discussion

The concept of using overhead remotely-sensed imagery from satellites or aircraft as a tool to aid inspections with respect to arms control verification is not new. In fact, the recently signed Open Skies Treaty has provided to many nations, not privy to national technical means imagery, a means of verification through aerial inspections. The suggestion of an aerial inspection protocol as an inspection tool for the CFE-1A Treaty was once

considered as an important option open for negotiation in Vienna, but fell short of fruition due to the inherent problems of negotiating such complex issues as aircraft ownership, sensors and quotas. Substantial research has been undertaken to address the value of overhead imagery for United Nations peacekeeping. The United Nations Special Commission (UNSCOM) now established to verify compliance by Iraq with Resolution 687 is currently being supplied with aerial photography through weekly overflights by surveillance aircraft. There has been research into the potential use of aerial inspections for verification of the Chemical Weapons Convention in relation to production and storage facilities. The logical question then arises, as a follow-on to the past work conducted on the use of overhead imaging: could overhead remote sensing methods assist in verification in relation to biological weapons and related facilities and thereby strengthen the Biological and Toxin Weapons Convention?

Arms control monitoring regimes are designed to collect information on treaty-related activities, to verify compliance with the terms of the treaty, and to assist in providing indicators of suspicious activity. Overhead inspections using commercially available satellite and airborne imagery, when used in conjunction with routine, ad hoc, or short notice inspections can increase the probability of detection. Overhead imagery could also enhance detection capabilities by aiding inspectors to choose the most appropriate areas within specific suspect sites and providing additional information regarding that site to which they may not normally have access. Broad area coverage by means of satellite imagery or aerial inspections could provide indirect evidence of suspect activity related to BW activities. The acquisition and use of this type of imagery could significantly improve the effectiveness of the verification activity by serving as a conduit through which information gained by other means can be incorporated into the system for use in support of on-site inspection and other operations.

Satellite Imagery

Commercially available satellite imagery, such as that of the French SPOT satellite system and others, can provide a non-sensitive information source. The utility of this type of imagery, albeit in an entirely different context, is suggested through its use during the Gulf war by coalition forces. The multispectral imaging of the French SPOT satellite was used extensively for tactical plans, map updates, terrain analysis and sensor fusion. Acquisition and use of this type of imagery for BTWC purposes could provide a useful but low profile cross-over capability to assimilate into the verification database information received from other sources.

Although the ground spatial resolution of SPOT data (10 meter x 10 meter) is much less than that of NTM imagery, a

significant amount of useful information can be gained with the proper analysis. For example, major military installations, new construction starts, airfields, and major transportation routes are readily discernable on SPOT imagery. Change detection of a particular area using multi-temporal imagery can be conducted.

It is recognized, however, that this type of information is not really suitable for detailed monitoring of smaller features that would normally be related to BW activity, especially when BW activity may require very little area and be conducted within the confines of a building. Combined with the results of airborne imaging and of on-site inspections, in addition to collateral information, this type of imaging could perform a useful overlay type of function. Such imagery would have most utility in providing information related to background and context. Site diagrams for use in on-site inspections might be prepared using commercially available satellite imagery.

Aerial Imagery

Aerial inspection in the BTWC would support the verification objectives of detection, deterrence and confidence-building while increasing the effectiveness and efficiency of ground inspections. Aerial inspections cannot fully substitute for on-site inspection; however, they could be used as satisfactory alternatives in certain cases if specific imaging and other sensors are allowed.

Airborne imagery comes in a variety of forms. The simplest and least expensive airborne data available is the product of the oldest surveillance technique, aerial photography. Aerial photography can provide very high spatial resolution imagery without the need for a highly sophisticated aircraft platform or complex data processing and interpretation equipment. Other camera-related technology that provide high resolution daytime images include electro-optical systems such as multi-spectral cameras, charge-coupled devices and video cameras. The major drawback to aerial cameras such as these is their limited operational window during daylight hours in good weather conditions. The high resolution images that they acquire, however, make them one of the best airborne sensors when very detailed imagery is essential. The subsequent recognition and identification of certain specific features related to BW activity could be readily discernable using this type of imagery.

Infrared linescanning or forward-looking infrared techniques could assist BTWC monitoring by the recording of a facility's operational status through the detection of heat sources related to a specific activity. Thermal infrared systems detect radiant heat energy emitted by all objects. The warmer an object is, the more energy is emitted and the more readily it appears on an infrared image. Thermal infrared techniques are best suited

during nighttime operation, and, like aerial cameras, are restricted to good weather conditions. The spatial resolution of infrared systems is slightly poorer than that of aerial cameras, however sufficient detail can be acquired to adequately resolve militarily significant features such as operational buildings, conduit lines, vehicles and personnel.

Synthetic aperture radars (SAR) are active sensors that use reflected microwave energy to produce an image. The higher the reflectance properties of a particular object, the brighter it appears on a SAR image. The spatial resolutions of present day commercial SAR systems are in the order of 3 to 6 meters, not sufficient for the recognition or identification of smaller features. However, due to the nature of microwave reflection, very small objects (such as small vehicles) are detectable because of corner reflecting capabilities. A SAR image of a suspect BW facility may reveal details that regular photography may not exhibit, such as feed lines and power lines. Unlike aerial camera systems and infrared sensors, SARs are undaunted by poor weather conditions. SAR systems are also very useful for broad area coverage and typically image 60,000 square kilometers in one mission.

Conclusion

It is understood that BW related activities will be very difficult to verify directly using spaceborne or airborne imaging techniques since the majority of activity of concern will likely occur within buildings. It is also recognized that overhead imaging technologies are limited in their capabilities to monitor only exterior activities and features of suspect BW related facilities. The ability of an overhead imaging capability in a BTWC context could be used to enhance the effectiveness of any on-site inspection and to discourage covert activities. Commercial satellite imagery could help produce new, or update existing, maps before inspectors enter into an area. Aerial sensors could be used to produce more detailed site maps of an area subject to future inspection and to familiarize inspectors before ad hoc inspections are initiated. The use of aircraft and appropriate sensors could become useful tools in carrying out inspections. Broad area coverage to aid in the identification of areas that may be subject to future inspection could be undertaken using overhead imaging. It may be the case that the addition of aerial inspections can have synergistic effects by increasing the ability to conduct more effective ground inspections and permit more cost-effective, less intrusive operations.