Chapter 2

WHY AERIAL SURVEILLANCE?

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Summary

Cooperative aerial surveillance could be the subject of a stand-alone agreement in which the flights are both the means and the objective (as in Open Skies); it could be one provision among several supporting the ultimate goals of an agreement (as in the Conventional Armed Forces in Europe Treaty (CFE)); or it could be the subject of an agreement that supports the goals of another agreement that does not itself provide for equivalent overflights (as in CFE IA).

Aerial surveillance has three main uses: mutual confidence building; aerial monitoring of specific targets, sites, or activities; and collateral information gathering. Confidence building and aerial monitoring would be explicit functions written into an overflight regime, whereas the collection of collateral information is an implicit byproduct contrary to the spirit of an agreement. Aerial monitoring can be used to search for, inspect for, deter, detect, and warn of noncompliant behavior, as well as to provide information that might assist other means of monitoring. Collateral information can supplement agreed sources of information about treaty compliance or it can be used for other intelligence purposes, e.g., strategic assessments, targeting, and general warning.

Aerial surveillance can work collectively and synergistically with on-site inspections (OSIs), other cooperative measures, and national technical means (NTM) of verification. The decision to include aerial surveillance in an accord would depend on the goals of the accord, an assessment of the relative strengths and weaknesses of the different monitoring options, the costs and benefits of the regime, interactions with other agreements, and negotiability.

Introduction

In 1955 President Dwight D. Eisenhower proposed "Open Skies," a plan for an international program of reconnaissance flights intended to reduce fears of surprise military attack. The Soviet Government rejected this proposal as a U.S. effort to spy on the Soviet Union. But after President George Bush revived the proposal in May 1989, a transformed Soviet Union seemed more receptive. It agreed to interalliance negotiations on an Open Skies Treaty to build mutual confidence. The same 23 nations[1] were already negotiating provisions for cooperative aerial surveillance as part of the CFE Treaty's compliance monitoring regime.

The Open Skies negotiations eventually stalled and the CFE Treaty was signed on November 19, 1990, without extensive aerial monitoring provisions (though further negotiations--CFE IA-may yet add such provisions).[3] The fact that these cooperative aerial surveillance negotiations took place reflects the promise of the idea; their inconclusiveness reflects the difficulties of designing an overflight regime that would satisfy the goals and concerns of different nations.

This chapter qualitatively examines the utility of aerial surveillance in supporting the goals of an agreement.[4] Depending on how they are implemented, overflights can build confidence in the inoffensiveness or benignancy of the other parties, monitor agreements, or gather collateral information. This chapter also explores the interaction of aerial surveillance with NTM and OSI.

What Is Cooperative Aerial Surveillance?

"Cooperative aerial surveillance" describes a collection of concepts for using sensors on airborne

[1]This number became 22 with the unification of Germany in October 1990.

[2]For the purposes of this report, "aerial surveillance," "aerial observation," and "aerial reconnaissance" are regarded as synonymous and encompass all types of airborne observation described.

[3]When the CFE Treaty enters into force, it will be verified by NTM and cooperative measures, such as OSIS. Aerial inspections will be included, but they will be limited to brief host-operated helicopter flights over inspection sites. These overflights are much less extensive and intrusive than those under consideration for CFE IA. The signing of CFE before the completion of all its aerial monitoring provisions implies that the CFE IA flights may serve a more supplementary, than critical, role in verification.

[4]Aerial monitoring, in particular, lends itself to quantitative analysis. The foundations for such an analysis are presented in chs. 3 and 6.

platforms as an important element in bilateral and multinational agreements. A party to an agreement providing for aerial surveillance would allow overflights of its territory in exchange for rights to similar flights over the territories of the other parties.[5]

While generally thought of as involving only airplanes and cameras, cooperative aerial surveillance could take many forms. Possible choices for aerial platforms include airplanes, helicopters, unmanned aerial vehicles (UAVs), or lighter-than-air craft such as blimps. Sensor choices include photographic, electro-optical, and radar imaging devices, as well as radio receivers, air samplers, radiation or magnetic anomaly detectors, and acoustic devices. The selection of platform and sensor will depend on the nature of the agreement being negotiated.

Cooperative aerial surveillance could be included in an agreement in three general ways: it could be both the means and the objective (as in Open Skies); it could be one provision among several supporting the ultimate goals of an agreement; or it could be the basis for an agreement that explicitly supports the goals of another agreement that does not itself provide for overflights.

Although this report focuses primarily on negotiations of which the United States and the Soviet Union are a part, the principles discussed would be equally applicable to any set of nations.

The Utility of Aerial Surveillance

Cooperative aerial surveillance could have three main uses in an international accord: mutual confidence building, aerial monitoring of specific targets or activities, and collateral information collection (see figure 2-l). Confidence building and aerial monitoring are legitimate functions, which follow the letter and spirit of an accord. The collection of collateral information is a generally unavoidable byproduct of an overflight regime which tries to restrict either the quantity or quality of the data collected.

Confidence about the inoffensiveness or benignancy of another country's intentions and capabilities can be built when two or more states work cooperatively and open themselves to outside scrutiny. The Open Skies Treaty is an example of an overflight regime whose primary purpose would be to build mutual confidence among the signatories. The phrase "confidence building" is fairly amorphous, but captures a range of positive concepts, e.g., a reduction of tensions, greater transparency, and the development of common understanding through increased contact and openness.

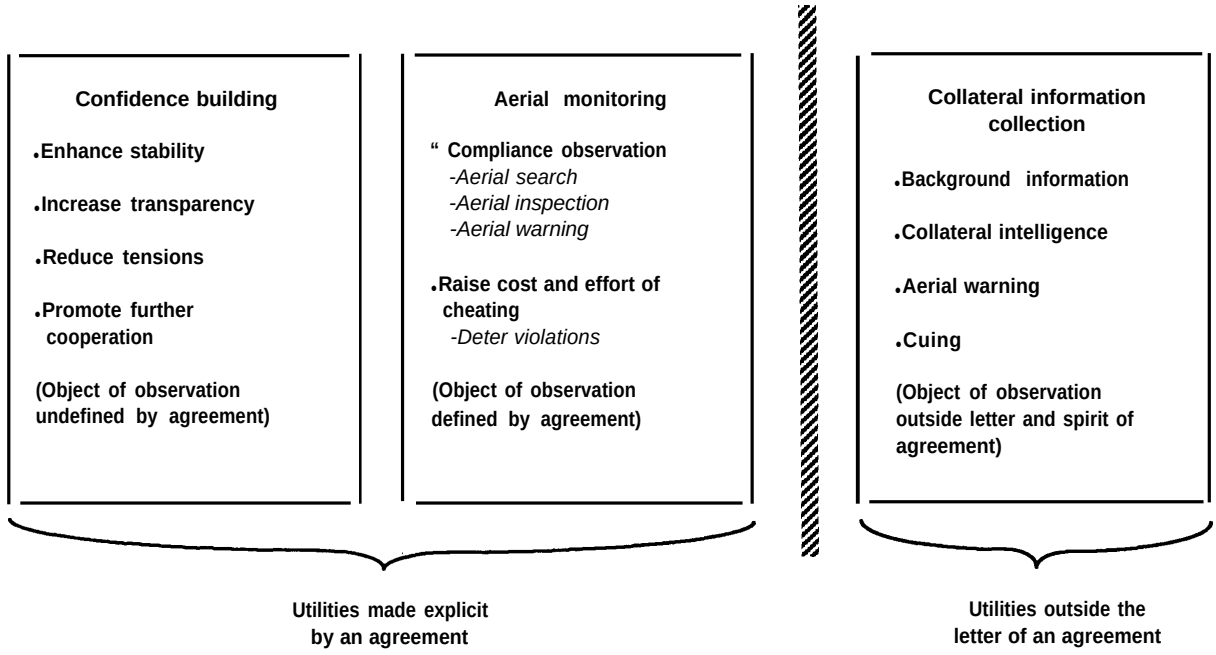
"Aerial monitoring," as distinct from confidence building, is the process of observing from the air specific objects, sites, or activities (described by the movement of discrete objects). The objects and activities may be declared with their locations known (e.g., a production plant), or they may be mobile and difficult to see. Aerial monitoring flights are likely to be included in arms control agreements to search for, inspect for, raise the cost of, deter, detect, or warn of compliance violations as well as to provide information that might assist other means of monitoring, but flights can also be used to monitor civil agreements (e.g., pollution levels).

Overflights could also be used to gather information beyond the letter and spirit of an agreement. Indeed, the gathering of some such information would be hard to avoid. The use of this collateral information could support the stated goals of the agreement, or it could serve other intelligence purposes, e.g., strategic assessments, targeting, and general warning. Because of fears of spying, negotiators may seek to limit the gathering of collateral information to an absolute minimum by placing restrictions on overflights and the equipment carried aboard.

There are only two instances in which the utility of the overflights and the purposes of an agreement might coincide completely, but these are extreme cases that will not likely form the basis for a negotiable agreement. First and most simply, parties to the agreement could recognize and legitimate the broad capabilities of aerial surveillance. The parties could then gather as much information as the negotiated sensors would allow. By definition, there would be no collateral information to gather, since all information would be fair game. At the other extreme, exceptionally tight controls could be placed on the inspection team, aircraft, sensors, and data to ensure that only information related to the agreement would be gathered and processed.

[5]Military and intelligence flights over or parallel to the borders of a noncooperative nation are not included in this discussion.

Figure 2-l—Utilities of Cooperative Aerial Surveillance



SOURCE: Office of Technology Assessment, 1991.

Negotiators are unlikely to agree to these two extreme cases. They are more likely to pursue restrictions on both the methods of information collection and the type of information collected. Parties will negotiate a middle ground, trading some benefits of confidence building or monitoring for some losses of collateral information. Striking this balance is perhaps the most difficult challenge facing overflight regime designers.

Confidence Building

The role of aerial surveillance in confidence building is epitomized in the current negotiations over an Open Skies Treaty. The stated goal of Open Skies is primarily confidence building. The framers of *this* treaty do not envision it as an arms control agreement that uses aerial surveillance to monitor limits on military hardware or activities. Instead, they have argued simply for greater international openness on the grounds that transparency leads to enhanced stability and predictability, reduced tensions, and international cooperation, and lays the foundation for future, more specific arms control measures.[6]

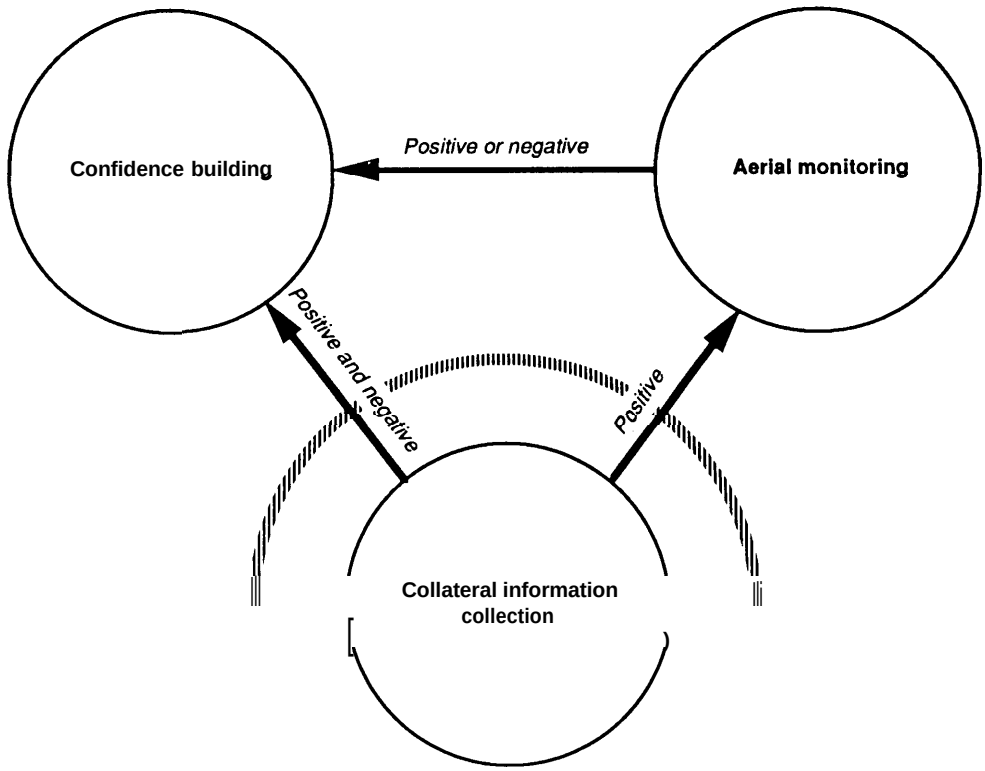
The potential for aerial surveillance to gather information about the inspected party is great. To the extent that this information corroborates positive declarations and policies or deters undesirable behavior, the agreement can be said to enhance stability, reduce tensions, and thus build general confidence. To the degree that this information would be able to reveal in a timely fashion duplicity or bad faith, should such occur, confidence is built in the agreement itself.[7] Ironically, if such duplicity is discovered, it would, at least temporarily, exacerbate instability and tensions. (See figure 2-2.)

The confidence-building aspect of aerial surveillance is also reflected symbolically in nations pursuing common goals, in multinational inspection teams (possibly dominated by military personnel)

[6]The Open Skies negotiating partners released a joint communique on Feb. 13, 1990 stating that Open Skies overflights "would contribute to the process of arms reduction agreements and existing observation capabilities." However, the parties have not as yet specified any agreements that Open Skies will support. This differs from an agreement like CFE that includes limited helicopter surveys of inspection sites or the CFE follow-on treaty (dubbed "CFE LA") currently being negotiated that is explicitly designed to provide monitoring of CFE restrictions. Open Skies is discussed in ch. 4; CFE and CFE IA are discussed in ch. 5. (" 'Open Skies' Communique," *Official Text,* U.S. Arms Control and Disarmament Agency, Feb. 13, 1990.)

[7]The detection of cheating does not necessarily mean that a treaty is flawed. It maybe that this level of activity would not have been detectable without the monitoring provisiona of the treaty. The cheating does, however, require some appropriate response including possibly the abrogation of the treaty.

Figure 2-2—interaction of Utilities



SOURCE: Office of Technology Assessment, 1991.

working side-by-side, and in laying groundwork for more ambitious cooperative efforts.

Confidence building is likely to be a part-either as a primary goal or as a side benefit--of all potential agreements that include provisions for cooperative aerial surveillance. For example, mutual aerial surveillance of nuclear reactors to ensure their safe operation might have the specific utility of measuring reactor radiation levels, but they might also foster a cooperative atmosphere. The only instances where confidence might be undermined by overflights of countries following both the spirit and the letter of an agreement (i.e., compliant countries) would occur when a signatory has underestimated the potential of overflights to be used against it for gathering collateral information (see below).

Aerial Monitoring

Aerial monitoring is the process of observing from the air objects, sites, or activities (described by the movement of discrete objects) that have been specifically designated in an agreement. Because the subject of observation is explicitly defined (e.g., a tank, a chemical plant, a combined-arms exercise), negotiations over airborne platforms and sensors can be based to a larger degree on objective criteria. For example, an agreement that seeks to count individual tanks must provide for sensors that at a minimum can distinguish a tank from an automobile. In general, aerial monitoring regimes can be subjected to quantitative analyses (e.g., the number of flights needed to search a given area, the minimum requirements for a sensor suite) more readily than overflights intended only to build confidence. Theoretically, this should make negotiations somewhat clearer.

Parties to an agreement with provisions that require verification could employ aerial monitoring for purposes of search, inspection, or warning. Aerial monitoring could also, by its very presence, raise the expense of, and possibly deter, cheating.

Photo credit: U.S. Department of Defense, On-Site Inspection Agency

Working side-by-side, inspectors and their escorts sometimes develop a better understanding of their former adversaries and perhaps even mutual respect. Here, the Soviet inspection team chief and his American escort counterpart sign the official report that marks the completion on an Intermediate-Range Nuclear Forces Treaty inspection.

Compliance Observability

An agreement that includes numerical limits, bans, or restrictions on actual weapons, equipment, facilities, or activities may permit aerial monitoring to observe compliance. Compliance observability is most often discussed in the context of arms control agreements. However, there are many potential applications for aerial monitoring where it might be desirable to observe activities or objects that have little or nothing to do with traditional arms control (e.g., peacekeeping or pollution monitoring).

Aerial monitoring, as used in this report, encompasses the narrower terms: "aerial search," "aerial inspection, ' and "aerial warning. ' Aerial search refers to overflights that survey wide areas to detect and determine the legitimacy of specfied objects or activities. Aerial inspection differs from aerial searches only in that it focuses on objects or activities at specific sites. Aerial warning ***also*** involves the observation of specific activities, objects, or sites, but with the intent to warn of threatening acts. These distinctions are artificial and partially overlap, but they are a useful tool in clarifying the discussion.

Aerial Search[8]—Aerial searches are intended to survey wide areas in order to provide information that will assist policymakers in making a determination of compliance with an agreement. These searches have two aspects: one is to locate and document legal objects and activities; the other is to detect objects or activities that violate an agreement. For example, an agreement might allow a certain number of objects, which aerial search could help count. If the objects were entire facilities (e.g., Intercontinental Ballistic Missile (ICBM) silos or chemical plants) or large-scale activities (e.g., division-sized exercises), this might be a relatively straightforward

[8]See ch. 6, which builds an analytical framework for examining the effectiveness of serial search.

mission. Smaller and relocatable treaty-limited items (TLIs), e.g., cruise missiles, would add more difficulties.[9] If monitoring is possible at all from the air, it might be facilitated by focusing on chokepoints that the TLI must pass through (e.g., a final assembly plant, abridge, or a railroad junction), or by remotely reading active tags on the TLI.[10]

The second aspect of compliance observability is to ensure that the observed party is not significantly violating the provisions of an accord through the possession of prohibited items or the conduct of restricted activities. As above, the size and mobility of the TLIs in question is often important. Most troublesome are small and mobile TLIs that can be concealed or moved before an overflight. Under a plan suggested by North Atlantic Treaty Organization (NATO) for Open Skies, the amount of time an illegal TLI would have available to hide would be 46 hours plus the time to fly to the TLI if concealment began at the time of flight notification, or 24 hours plus the time to fly to the TLI if this concealment began with the filing of the flight plan. (See discussion inch. 4.) Clearly, this would an ineffective interval for detecting easily hidden, illegal TLIs. Thus, negotiators must take such timelines into account when deciding to include an aerial surveillance option and adjusting it to fit the TLI under observation. The interval must be short enough to detect cheating or at least to flush the TLI into the open for detection by other means.[11]

For some classes of objects or activities, signatures other than size are most important for violation detection. For example, a plant releasing restricted pollutants might be detectable not so much by its dimensions, but rather by its effluents. Air samplers on aircraft might be able to detect these emissions or their residue if the time it takes for the aircraft to arrive is less than the time for the emissions to dissipate after the violator shuts down operations.

Even if aerial searches are unable to provide concrete evidence of violations, they might collect useful information that could be used to plan ground inspections. (For more on the interaction of OSI and aerial surveillance, see below.)

Photo credit: U.S. Central Intelligence Agency

In the 1962 Cuban missile crisis, military reconnaissance aircraft were used to search for and document Soviet medium-range nuclear missile emplacements. This photograph of a missile preparation area was taken at an altitude of about 250 feet, and at the speed of sound.

Aerial Inspection-Potential aerial inspections differ from aerial searches in that they seek to monitor compliance at known (and often treaty-designated) locations. Some aerial inspections might closely resemble a search, only over a smaller region. For example, photographs taken by the inspection team from a helicopter might be used to look for illicit TLIs within the grounds of a restricted deployment area. However, other types of aerial inspection might be very different. Among other things, they might be used to:

- establish baseline TLI counts and documentation;
- conduct preparatory work for OSIs by developing site maps and pinpointing the most promising search strategy;[12]

[9] See ch. 6 for a quantitative discussion of the challenge of searching for such TLIs from the air.

[10] See box 2-C.

[11] Safety and logistical reasons will limit the reduction of this interval, as may security concerns.

[12] Amy Smithson and Michael Krepon, "Strengthening the Chemical Weapons Convention Through Aerial Monitoring," Occasional Paper No. 4, The Henry L. Stimson Center, Washington.L DC, April 1991, pp. 14, 17-23.

- document the elimination of large TLIs and monitor their status;[13]
- monitor the status of closed-out facilities and bases; or
- monitor the perimeter around a facility before an OSI team can arrive.

Aerial Warning—Besides monitoring the number or existence of certain objects and activities, aerial monitoring might be written into an agreement to provide warning of hostile acts. This warning might be the product of discovering too many objects, too much activity, or the presence of objects and activity at restricted sites; or conversely, the absence of legitimate objects or activities from designated areas with the implication that they might be somewhere more threatening. Functionally similar to aerial searches or aerial inspections, aerial warning flights could observe compliance with military exclusion zones, border restrictions, or military exercise limitations. Unlike confidence-building flights, warning flights would be explicitly tailored to sense a specific set of objects or activities (defined by objects). (See ch. 5 for some current and potential examples of aerial warning.)

One of the chief concerns of any party to a militarily significant agreement, and the predominant reason for its monitoring regime, is the threat of a dramatic breakout from the terms of an agreement by another party. Breakout can be defined as a violation of an accord so rapid as to confer a militarily significant advantage before the other side(s) has time to react. No agreement can prevent a party from attempting a breakout; however, a good monitoring regime and effective intelligence could make successful breakout impossible by being able to detect the intended action with sufficient time to respond, thus providing strategic warning.[14] (Responses could be diplomatic, economic, or military; and reciprocal or asymmetric.[15])

Make Cheating More Difficult and Expensive

A side benefit of being able to observe compliance from an aircraft is that any attempt by a country to cheat on an agreement, even if the violation is not in the end detected, is necessarily more difficult and expensive than if overflights were not permitted. This is because the violator must expend some effort to avoid detection. If the agreement were poorly formulated or if the sensors carried aboard the aircraft were inadequate, this effort might be minimal (e.g., raising a camouflage net).[16] However, if the agreement were designed with potential evasion paths in mind, the difficulty and expense of cheating might be raised to some deterrent level (e.g., by forcing the violator to avoid a TLI's legal manufacturing, testing, and support infrastructure, and to build an entire covert one). The idea is to make the anticipated gain of cheating not worth the effort (see box 2-A). Note that an agreement that does not restrict or allow the inspection of sensors has the greatest deterrent potential since the overflown country can only guess at the capabilities onboard and would probably be inclined to make a conservative estimate.[17]

Collateral Information Collection

Another utility of overflights is the gathering of information not specifically mandated by an accord (what the Soviets have sometimes labeled spying) .18 This collection is very hard for both the host country and the observers to limit. For example, a flight looking for a missile silo may take hundreds of square miles' worth of photographs for every hundred square feet of silo. Similarly, an air sampling spectrometer may reveal more compounds than just the ones subject to the accord. At a minimum, the inspectors aboard a plane must be allowed to confirm visually that the plane is following its

[13]For example, under the SALT II Treaty, retired bombers were cut up and placed out in the open so that NTM satellites could verify their elimination.

[14]The national intelligence community would have responsibility for detecting militarily significant developments with or without a treaty.

[15]Reciprocal responses sometimes have the negative quality of allowing the violator to control the arena of competition. For example, if a party with adominant air force violates a conventional arms accord by building extra attack aircraft, it might make more sense for a less sophisticated cosignatory to buildup antiaircraft batteries, rather than build a like number of relatively inferior planes.

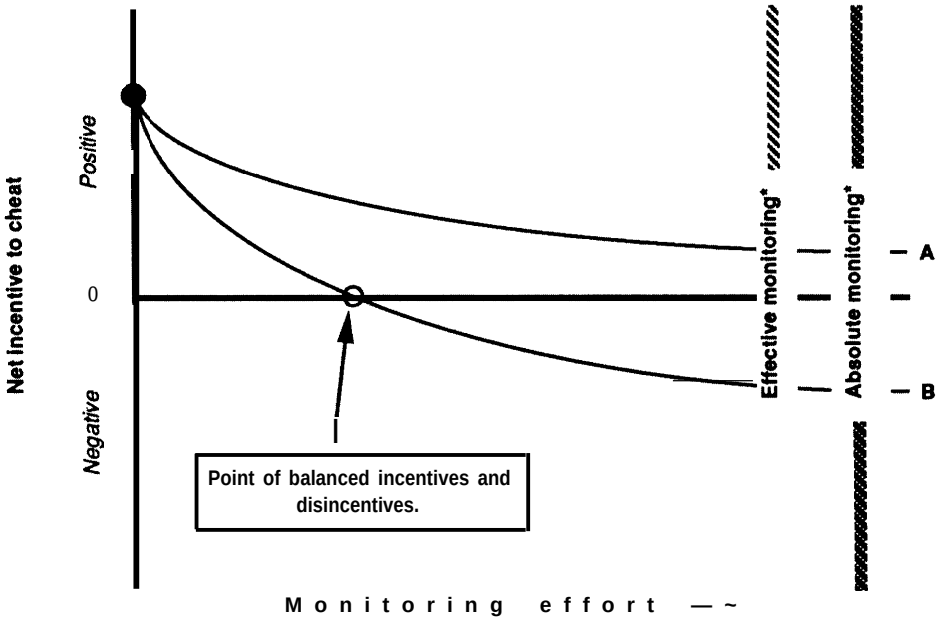
[16]Of course, if compliance were not observable from the air, Overflights would have no deterrent value, and m@ in fact act to make the overflying nation unjustifiably confident.

[17]If a country did not make an accurate estimate and chose to cheat, its violation would likely be detected. (See Smithson and Krepon, Op. Cit., footnote 12, p. 4.)

[18]The Office of Technology Assessment does not endorse the collection of collateral information, but presents it as an important factor in determining the risks and benefits of aerial surveillance.

Box 2-A—Balancing Monitoring and Incentives To Cheat

The conceptual graph below depicts two general cases of how the balance of incentives might be related to the monitoring provisions of an agreement. The curves generated by the examination of a real treaty are bound to be much more complex, with many nuances and ambiguities.



***Effective or absolute monitoring may not be possible for all agreements.**

SOURCE: Office of Technology Assessment, 1991.

The characteristics of the objector activity to be monitored and how they fit into the monitored country's security arrangements, as well as the propensity of the country toward cheating, provide the starting point on this graph. This point is the net incentive to cheat on the agreement in the absence of all monitoring. In this graph, the more interesting example of a positive net incentive without monitoring is described, but for some violations there may be no incentive to cheat at all.[1]

Curve A depicts the case where no amount of monitoring will lower the net incentive to cheat to zero. This might occur when violations are too easily hidden to monitor effectively, when the positive incentives to cheat are extraordinarily high, or when the cost of getting caught is comparatively low. Even if effective monitoring (defined as monitoring that detects any significant violation in time to respond) or absolute monitoring (defined as monitoring that detects all cheating) are possible--and not all potential agreements can be effectively monitored, the positive incentives to cheat continue to outweigh the disincentives.[2] In this case, the best that can be hoped for is an agreement that provides, at a minimum, an effective monitoring effort.

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[1]If the monitored country imputes no value to the treaty, then this point would equal the net incentive to engage in the restricted activity (e.g., build another bomber) without the agreement. However, if the country values the agreement on its own merits, then the country will have a lower incentive to engage in the restricted activity than it did without the agreement. In some cases, the legal and moral imperative of the treaty itself may be enough to lower the incentive to cheat below zero. On the other hand, the existence of an agreement might actually raise the net incentive to cheat above the preagreement level if mutual restrictions opened new opportunities for gaining strategic advantages. For example, building another bomber might make little sense if the other side were doing the same; however, an advantage might be gained by building that same bomber if the other side were abiding by an agreement not to do so.

[2]This graph also illustrates how the monitoring party might unwisely squander limited monitoring resources by paying for monitoring beyond what is required for deterrence, or effective or absolute monitoring.

Curve B illustrates the case where some amount of monitoring lowers the incentive to cheat past the level of indifference (i.e., the zero line where incentives and disincentives are balanced) until the costs and difficulties of cheating offset the expected benefits. It is in this region below the indifference line where deterrence operates. An agreement might be considered to have sufficient monitoring if the net incentive to cheat could be forced into this negative region, regardless of whether or not the monitoring regime was deemed "effective" or "absolute."

Of course, the real world is more complicated than this. The incentive structure of the monitored party and how it varies with increasing monitoring is hard for the monitoring party to gauge. Because of this element of uncertainty, a real graph would be less well defined and the monitoring party would want the disincentives to cheating to fall well below the line of indifference, rather than just across it. Moreover, the monitoring party must be prepared for sudden shifts in the incentive structure--shifts that would void the deterrent value of monitoring.

proper path and not being flown off course by its host country pilots, should they be piloting.[19]

The definition of what constitutes collateral information in an aerial monitoring regime is relatively simple since the objects of observation (e.g., tanks, bombers, military exercises) are stated in the agreement text. Any information gathered that does not specifically conform to the letter and spirit of the text is collateral. In the case of confidence-building regimes, however, this distinction is less clear since the object of observation is undefined. Yet, there will likely remain some degree of consensus—reflected in the selection of airborne platform, sensors, and operational procedures-as to what is expected of the confidence-building overflights and what behavior violates the spirit of the agreement.

For the country conducting a cooperative overflight, collateral information can be a side benefit (obtained passively or actively) of an agreement, providing background information on the agreement, collateral intelligence, warning, or cuing. For the side being overflown, collateral information may be going to a country that may not have the overflown country's best interests at heart. Of course, cooperative aerial surveillance is likely to be reciprocal, so each country will both enjoy the benefits and suffer the loss of collateral information.

Negotiated constraints could limit the compromise of this type of information. These include:

- closing sensitive airspace to overflights;
- permitting flights only at night or at high altitudes;
- restricting sensor and data storage capabilities;
- disallowing storage of data (all monitoring would have to be done by an inspector in real time);
- passing collected information (raw data) through host country preprocessing;[20] and
- employing only UAVs.[21]

Moreover, not all of this information is equally valuable (to the inspecting party or the host country). Each party must weigh its potential informational losses against the gains of the accord and the gains from conducting its own overflights.[22]

Background Information

Background information is that acquired beyond the specific mandate of the agreement, but still useful for achieving its goals. For example, a treaty may call exclusively for the aerial counting of a hypothetical TLI. During the overflight, sensors image the sole production facility for the TLI. Using photogrammetric techniques, the volume of the facility is measured and combined with other clues (e.g., on-hand supplies and storage areas) to estimate its production potential. If this potential correlates with the legal number of TLIs, confidence in the treaty is enhanced; if the figures do not correspond, and there appears to be excess capacity, then the inspecting party would be alerted to the possible presence of covert TLIs.

[19]Technically, this could be confirmed by navigation equipment alone (as might be necessary at night). However, if the level of animosity is high (and thus the stakes as well), the observers may want to see for themselves that the aircraft is on course.

[20]Preprocessing might involve the manual expurgation or computer filtration of all material not deemed necessary for the purposes of the agreement.

[21]UAVs are discussed in more detail in ch. 3.

[22]Because the Soviet Union and the United States already enjoy advantages provided by NTM, their informational gains will be relatively small compared to those of other, less advanced countries. (The French SPOT-Image multispectral remote-sensing satellite produces relatively low resolution imagery for international sale.)

Collateral Intelligence

Information collected that is not related to an agreement, but instead covers the gamut of social, economic, political, and military targets is collateral intelligence.[23] This information ranges from the trivial to the vital. Collateral intelligence can provide a clear view of a previously obscure fact or confirm other, unverified facts. One example of collateral intelligence is the collection of imagery of agricultural areas to get a better understanding of annual crop yields and potential shortages. Another example would be photographs of a piece of sensitive military hardware.

Also in the class of collateral intelligence would be all information gained from training sensors on parties not subject to an overflight agreement when flying near their border or during transit over their territory to or from a host country. Transit flights would probably be restricted to commercial air corridors.[24]

Through the collection of intelligence, a nation refines its strategic assessment of another country and acquires a better understanding of the threat it may pose.[25] It is in the national security interest of each country to know the most it can about the others. The paradox is, however, that it is not always in each country's national security interest to share like information about themselves with others. Certainly, the United States has all sorts of sensitive facilities it might not like the Soviets to fly over. On the other hand, U.S. analysts would like to get a peek at comparable Soviet sites.

The conflict between a desire to maximize the intrusiveness of overflights over other countries and the need to minimize this same intrusiveness over one's own country is central to aerial surveillance negotiations. Increased transparency may not always build confidence and good relations. There are two levels of transparency: the macro and the micro. At the macro level, information on force structures, military readiness, and operational practices can indeed add confidence that one power does not pose an immediate threat and perhaps has adopted a more defensive posture (e.g., moving troops away from the border). However, at a lower, micro level, little additional confidence is won by granting more information (e.g., a weapon's design), and perhaps something important is lost to potential adversaries (e.g., knowledge of a weapon's vulnerabilities).

In negotiating an overflight regime, the issue of what the agreement will cost in terms of information lost must be weighed against the benefits.

Aerial Warning

Unlike the other categories of information collection, aerial warning might actually be a specified and negotiated utility of an overflight regime (see above). However, even if aerial warning is not an intended utility, aerial reconnaissance over militarily significant areas might provide warning at the tactical or strategic level.[26]

Aerial surveillance could add to a monitoring regime's ability to reveal a breakout attempt by providing treaty-mandated information and collateral information, which could be synthesized and combined with other sources of information.[27]

Similarly, militarily significant developments that may or may not be restricted by another treaty might also be revealed by overflights negotiated for some unrelated function. For example, aircraft monitoring air pollution levels over large cities might detect the

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[23] Note that what is defined as "collateral intelligence" and what is "background information" is based explicitly and implicitly On the wording Of an agreement.

[24] This report does not address the illegal collection of intelligence except to mention that preflight inspections may be necessary to uncover illegal sensors secreted among the legitimate sensors. Illegal efforts could include covert sensors and intentional diversions from an agreed flight profile (e.g., dipping below minimum altitude to enhance sensor resolution beyond legal limits or changing course to document some event off the flight path). The collection of collateral information differs from the illegal collection of intelligence in that collateral information is collected as a byproduct of the overflights and does not violate any law.

[25] The discussion here of information gathering, particularly of collateral intelligence, parallels that developed earlier on confidence building. The difference is that background information% collateral intelligence, warning, and cuing, as defined in this report, are collected outside the provisions and spirit of an accord, while the information gathered for confidence building is countenanced by an accord. The same information might be labeled as confidence building in one regime and collateral information in another.

[26] The U.S. Defense Department defines tactical warning as "a warning after initiation of a threatening or hostile act based on an evaluation Of information from all available sources" and strategic warning as "a warning prior to the initiation of a threatening act." (U.S. Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms,* Joint Pub. 1-02, Dec. 1, 1989, pp. *350, 363.)*

[27] In turn this interaction of information would lead t. a more efficient use of available monitoring resources. See ch. 6 for a discussion of how prior information can be used to enhance the utility of overflights.

movement of large military formations toward a border.

Overflights might also indirectly indicate the possibility of threatening activities. This would be the case if a party suddenly began to refuse overflights of certain areas or over its territory as a whole. Refusals would alert the observing party to possible mischief, compel it to focus other assets more intently, and, if no satisfactory resolution to the problem is found, respond as if militarily significant activities were occurring.

Furthermore, the inspecting party might use aerial surveillance to disrupt or delay an impending breakout by requesting overflights of critical areas (e.g., forward staging areas for conventional forces) and forcing the host country to conceal this hardware or activity (potentially throwing off its entire breakout schedule), or to expose it prematurely, thus giving the inspecting party time to react.[28]

Cuing[29]

As with collateral intelligence gathering, the potential role for aerial surveillance in cuing or targeting is controversial. It is arguable that using overflights to direct other systems may go against the spirit of an accord; but some types of cuing can reinforce the main goals of an agreement. This is the case when overflights uncover ambiguous activities or objects that are beyond the airborne sensors' ability to resolve. If the inspecting country did not have any other way of determiningg the legitimacy of its discovery, the result might be unfounded recriminations or an unanswered threat, thus raising tensions or danger. However, if the location of the discovery could be passed on to human inspectors or NTM, the ambiguity might be easily resolved.

But cuing can also be used in a way that is obviously antithetical to the spirit of most agreements: the same information that can localize an ambiguity for further observation may also be used to target the items being observed (or others not related to an accord) for military attack or covert operations. Target information can be specific, e.g., coordinates of a fixed site; or it can be general, e.g., the operational behavior of mobile systems or groups of forces. Aerial surveillance could also be used to provide accurate tactical maps for military or other purposes. These are further examples of how transparency may not be a wholly beneficial objective.

Aerial Surveillance and Other Means of Observation

The utility of aerial surveillance to gather information in support of an agreement is not unique. Many of its features are shared with NTM and OSI. The selection of which monitoring systems to use, and in what combinations, will be determined by the negotiating parties based on the ability of each measure to detect the desired signatures, the synergistic effects of different sensors, the degree of cooperation possible between parties, the capabilities and capacity of NTM, the political advantages of open cooperation, the intrusiveness of the measure, and financial costs.[30]

Aerial Surveillance and NTM

There is considerable overlap in the potential roles of aerial surveillance and NTM. Both kinds of systems can take imagery from overhead and over wide areas. However, while aerial surveillance as described here is cooperative, NTM is generally unilateral or alliance-based. Cooperative measures can be (and have been) negotiated to enhance NTM capabilities, but the sensors and platforms themselves can operate independently of any agreement.

Among the potential advantages that aerial surveillance holds over at least some NTM assets are greater flexibility, possible real-time physical access to the sensors, direct cooperation between parties,[31] and relative political and technological insensitivity.

An aerial surveillance regime could be negotiated to be more flexible than some NTM, varying flight

[28]For one application of this idea, see James R. Blaker, "On-Site Inspections: The Military Significance of an Arms Control Proposal," *Survival*, vol. *26*, May/June *1984*, pp. *98-106*.

[29]See ch. 6 for a discussion of the value of prior information.

[30]The relative financial costs of aerial surveillance, OSI, and NTM depend heavily on the specific details of a prospective agreement, as well as on the overlap of this agreement with other agreements and national security requirements. This report briefly examines the relative costs of NTM and aerial surveillance for synoptic search inch. 6, box 6-H.

[31]The limited cooperation between the United States and the Soviet Union on NTM has been confined to facilitating the observation of TLIs through movement freezes, nonconcealment, deliberate exposure, and noninterference.

profiles by timing, ground track, and altitude.[32] As a recent report to the U.S. Defense Department stated,

> The existence and utility of reconnaissance satellites is accepted by both sides. Satellite orbits are highly predictable. It is taken as a given by each side that the other will refrain from some activities, which would otherwise be observable, during a satellite pass--once or a few times per day, say for a total of 20 minutes. The long advance predictability of reconnaissance coverage makes it possible to hide, by careful advance scheduling, even very large and elaborate activities. Each side might worry, in the extreme case, that preparations for war or treaty breakout could be thus hidden.[33]

With a sufficiently narrow preflight notification period making it impossible to conceal a violation of an agreement before a plane might arrive, aerial surveillance might be able to plug gaps in NTM coverage. Airborne platforms might have the flexibility to adjust their flight profiles to optimize sun and sensor look angles, and to change altitude to maximize a sensor's resolution or field of view.[34] Aircraft might also be permitted to fly under cloud cover or loiter over areas of interest.

In addition, overflights could have the advantage, if negotiated, of real-time interaction between the sensors and the inspectors. An inspector manning a sensing device on a plane could maintain, free-tune, retarget, or change the focal length of the instrument if something interesting caught his or her attention.[35] The inspector could also mark and annotate important sightings to facilitate postflight analysis.[36]

And as mentioned above, because observers are in constant contact with host country escorts, a cooperative atmosphere can be nurtured that is wholly missing from NTM.[37] The confidence that arises from this may lay the foundation for more significant accords. And denial of requested flights could signal a less cooperative relationship, heightening vigilance by other means.

Lastly and perhaps most importantly, information collected by an overt airborne sensor—particularly if parties inspect or share sensors--could more easily be released publicly to confirm compliance, build general confidence, or support charges of noncompliance. Direct release of NTM data is contrary to government policy and is done so only in the most extreme cases. Even in these cases, the evidence of violation displayed is likely to be degraded to avoid giving away information about which system uncovered the violation and how advanced the NTM sensors really are.

The primary advantage of NTM assets is that they are largely independent of political events and negotiations. If an important agreement is abrogated or if surveillance flights are refused, aerial surveillance could leave a country blind to critical developments. NTM would remain unaffected, because it does not usually depend on the cooperation of the country under observation.[38] NTM employment is also not constrained by sensor-limiting compromises, formal notifications, or flight plans. A second advantage of NTM assets is that they can monitor more than one agreement at a time.

Of course, the choice for the United States and the Soviet Union probably will not be between aerial observation and NTM. The questions are more likely to be: what can aerial observation add to current NTM and how can they interact effectively? According to the NATO Open Skies proposal, aerial surveillance is supposed to "complement" NTM.[39]

Besides filling gaps in NTM coverage and capabilities, overflights might be used to cue NTM to particularly interesting sites and to clarify ambiguous NTM information.[40] Overflights or their notification might also be designed to trigger activity that

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[32] On the other ~@ negotiators @@ agree to limitations and restrictions on overflights that would make them relatively less flexible.

[33] S. Drell et al., Verification Technology: *Unclassified Version,* JASON Report, r89-100-11, The MITRE Corp., McLean, VA, Mar. 7,1990, p. 131.

[34] "Open Skies Aircraft: A Review of Sensor Suite Considerations," The MITRE Corp., Bedford, MA, unpublished manuscript.

[35] Ibid.

[36] On the other hand, escorts would be looking over the inspector's shoulder and could thus get an idea of what the inspector thought important. This information could be useful in refining concealment techniques.

[37] @ the other hand, close contact has the potential for_ into friction should relations take a turn for the worse.

[38] As mentioned above, the United States and the Soviet Union have negotiated some cooperative measures that assist NTM.

[39] See app. D.

[40] See ch. 6.

Box 2-B—Aerial Surveillance for Countries Without Advanced NTM

Until fairly recently, countries with little or no NTM have had to rely on the generosity of the superpowers for a detailed view of the world, including information about the compliance of their neighbors with international agreements. The superpowers' monopoly on advanced NTM limited the quality, quantity, and timeliness of NTM information available to third parties. Yet increasingly, countries have other options: participation in consortia to develop independent NTM or the purchase of commercial imagery from other countries. France, Italy, and Spain are investing in the Helios military reconnaissance satellite system to be operational in early 1994. The United States, France, and the Soviet Union sell relatively low-grade satellite imagery. In the future, international organizations might pool national resources to deploy reconnaissance satellites to monitor agreements or increase global transparency.

Cooperative aerial surveillance might also be used to fulfill the informational need of some countries. With the negotiation of mutual overflights, these countries would at last obtain an independent source of compliance observation and confidence building. If the cost of an aerial surveillance regime remained beyond their reach, they might spread the cost among like-minded countries by maintaining a fleet of common aircraft or by promoting aerial surveillance by international organizations. If they are willing to negotiate the use of an advanced airborne sensor suite, they might even eventually narrow the current informational gap between themselves and the superpowers. This capability will still be limited to overflights of participating states, so participants would still lack the NTM owners' ability to monitor the territory of potential adversaries without their consent.

Granting foreign countries the right to overfly U.S. territory has important implications for the U.S. Government. Such overflights will, to a certain extent, level the informational balance between these countries and the United States, ending an American advantage over all countries except the Soviet Union. How important this leveling is must be determined by U.S. policymakers. It may be the necessary price to get other countries to sign onto important treaties that had traditionally been left to the superpowers to verify. It may also be the price of a more open world. (See table 4-2 in chapter 4 for a listing of the asymmetric advantages and disadvantages of countries negotiating Open Skies.)

would be detectable by NTM. For example, NTM might be able to spot a large mobile TLI-during its transit from an area to be overflown to shelter elsewhere. In some areas, aerial surveillance might even be used to free up NTM assets for other targets. (See box 2-B.)

Aerial Surveillance and OSI [41]

Unlike NTM or aerial surveillance, an OSI is an inherently close-up, but local, affair. OSIs, like aerial surveillance, are also cooperative measures, requiring the consent of the inspected state. On-site inspectors can go places and do things that would be impossible for other monitoring systems. For example, only an OSI can take radiation measurements of a warhead from close enough to negate concerns over shielding; only an OSI can examine the interior of a closed-out production facility. Yet on-site inspectors are limited in the territory they can cover during a given inspection. A similarity between aerial surveillance and OSI, not shared with NTM, is that they both take place inside the earth's atmosphere and thus can both take part in air sampling. All forms of monitoring, with the right technology, could take pictures and read identifying tags on TLIs.

It is in the areas where aerial surveillance and OSI are dissimilar that they may work best interactively. At a minimum, OSI can cover the declared inspection sites, while aerial surveillance flights (and NTM) survey the potentially vast territory not subject to inspection. If ambiguous or suspicious activities or objects are detected during these flights, an inspection team might be sent to visit the site, perhaps while the aircraft loiters overhead.[42] A broad aerial search could trigger a more time-consuming, but more precise, inspection. Conversely, overflights might be used to examine several inspectable sites at a time, both to prioritize subse-

[41]For a discussion of on-site inspection types, benefits, and costs, see U.S. Congress, Office of Technology Assessment-i *Verification* Technologies: *Measures for Monitoring Compliance With the START Treaty—Summary*, OTA-ISC-479 (Washington, DC: U. S.Government Printing Office, December 1990).

[42]This is provided that the sit, is on a negotiated list of inspectable sites or the treaty allows for suspect-site or invitational inspections.

Box 2-C—Reading Tags From Aircraft

Tags on treaty-limited items (TLIs) have been suggested as a method for identifying and counting legal TLIs and for making it more difficult for a potential treaty violator to intersperse illegal TLIs among legal TLIs.[1] Tags that might be read from an aircraft are of three basic types: 1) self-powered tags that send a signal to a receiver on the aircraft; 2) tags that are powered by an interrogation signal from the aircraft and respond; and 3) tags that are powered by the host country at the time of overflight.

Reading tags remotely has been a controversial issue, because of a fear that the tag could be used to militarily target the tagged TLI in a crisis. Although it might be possible to design a tag incapable of being used for this purpose, the somewhat irrational fear of compromising legal TLIs remains, making negotiations difficult

The first and second types of tag bring out targeting concerns the most often. It is argued that during a crisis these tags could be read (either by a direct signal[2] or an illumination-induced signal) and their corresponding TLI targeted. One relatively simple solution would be to provide each local commander with a hammer to destroy the tags early in a crisis. However, while this solution may lower the potential for direct targeting, it does not address the possibility that operational analysis of the tagged TLIs' positions would, over time, provide general targeting information and movement predictability.[3]

The potential for targeting TLI through the operational analysis of tag reading data also applies to tags that are incapable of transmitting without an attached power source under the control of the host country. However, these tags leave less room for misuse of the tags. They could not be covertly interrogated for position information. With this third type of remote tag, when an overflight begins, the host country activates all of its tags so that they can be read from the plane. TLIs not transmitting or responding with invalid information would be considered violations, After the exercise the power supplies would be switched off.

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[1]This task can be particularly important if look-alike objects are both covered by a treaty and also outside its jurisdiction. For example, the Conventional Armed Forces in Europe Treaty does not cover Soviet naval equipment that is physically indistinguishable from its army counterpart which is restricted.

[2]Some argue that the signal power of an active tag could be set low enough so that only planes at very low altitude (and thus only cooperatively) could read them. However, the example of the extremely low-powered Voyager II spacecraft transmissions being picked up at interplanetary distances casts doubt in some minds about the electiveness of such power restrictions. Another suggestion is that infrared tags be used which could be shielded against pulsed infrared detection. Likewise, some shielding might be made for the other types of tags as well. Three suggestions are really variations of the third category of tags: those that can essentially be turned off except during overflights.

[3]This is true for any monitoring mechanism that examines deployed TLIs.

quent inspector visits and to avoid using up a ground inspection quota on obviously compliant locations.

Further in the future, over-flights and inspections might be combined in a kind of ''SWAT team' approach. A long-range helicopter loaded with inspectors and escorts would fly over the host country searching for suspect TLIs. Upon seeing a TLI, the helicopter would have the option to land and conduct a ground inspection (e.g., a tag reading). The helicopter would then continue its flight, stopping for further inspections, perhaps according to a set quota. Another unconventional idea would be to have aerostats anchored at perimeter portal monitoring sites as a kind of floating perimeter control.[43] Sensors on the balloon would detect the movement of TLIs into or out of the monitored site.

Aerial surveillance does have some advantages over OSI. Overflights could be used to examine sites considered too militarily sensitive to allow inspections. And because of their ability to cover large amounts of territory quickly, over-flights could be used to read tags remotely on large numbers of far-flung TLIs (see box 2-C).

Overlapping Agreements and Assets

Current international agreements and security concerns already require U.S. surveillance of most of the world's land masses. This surveillance is mainly in the form of NTM, but includes cooperative arrangements such as OSIs. Future agreements will probably mean more intensive and extensive coverage. Examining each prospective agreement separate from others that cover much the same ter-

[43]Radar-equipped aerostats are currently used along the U.S.-Mexican border to monitor the illegal entry Of aircraft into U.S. airspace. Concerns over operations in severe weather would need to be addressed.

Photo credit: U.S. Air Force by M. Sgt. Ken Hammond

Warsaw Pact observers and their NATO hosts disembark from a German Army CH53 helicopter during the 1987 Reforger Exercise held in then-West Germany. In the future, inspection "SWAT" teams might combine the best aspects of aerial surveillance and OSIs.

ritory may result in an inefficient and costly allocation of surveillance assets as well as a duplication of support and organizational resources. This is particularly true for Europe, where a series of overlapping agreements are in force with several others under negotiation. For example, an aerial surveillance agreement covering a small region may be relatively cost-effective when compared to anew photo reconnaissance satellite, but the same satellite might be able to adequately monitor several other treaties as well at a lower net cost.[44] The executive branch and the Congress need to consider how different verification regimes might interact.

Conclusion

Whether an agreement is intended primarily to foster good will, watch over a tense border, prepare for an OSI, or search for illegal weapons, aerial surveillance may be able to play a role. It can be the central mechanism of an accord or one provision among many, performing only those functions it can do most effectively and cheaply. Through the collection of collateral information, it can also lend additional support to treaty monitoring, hone our assessments of our adversaries, and warn of threatening activities. The decision to include provisions for aerial surveillance in an accord should result from an assessment of the suitability of overflights for the task at hand, the unique qualities of the different monitoring options, the potential for synergism with NTM and OSI, and possible interactions with other verification regimes. Finally, the ideal verification package will have to be weighed against financial and intelligence costs, as well as negotiability.

44SW box **6-H in ch.** *6* **for some rough cost estimates.**