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A Cooperative Approach to Military Transparency and Confidence Building

Pál Dunay, Márton Krasznai, Hartwig Spitzer,
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UNIDIR/2004/18

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UNIDIR/2004/18

UNITED NATIONS PUBLICATION
Sales No. GV.E.04.0.18
ISBN 92-9045-164-5

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Cover page: designed by Diego Oyarzún-Reyes (UNCTAD)

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PREFACE

When on 10 February 1990 the first round of negotiations on an Open Skies regime opened in Ottawa it was the last time that the old bipolar order, which dominated Europe for almost 45 years, was represented. The Open Skies conference turned out to be the first step in the historical Two-plus-Four negotiations that led to German reunification, the end of the division of the European continent and of the confrontation between East and West.

The Open Skies Treaty, signed at Helsinki on 24 March 1992 on the occasion of the third follow-up meeting of the Conference for Security and Cooperation in Europe, is the first agreement that fully reflects the changed political conditions in Europe. It gives real meaning to the idea of a new cooperative perception of security and stability in Europe. Conceived as a broad multilateral confidence-building measure in arms control in order to enhance mutual confidence by promoting openness and transparency it revived the idea of mutual aerial observation flights for the purpose of collecting information on military forces, installations and activities. The Treaty introduces, for the first time, a verification process covering the entire territory "from Vancouver to Vladivostok". It is based on the placing of all states on an equal footing, be they large or small. It helped to facilitate the implementation of the 1990 Treaty on Conventional Armed Forces in Europe (CFE) as well as of the Vienna Document on Confidence and Security Building Measures first established in 1992, the cornerstones of Europe's new security architecture.

Almost ten years passed from the Treaty's signing until its entry into force in January 2002. During this time the functioning and practice of the Open Skies regime was tested and refined by a number of bilateral trial observation missions, which helped to establish and to deepen the cooperation between states formerly belonging to opposing military alliances. At the beginning of the 21st century it is time to emphasize the provisions of the Open Skies Treaty that allow to extend the Open Skies regime into additional fields. The Open Skies regime is not only a helpful instrument in facing global challenges such as crisis prevention, post-crisis management, the proliferation of weapons of mass destruction, environmental catastrophes or organized international terrorism—it also could serve as a blueprint in the establishment of cooperative observation regimes in other regions of the world.

This book co-authored by German, Hungarian and US experts is the result of a research project carried out between 1995 and 2000. It is the first publication in the English language that gives a detailed and extensive account of the concept of the Opens Skies regime, its concretization and its prospects. Published right in time to inspire future adaptations of the Open Skies Treaty practice, which will be reviewed in 2005, it helps to understand the Open Skies regime's spirit and shows how to make use of all its provisions in order to make the Treaty an element of a new cooperative world order.

Bonn, 2 June 2003 Hans-Dietrich Genscher

EXECUTIVE SUMMARY

1. The *origins of the idea of Open Skies* date back to the early years of the arms race between the United States and the Soviet Union. In 1955 US President Dwight D. Eisenhower suggested to the Soviet Union aerial photography as a means to create mutual transparency of the weapon arsenals on both sides in order to deter and lift suspicions of surprise attacks. The idea was also conceived as a verification measure to contribute to further disarmament. The proposal was strictly bilateral. It was soon turned down by the Soviet Union (Chapter 1).

2. The Open Skies idea was *introduced again in 1989* by US President George Bush Sr in the final phase of the Cold War. It was an attempt to overcome Cold War suspicion by mutually agreed openness. This time the proposal was for multilateral participation. All member states of NATO and the Warsaw Treaty Organization (WTO) were invited and participated in the negotiations, which began in early 1990. The Treaty was negotiated in parallel with the Treaty on Conventional Forces in Europe (CFE) with the **threefold objective of improving openness and transparency, of supporting the verification of existing of future arms control agreements and of strengthening the capacity for conflict prevention and crisis management** (see the Preamble of the Treaty in Appendix I). The Treaty was finally signed in March 1992 (sections 2.1 and 2.2).

3. The *essence of the Treaty* is the right to observe any point on the territory of the states parties—from Vancouver to Vladivostok. The legitimate interests of the observed state party are taken into account by ensuring that the maximum ground resolution of the sensors to be used allows for the reliable identification of major weapon systems, but not for detailed analysis. The Treaty incorporates several innovations: it has a strong cooperative element, since flight preparation, execution and follow-up as well as aircraft certification are carried out by bilateral or multilateral teams. The imagery taken during observation flights is accessible to all states parties. *Thus the Treaty places all states parties on an equal footing. It prevents a monopoly on information and ensures reciprocity of observation, in stark contrast to monitoring by*

reconnaissance satellites owned and operated by individual states (section 2.3).

4. Initially the Treaty had 26 signatories. By 1995 most member states had completed their *ratification processes* and deposited their instruments of ratification. These were Belgium, Bulgaria, Canada, the Czech Republic, Denmark, France, Germany, Greece, Hungary, Iceland, Italy, Luxembourg, Norway, Poland, Portugal, Romania, Slovakia, Spain, the Netherlands, Turkey, the United Kingdom and the United States. Georgia followed in 1998. Kyrgyzstan has signed the Treaty but has not started its ratification process. Belarus, Russia and Ukraine did not ratify until 2000-01. This delayed the Treaty's entry into force until 1 January 2002 (Chapter 3).

5. The long time period between signature and entry into force was used in two ways. *An Open Skies Consultative Commission (OSCC)* was established in Vienna. The Commission discussed and decided upon many technical and procedural issues, which were left open by the Treaty text, in particular procedures for verifying that the image sensors would not underpass the agreed ground resolution (through a certification procedure). In parallel an extended programme of *test flights* was carried out under conditions very close to the Treaty regulations. Most of the imaging sensor types, which are foreseen by the Treaty were tested:
   - Vertical and oblique optical framing cameras at 30 centimetres resolution (ground sample distance);
   - Panorama cameras at 30 centimetres ground resolution;
   - Thermal infrared line scanners at 50 centimetres resolution;
   - Sideward looking synthetic aperture radar (SAR) at 3 metres resolution.

   In the trial implementation phase 18 states provided aircraft for Open Skies use. *In the end nearly 400 bilateral or multilateral test flights were performed. They provided results, of a quality which came close to those from a full implementation of the Treaty* (section 3.2 and Chapter 4).

6. After entry into force, on 1 January 2002, the aircraft and sensors of 16 states parties successfully passed the certification procedure. Observation flights under Treaty conditions began on 1 August 2002

within an agreed framework of flight quota. Initially larger states like the Russian Federation with Belarus have to accept 31 overflights annually, whereas Germany has to receive four overflights.

In spite of the deep changes in European security relations since signature, the Treaty has retained its relevance through established cooperation and by attracting new members. The formerly neutral states of Finland and Sweden as well as Bosnia and Herzegovina and Latvia have acceded the Treaty recently. Croatia, Estonia, Lithuania and Slovenia have applied for accession (Chapter 5).

7. *Open Skies images* may be used for *monitoring* all kinds of military installations and activities, but also for assessing transport infrastructure and industries. Crisis monitoring applications will include the detection of illegal traffic in border zones, refugee camps, terrorist training camps, freshly laid minefields and post-conflict damage assessment. Photographic black and white images at 30 centimetres resolution will allow for the detection and general identification of land vehicles and military infrastructure. In addition, test missions have demonstrated an excellent capacity for monitoring the effects of environmental disasters such as floods and hurricanes. In the context of Open Skies, thermal infrared imaging (not to be used until 2006) will be particularly useful for monitoring military manoevres and production plants at day and night. The operational status of vehicles and equipment can be deduced from their heat profile. SAR images can be taken through cloud cover and in darkness. The 3-metre resolution under Open Skies, however, is quite crude: it will permit only the detection and general identification of large structures such as buildings, airports and ships.

   Open Skies images have already been successfully used to support the verification of several arms control agreements or arrangements. Once the full sensor set is operative, its potential for such a contribution will be significantly enhanced (Chapter 6).

8. *Open Skies imagery competes well and is often superior in comparison with commercial satellite images, which are now available to every member state irrespective of their access to information derived from military reconnaissance satellites*. First, the resolution of the photographic cameras (30 centimetres) used in Open Skies is

unmatched by existing commercial imaging satellites, which reach 60 centimetres at best. Moreover, Open Skies images are routinely taken in stereo mode, which provides much enhanced power for object identification through height determination. Second, it would be extremely difficult to match from space the 50 centimetres resolution of Open Skies thermal infrared images. It would require mirrors of 5 metres in diameter or more. No commercial satellite provides thermal images even at 10 metres resolution, nor does any military satellite provide thermal images at a resolution comparable to that of Open Skies. In contrast, the 3 metres radar image resolution under Open Skies will soon be overtaken by a commercial radar satellite of 1-metre ground resolution developed by the German Aerospace Establishment (Deutsches Luft- und Raumfahrtzentrum, DLR), which is due for deployment in 2005 (Chapter 9).

9. Open Skies approaches have been applied successfully *regionally*. First of all, Hungary and Romania have been the pioneers by concluding a bilateral Open Skies Agreement already in 1991. The Open Skies idea was also introduced to the war-torn entities of Bosnia and Herzegovina through seven demonstration flights from 1997 to 2001. The United States publicized the Open Skies concept in bilateral and multilateral exchanges in Latin America and Asia. *Both the (technically much simpler) Hungarian Romanian Open Skies Agreement and the (technically more demanding) multilateral Open Skies Treaty can serve as models for other regions of the world* (Chapter 8).

10. *The multilateral Open Skies Treaty can and should be adapted to current security needs and technological trends.* Many of the recommended adaptations can be arranged within the legal framework of the existing Treaty, in particular:
    - Inclusion of additional states parties in crisis-prone regions of the application area (former Yugoslavia, Caucasus states, Central Asian republics);
    - Applications for conflict prevention, crisis management and support of non-proliferation of weapons of mass destruction within the Treaty area;
    - Monitoring of environmental disasters and border crossing environmental problems based on mutual voluntary agreement of the states parties involved (within the Open Skies framework).

The Open Skies Treaty provides a very flexible, modern and future-oriented instrument. Most of the recommended technical adaptations require a Decision of the OSCC but not any further ratification step, in particular inclusion of additional sensors and readout media (multispectral and electro-optical sensors, colour infrared film, Laser Fluorescent Spectrometers, digital readout of photographic cameras). It will be important to make arrangements that the Organization for Security and Cooperation in Europe (OSCE), the United Nations and other international security organizations can request Open Skies support, as foreseen in the preamble of the Treaty (Chapters 7 and 10). *The review conference of 2005 will be an excellent opportunity to adapt the Treaty implementation to current and future needs*.

ABOUT THE AUTHORS

Pál Dunay holds a Dr. Universitatis degree in international law from the Loránd Eötvös University (1992) and a Ph.D. in international relations from the Budapest University of Economics (2001), both "summa cum laude". Between 1982 and 1996 he worked at the International Law Department of Loránd Eötvös University, in various capacities. From 1994 to 1996 he was Deputy Director of the Hungarian Institute of International Affairs, and from 1996 to 2004 he was Director of the International Training Course in Security Policy at the Geneva Centre for Security Policy (GCSP). Since August 2004 he is a senior researcher at the Stockholm International Peace Research Institute (SIPRI). He was legal adviser of the Hungarian delegation at the CFE talks in 1989-90 and at the final (Vienna) phase of the Open Skies negotiations (1992).

Márton Krasznai joined the Foreign Ministry of Hungary in 1978. He participated in the CFE and Open Skies negotiations. In 1991 he was chief negotiator of the Hungarian-Romanian Open Skies Agreement. In 1995 he was the Chairman of the Permanent Council of the Organization for Security and Cooperation in Europe (OSCE). In 1996-97 he was Personal Representative of the OSCE Chairman-in-Office in Bosnia and Herzegovina; in that capacity he organized several Open Skies demonstration flights in support of the implementation of the Dayton Agreement. From 1998 to 2002 he served as Director of the Conflict Prevention Centre of the OSCE.

Hartwig Spitzer received his Ph.D. in physics from the University of Hamburg in 1967. From 1970 to 1971 he was a visiting scientist at the Stanford Linear Accelerator Center, Stanford, USA. Since 1972 he is Professor of Physics at the University of Hamburg, Germany. At the DESY-Laboratory in Hamburg, he did research on elementary particle physics and instrumentation, including questions of pattern recognition and multidimensional computer aided data analysis. Since 1983 he is engaged in arms control and disarmament studies at the University of Hamburg. He is co-founder and spokesman of the Center for Science and International

Security (CENSIS) at the University of Hamburg. Since 1990 he heads the CENSIS project on “Physical Principles in Remote Sensing and Applications for Arms Control Verification and Environmental Monitoring” and conducts research on image analysis of multispectral aerial and satellite imagery.

Rafael Wiemker received a M.S. degree in physics and astronomy from the Georgia State University, Atlanta, in 1992 and a Ph.D. in physics from the University of Hamburg, Germany, in 1997. As a research assistant with the CENSIS group at the Physics and Computer Science departments, University of Hamburg, from 1993 to 1998, he has developed image processing methods for multispectral aerial images in the 1-metre ground resolution range. He is currently with Philips Research Labs, Hamburg, working on medical image analysis.

William Wynne received his Ph.D. in political science from the Claremont Graduate School, USA. Dr. Wynne served as a US Department of Defense technical advisor to the US Open Skies Delegation in Vienna during the Treaty's negotiation. In that capacity, Dr. Wynne also worked very closely with the Chair of the Conflict Prevention Centre in helping to design an Open Skies education programme for the members of the Dayton Contact Group, and served as a technical advisor on the potential applications of an aerial monitoring regime to the US Delegation to the Association of Southeast Asian Nations' (ASEAN) Regional Security Forum. Dr. Wynne is currently a foreign affairs specialist with the Advanced Systems and Concepts Office of the US Defense Threat Reduction Agency.

ACRONYMS

CENSIS	Center for Science and International Security (University of Hamburg)
CCD	Charge Coupled Device
CFE	Conventional Armed Forces in Europe
CIR	Colour infrared film
CPC	Conflict Prevention Centre (of the OSCE)
CSBM	Confidence- and security-building measures
CSCE	Conference on Security and Co-operation in Europe
CTBT	Comprehensive Test Ban Treaty
CTF	Contrast Transfer Function
CWC	Chemical Weapons Convention
DEM	Digital Elevation Model
DTM	Digital Terrain Model
DTRA	Defense Threat Reduction Agency
FAA	Federal Aviation Administration
FOV	Field of View
GCP	Ground Control Point
GDR	German Democratic Republic
GIS	Geographic Information System
GPS	Global Positioning System
GRD	Ground Resolved Distance
GSD	Ground Sampled Distance
HVO	Croatian component of the Army of the Bosnian-Croat Federation in Bosnia and Herzegovina
IAEA	International Atomic Energy Agency
ICAO	International Civil Aviation Organization
ICBM	Intercontinental Ballistic Missile
INF	Intermediate Nuclear Forces
INS	Inertial Navigation System
IRLS	Infrared Line Scanner
IWG	Informal Working Group
Lidar	Laser Reflection Measurements
MBFR	Mutual and Balanced Force Reductions
MTCR	Missile Technology Control Regime
MTF	Modulation Transfer Function

NATO	North Atlantic Treaty Organization
NGA	National Geospatial-Intelligence Agency (USA)
NIMA	National Imagery and Mapping Agency (USA)
NPT	Nuclear Non-Proliferation Treaty
OAS	Organization of American States
OPCW	Organization for the Prohibition of Chemical Weapons
OSCC	Open Skies Consultative Commission
OSCE	Organization for Security and Cooperation in Europe
POE	Point of entry
PSF	Point Spread Function
PTBT	Partial Test Ban Treaty
RGB	Red, green, blue
OPCW	Organization for the Prohibition of Chemical Weapons
OSCE	Organization for Security and Cooperation in Europe
SAR	Synthetic aperture radar
SFOR	Stabilisation Force in Bosnia and Herzegovina
START	Strategic Arms Reductions Treaty
TCAS	Anti-collision warning system (aircraft)
TLE	Treaty Limited Equipment
UAV	Unmanned Aerial Vehicle
WEU	Western European Union
WMD	Weapons of Mass Destruction
WTO	Warsaw Treaty Organization

INTRODUCTION

Open Skies is the longest nurtured idea in the history of modern arms control. It has bridged over different periods of the second half of the 20th century from the peak of the Cold War with its unrestricted confrontation through its re-emergence at the end of the 1980s, when the Cold War was about to close, to the post-Cold War era. Throughout the decades its evolution followed the shifts in European history, albeit indirectly.

The end of the Cold War presents both a challenge and an opportunity for the intentions implicit in Open Skies. On the one hand, the importance of traditional arms control verification has diminished significantly. On the other, new avenues have opened based on cooperation that go much beyond the original scope of arms control. The changed European political landscape has modified the previous military and security outlook. Instead of bloc deterrence enhanced by arms control verification the different nature of contemporary conflicts has made the monitoring of conflict regions, particularly in post-conflict situations, necessary, while the emergence of a range of other security concerns whose redress relies in part on adequate observation has given monitoring an important role to play.

This book is the outcome of a research project on the "Extension of the Open Skies Treaty as a Contribution to European Security—Political Perspectives and Technical Options" which aimed to analyze the evolution of the concept of Open Skies, its realization in the Treaty on Open Skies and its prospects.

The project was carried out between 1995 and 2000 by German, Hungarian and US experts who, beyond their common interest in Open Skies, had different types of complementary expertise. Professor Hartwig Spitzer, who has been in charge of the project, is a physicist with a long-time background in experimental elementary particle physics. In 1989 he co-founded the Center for Science and International Security at the University of Hamburg (CENSIS), which specializes in the analysis of aerial images for arms control and urban planning applications. Doctor Pál Dunay, who is currently director of the International Training Course at the Geneva Centre for Security Policy, has taught public international law at Loránd Eötvös University in Budapest and was legal adviser to the Hungarian delegation to the final (Vienna) phase of the Open Skies Treaty negotiations. Ambassador Márton Krasznai was involved in the negotiation of the Open Skies Treaty as a Hungarian diplomat from 1990. He also participated in the negotiation of the Hungarian-Romanian bilateral Open Skies Agreement. He has been head of the Conflict Prevention Centre of the Organization for Security and Cooperation in Europe (OSCE) in Vienna. Doctor Rafael Wiemker is a physicist. He has worked with CENSIS at Hamburg University for four years on developing image analysis. At present he is with Philips Research Lab, Hamburg. William Wynne has a doctoral degree in political science. He has worked on Open Skies matters as a member of the United States On-Site Inspection Agency since 1991 and as a technical advisor of the US Open Skies Delegation in Vienna. He currently has other responsibilities in the US Defense Threat Reduction Agency.

This book addresses practitioners, policy makers and scientists, who are interested or involved in Open Skies. It examines the concept, practice and future of the multilateral Open Skies Treaty from different perspectives: political, technical and operational. As such, some of the chapters will be of higher interest to one professional community than to another. Everyone will find an overview of the substance of the Treaty in section 2.3 and a general overview in the Executive Summary. The political context, historical development and political outlook of the Treaty are covered in Chapters 1-3, 5 and 10. All those interested in the practice of Open Skies flights and their results are referred to Chapters 4 and 6, where Chapter 6 emphasizes the information potential of Open Skies imagery. Chapter 7 addresses in particular policy makers who are in charge of developing Open Skies further. The chapter has been written in order to stimulate discussion in preparation for the 2005 review conference of the Open Skies Treaty. Chapter 9 demonstrates that Open Skies image data compare favourably to imagery from commercial satellites. Finally, policy makers, security practitioners and scientists from all over the world will find Chapter 8 a useful guide on how bilateral or multilateral Open Skies agreements could be developed outside of Europe and North America.

The project has been greatly facilitated by several interviews conducted by the authors, who gratefully acknowledge the support of those diplomats and military experts who were ready to share their invaluable insights with them during the project. As the interviews were conducted under conditions of anonymity we would like to thank them without mentioning their names. We appreciate the assistance provided by the Open Skies Division of the Verification Centre of the German Armed Forces and of the Open Skies division of the German Ministry of Defence, in particular by Col. Britting, Lt.Col. Fensch, Wing Commander Lohr, Lt.Col. Saar and Col. Sperling. Special thanks go to the Volkswagen Foundation, which financed the project and has patiently awaited this final report.

Geneva, Hamburg, June 2003

CHAPTER 1

ARMS CONTROL IN THE POST-COLD WAR WORLD

Pál Dunay

The concept of Open Skies emerged as an element of military transparency in the mid-1950s and was the first, somewhat vaguely formulated, proposal that sought to overcome the Cold War system characterized by the militarily confrontation between the Soviet Union and the United States. Even though the term arms control per se did not exist at the time Open Skies was first proposed, the latter has retrospectively always been considered to be an arms control policy. Open Skies was in fact the first non-nuclear arms control initiative in the nuclear age. Since Open Skies is thus essentially an arms control policy, a study of the Open Skies Treaty must arguably commence with an inquiry into the arms control context in which it emerged, and of which it is still part.

1.1 THE LEGACY OF THE PAST

By the beginning of the 1960s the generation-old idea of general and complete disarmament had been replaced by the less ambitious, and more realistic, goal of *arms control*. At about the same time, during the Cuban Missile Crisis, the Soviet Union and the United States nearly went to war with each other. The fact that the two leading military powers of the world went to the brink of a nuclear disaster turned out to be conducive to arms control and confidence building. The initial confirmation of this was the *Partial Test Ban Treaty (PTBT)* and the first US-Soviet accord on the establishment of a communication *"hotline"*.

It is important to note that these first arms control accords did not oblige the parties to reduce their arsenals. Rather, they introduced measures that sought to improve the political climate between them and that encouraged communication even, or particularly, in times of difficulty.

Thus, by the time the PTBT was signed both the United States and the Soviet Union were capable of carrying out underground test explosions, and so the Treaty had no impact on their development of nuclear arms.[1] Likewise, the hotline agreement was clearly aimed at enhancing the capacity of the parties to communicate in times of crises, and was not meant to affect the state of their armaments.

Arms control, as an enterprise, is always premised on a certain level of *mutual confidence* between the parties involved. To fully appreciate this point it suffices to consider two alternative extremes: when states have full confidence in each other, and when they have no confidence whatsoever in one another. In case of the former arms control is unnecessary; in case of the latter it is impossible. The *Treaty on Conventional Armed Forces in Europe (CFE)*, in its original form, offers a good illustration of the former. The CFE Treaty regulated the military deployments of the Eastern and Western alliances, but did not deem it necessary to address intra-alliance military alignments.[2] The supervision of these was left up to the members of each respective alliance. North Atlantic Treaty Organization (NATO) states, in a gentleman's agreement, have relinquished the right to carry out inspections of each other's armed forces. One may conclude from this that in the absence of perceived threats countries have no need of arms control agreements. On the other hand, when the relationship among states is entirely hostile, arms control arrangements among countries become impossible. This was the case of US-Soviet relations in the late 1940s and the first half of the 1950s when each saw the other exclusively as an adversary. Between 1946 and 1955 the two countries did not even attempt to negotiate arms control provisions. This shows that a certain level of mutual confidence among countries is necessary in order for arms control to be feasible. This same observation is phrased by Thomas Schelling and Morton Halperin in their classical book as follows: "The essential feature of arms control is the recognition of the common interest, of the possibility of reciprocation and cooperation even between potential enemies with respect to their military establishments."[3]

Arms control does not function in a vacuum. Rather, its existence is contingent on prevailing needs and opportunities. Experience with arms control is fairly limited. Other than in the specific European context it is largely confined to some global measures. Consequently, there is little that can be inferred from the past about its eventual applicability to other regions of the world. This counsels caution when such an application is contemplated.

Historically *two types of arms control* may be distinguished: structural and operational. *Structural* arms control limits the possession of the amount or type of weapons by a country. *Operational* arms control restrains certain military activities, such as troop movements and manoeuvres, or establishes transparency measures, like the exchange of information on military budgets or visits at military facilities.

The following measures are typical of *structural* arms control:

- The complete ban of a certain type of weapon;
- A quantitative limitation on the possession of a certain type of weapon;
- The prohibition to station a given type of arms in a particular geographic area;
- The prevention of the proliferation of certain types of weapons.

Structural arms control has always entailed one or some combination of the above measures.

Operational arms control involves a greater variety of measures than the structural kind, and is hence less amenable to accurate definition. As well, operational arms control has a more diffuse history than structural arms control, which also complicates matters. Still, four types of operational arms control measures are fairly discernible:

- Measures that facilitate communication in the event of a crisis or in general;
- Measures that make force postures less offensive;
- Measures that indirectly decrease the reliability of armed forces and their weapons;
- Measures that reduce secrecy and increase transparency in military matters.

The difference between structural and operational arms control is not absolute, however. For example, some instruments contain provisions that are a mixture of both, and either type can work towards similar objectives. Nevertheless, historically the differentiation has been relevant in the European context, where the distinction of measures has been accompanied by a differentiation of countries involved.[4] Thus, while European operational arms control covers all participating states of the OSCE,[5] structural (conventional) arms control is limited to the members of NATO and of the former Warsaw Treaty (and its successor states). Today, of course, such a geographic distinction makes little sense, yet calls to harmonize arms control commitments, issued at the 1992 Helsinki summit meeting of the CSCE, went nowhere.[6] The historicity of division is also reflected in the adaptation of the CFE Treaty. Although the Treaty was signed in late 1999, its ratification is still on going and will certainly not be completed before 2005. The Treaty will not be opened for the accession to the former non-aligned and neutral countries at least until its entry into force. This will postpone an eventual harmonization of commitments well into the middle of this decade. Harmonization, as far as the most important exception to European structural arms control, the area of the former Yugoslavia, may by then be less relevant as special arms control regimes have been implemented there since the mid-1990s. On the other hand, further regional arms control agreements beyond the confines of the former Yugoslavia are unlikely, since eventual candidates prefer to accede to the pan-European instruments rather than to local ones.

The legacy of the past of arms control embraces both the Cold War era and the subsequent period of the 1990s through to the present. It is, of course, much easier to draw conclusions about the former than about the latter. The former was a time of rigid adversarial relations between two superpowers that dominated the international system. Throughout most of the era arms control played a substantial political role in terms of *a means of communication* through which the two superpowers could discuss issues of mutual interest irrespective of the prevailing level of tension. During the Cold War, thus, arms control contributed mainly to bettering political relations, while its military impact remained marginal. Although several accords were achieved, these had symbolic political importance rather than military significance. The militarily significant agreements, namely the ones that affected force postures, were concluded only in the late 1980s when the might of the Soviet Union had largely vanished and the Cold War was on the wane.

It is important to note, however, that during the Cold War results in the area of operational arms control preceded those in the area of structural arms control. While this may be regarded as sheer coincidence, it may also be an indication that when adversarial relations predominate, structural arms control needs to be preceded by some sort of operational measures that establish a minimum level of confidence. Although we know fairly little about how confidence building actually works, it may well be that the entire process begins with measures that promote transparency.[7]

It is more difficult to draw conclusions as far as *multilateral* conventional arms control in Europe in the broad sense is concerned. The absence of any tangible results until the mid-1980s deprives us of any measurable experience, and the legally or politically binding agreements that were subsequently reached intervened at a time of transition from the Cold War to the post-Cold War and are thus not representative of what arms control could achieve during the times of confrontation. The drafting of the CFE and Open Skies Treaties paralleled the demise of the Cold War.

1.2 Prospects for the Future

Taking a closer look at the more recent situation that has emerged since the collapse of the Soviet Union the following observations may be noted. First, the bipolar structure of the international system of the Cold War has dissipated and with it so has the all-out confrontation between its main protagonists, although, as the second half of the 1990s illustrated, residual tensions may have still remained. Second, the United States has emerged as the sole global power whose worldwide reach and interests give it a unique perception of international security, which has important repercussions for its policies in strategic matters, including arms control. Third, these changes in the structure of the international system have placed a question mark over the role of arms control in the new European security context. Thus, during the 1990s, whereas global arms control centred on the non-proliferation of weapons of mass destruction (WMD) and of their long-range delivery vehicles retained its importance, in Europe, most of the main arms control regimes, like the CFE Treaty or the Vienna Documents, maintained only a marginal relevance in relation to the main function of arms control of decreasing the likelihood of war. Instead, with the exception of the Dayton Agreement, European arms control since the end of the Cold War has served mainly as a framework for dividing up the conventional forces of the former Warsaw Treaty and of the Soviet Union as a reassurance for some countries against some others, to marginally limit arms transfers by dictating the destruction of demobilized weapons and to introduce a heretofore unknown level of transparency.

From the above it is apparent why since the end of the Cold War European arms control has unfolded in fits and starts. A precise overarching motivation for it has been missing. A brief look at the course of European arms control in the past decade illustrates the point.

In the period between late 1990 and mid-1992 European arms control faced four groups of issues pending from the end of the Cold War. First, Cold War era negotiations that were still on going had to be completed. The Open Skies talks are an example of such discussions. Second, the CFE Treaty, the single most important achievement of European arms control, had to be brought into force. Bearing in mind the constant changes (mainly in the form of the dissolution of states) unfolding in Europe at the time, this proved to be a demanding task.[8] Third, when the Warsaw Treaty Organization collapsed, the distinction between allied and non-aligned countries disappeared and the way was opened for a harmonization of arms control commitments by different countries. This idea launched at the CSCE Helsinki summit of 1992 has failed badly, at least for the time being. Fourth, it turned out that the existing treaties and institutions were not adequate to prevent or mediate the upcoming military conflicts in the former Yugoslavia and in the Caucasus area.

In the latter half of the 1990s European arms control was shaped by the emergence of *two major challenges*. The first concerned the outbreak of internecine and border armed conflicts as in the former Yugoslavia, which indicated the need to establish arms control regime(s) directly relevant to such zones of conflict. The Dayton Agreement and the two accords adopted in January and June 1996 on confidence building and structural arms control addressed this concern with respect to Bosnia and Herzegovina. The second concerned the adaptation of those Cold War arms control accords that had been sorely overtaken by events, primarily the CFE Treaty.[9] The experience of the last few years shows how difficult it is to adapt a treaty to fundamentally changed political conditions. In addition to having to redraw some provisions, the adaptation process was nearly blocked by some pending conflicts. Namely, Georgia and Moldova insisted upon establishing a link between their agreement to the adaptation of the Treaty and the withdrawal of Russian troops from their respective territories.[10] It may still happen that ratification of the adapted Treaty will be delayed should Russia fail to withdraw its troops. Here, it is worth noting that an eventual withdrawal of Russian troops could be verified through aerial monitoring.

In sum, the experience of European arms control over the last decade can be summarized as follows. First, a clear overarching principle of post-Cold War arms control has been lacking. In the absence of significant residual threat perceptions arms control has become stagnant. Second, the attempt to shift arms control from a confrontational to a cooperative basis has proved laborious. European arms control in the 1990s has been a trial-and-error process which has produced some results, but until now, no definite outcome. Third, arms control has evolved as a reaction of the community of European countries to the emergence of topical security problems, like internecine conflict. This approach, though useful, carries the risk of incoherence.

A quick look at global arms control yields similar conclusions, though with a slightly different emphasis. In the industrialized countries improved political relations since the end of the Cold War have given impetus to factions that seek to reduce the threat of weapons that commonly create extensive human suffering in conflicts as opposed to banning seldom-used armaments. For example, non-governmental organizations motivated by humanitarian concerns have lobbied extensively for initiatives that could end up as "hard to verify" commitments. This is the case of the ban on *anti-personnel landmines,* and it may yet be the case of certain categories of small arms and light weapons. It is important to note to what extent the international community has relinquished the stringent verification requirements applied until the end of the Cold War. Unless the international political climate changes considerably, the number of non-verifiable commitments is certain to increase further still. This trend is contrary to the one observed in the control of weapons of mass destruction, where verification measures are increasingly stringent and their observance is supported by international agencies.

It is difficult, or rather impossible, to offer specific comments about the future of arms control. Instead it is more prudent to take a more cautious approach and speak of general trends. With the end of the Cold War, the importance of US-Russian arms control has declined sharply. There is a residual risk stemming from the size of the arsenal of the Russian Federation, addressed through cooperative measures, and the political uncertainties in that country, although this risk is neither pronounced nor imminent. Furthermore, the risk is most directly related to the state of the post-Soviet arsenal of weapons of mass destruction, something that is better addressed through non-traditional cooperative means, like the US

Cooperative Threat Reduction programme, than through traditional arms control.

Beyond this there is the interest of the nuclear states, the five permanent members of the United Nations Security Council, to maintain their privileged status as far as their nuclear and long-range delivery capabilities are concerned. This entails preventing other countries from acquiring such capabilities, meaning that the preclusion of the emergence of other states with nuclear, chemical or biological weapons or with long range power projection, primarily in terms of missiles, capabilities will remain the focus of arms control. It should be pointed out, however, that the non-proliferation of weapons of mass destruction and long-range missiles is not the exclusive domain of arms control, as recent US foreign and defence policies have shown. It suffices to mention the so-called Proliferation Security Initiative, which, although addressing primarily threats stemming from weapons of mass destruction, is applicable to a broad range of weapons and dual use equipment.

As far as European arms control is concerned, the following seems likely. One, European arms control will be largely a *corollary of global efforts*. Four of the five nuclear powers belong to the Euro-Atlantic area and are participating states of the OSCE, and their interest often runs beyond Europe. Two, arms control will also contribute to tackling the residual *military problems* related to Russia, among others providing Russia with a status in the international system resembling that of the former Soviet Union, irrespective of its current weakness. Arms control, thus, has a residual importance as far as the regulation of post-Cold War power relations are concerned. Three, there seems to be broad-ranging interest in regulating military relations through arms control following *regional violent conflicts*. This has been shown in Bosnia and Herzegovina. It can be taken for granted that arms control, mixed with other post-conflict settlement measures, will be applied in other cases. The significance of this sort of measures depends, of course, on the presence of localized conflicts in Europe. In case the international community continues to apply such conflict-specific arms control measures, there is a danger of European arms control becoming fragmented. That would prevent the emergence of a common European security space bound, among others, by a common web of arms control commitments.

In the light of its recent past, it is tempting to conclude that the prospect of European arms control is dim. The principal reason for this is the absence of a readily identifiable threat that could be addressed by arms control. This has led to several efforts being made to refocus attention on cooperative arms control measures. These have achieved some success noticeable to experts and defence establishments, but not to the wider public. The current lack of political visibility of arms control makes it doubtful whether arms control is domestically necessary any longer. This impression is widely shared by decision makers in many countries, as well as by the media, which does not attribute as much importance to arms control as they did during the Cold War. Last, but not least, those security issues that could be influenced by arms control are not high on the agenda of public opinion in Europe and North America. Consequently, decision makers perceive no public pressure to address them.

The shift from confrontation to cooperation based arms control has been insufficient. Arms control has been able to maintain its relative significance only in areas where the element of confrontation is at least potentially present. Future arms control, thus, might be better oriented towards those residual threats and shaky inter-state relations where the role of arms control of decreasing the possibility of armed conflict still has value.

1.3 Open Skies as a Bridge in the Structure of Arms Control

As mentioned earlier, arms control may be divided into structural and operational measures. This division, however, is especially rigid and need not be particularly enduring. New arms control situations may appear which require a reconsideration of it. Furthermore, the division of arms control into structural and operational measures has been inferred from the evidence gathered from a dozen or so treaties and politically binding instruments from the European context, which scarcely amounts to a plentiful basis for this type of exercise.

Hardly any other concept raises as many questions concerning the differentiation of arms control as Open Skies. The notion of Open Skies emerged as a means of verification in the 1950s when on-site inspection was unthinkable and reconnaissance satellites were non-existent.[11] As such conceived, it continued thereafter to supplement both structural and operational European arms control. Nevertheless, verification measures can be associated with confidence-building measures just as much as they are with arms reduction ones, as the document on confidence- and security-building measures (CSBMs) adopted at the 1980 Madrid OSCE summit, which stipulates that the measures adopted "will be provided with adequate forms of verification which correspond to their content", clearly suggests.[12] Consequently, the role of Open Skies is dependent upon the measure with which it is associated.

Taking a closer look at the evolution of the notion of aerial inspection it is apparent that over time its contribution as a confidence-building measure has gradually increased, while its role as an associated measure of either structural or operational arms control has diminished. This is due primarily to intervening shifts in the context in which aerial inspection operates. Since its inauguration in 1955, two major developments have occurred, which have affected the role Open Skies could play. One of them is technological advance. Namely, the appearance and spread of *satellite monitoring* has dramatically altered the scope of aerial monitoring. Currently, the leading military powers are far less dependent upon aerial observation than they were in the mid-1950s when the Open Skies idea was launched and satellite observation simply did not exist. The other is the attitude of the great powers towards extensive *on-site inspections*. As long as this was unacceptable and thus politically inconceivable, aerial inspection could be assumed to provide the most fruitful means of verification. When the Soviet Union dropped its opposition to on-site inspections in the late 1980s,[13] the significance of Open Skies as an arms control measure lessened considerably. Hence, over time, Open Skies as a verification and transparency instrument has come under pressure from two sides: improving satellite capabilities has tended to make it less necessary, while at the same time the generalization of on-site inspections has tended to make it less useful.

In sum, the importance of the categorization of Open Skies either as a structural or as an operational arms control measure has diminished. Although initially CFE negotiations contained the idea of an aerial inspection regime, this notion did not reflect in the Treaty proper. Thus, when Open Skies finally materialized in the 1990s, it was codified as an element of post-Cold War European confidence building rather than as an arms control means. As such, the Treaty has remained separate from other European arms control instruments.

Notes

1 The United Kingdom was also capable of carrying out underground test explosions, whereas France, the other nuclear power at the time, which lacked such capabilities, did not enter the Treaty and continued to test above ground.

2 It is of course a gross simplification to claim that no fears and concerns exist between states that belong to the same alliance. In this respect it suffices to mention intra-Warsaw Treaty relations at the end of the 1980s.

3 T. C. Schelling and M. H. Halperin, *Strategy and Arms Control*, 2nd edition, Washington: Pergamon/Brassey's, 1975, p. 2.

4 The classical piece on the topic is still R. E. Darilek, "The future of conventional arms control in Europe, A tale of two cities: Stockholm, Vienna" in *SIPRI Yearbook 1987: World Armaments and Disarmament*, Oxford: Oxford University Press, 1987, pp. 339-54.

5 Prior to 1993 named the Conference on Security and Co-operation in Europe (CSCE).

6 The idea of harmonization aimed at addressing the "various existing instruments concerning arms control, disarmament and confidence- and security-building" so that the same commitments would apply to each CSCE/OSCE state. See "CSCE Forum for Security Cooperation", para. 12, *CSCE Helsinki Document 1992: The Challenges of Change, Helsinki Summit Declarations, Final Decisions*, Helsinki, 9-10 July 1992, http://www.osce.org/docs/english/1990-1999/summits/hels92e.pdf.

7 J. Macintosh, "Open Skies as a Confidence-Building Process", in M. Slack and H. Chestnutt (eds), *Open Skies—Technical, Organizational, Operational, Legal and Political Aspects*, Toronto: Centre for International and Strategic Studies, York University, 1990, p. 49.

8 The successful bringing of the CFE Treaty into force nearly two years after signature was not accompanied by the success of similar efforts with respect to Open Skies.

9 The dissolution of the Warsaw Treaty had rendered the bloc premise of the Treaty untenable.

10 The situation is easier in the case of Georgia as Russia has committed itself to withdraw its forces. See Annex 13: "Statement on behalf of the Republic of Moldova" and Annex 14: "Joint Statement of the Russian Federation and Georgia", of "Final Act of the Conference of the States Parties to the Treaty on Conventional Armed Forces in Europe", *OSCE Istanbul Document 1999*, Istanbul, 17 November 1999, http://www.osce.org/docs/english/1990-1999/summits/istan99e.pdf.

11 For more details see section 2.1 below.

12 "Questions Relating to Security in Europe", *CSCE Follow-up Meeting 1980-1983, Concluding Document*, Madrid, 11 November 1980-9 September 1993, http://www.osce.org/docs/english/1973-1990/follow_ups/madri83e.htm.

13 Then Soviet Foreign Minister Eduard Shevardnadze declared before the beginning of the negotiations on conventional armed forces in Europe in 1989: "We will insist on the strictest and most severe control, including inspections without the right of refusal, aerial observation of the situation and the verification of the communication under which the transfer of troops and armaments takes place. There is no such control measure that we would not be ready to examine and adopt on the basis of reciprocity." E. A. Shevardnadze, "Dan start Venskim peregovoram: Vystuplenie E. A. Shevardnadze", *Pravda,* 7 March 1989, p. 4.

CHAPTER 2

THE OPEN SKIES NEGOTIATIONS AND THE OPEN SKIES TREATY

Pál Dunay and Hartwig Spitzer

2.1 EARLY HISTORY (1955-1989)

Open Skies is the single longest-lived idea of modern, post-World War II, European arms control. It was the first arms control initiative presented at the height of the Cold War in 1955 at the Geneva Conference of Heads of Government.[1] The outlines of the proposal made by US President Dwight Eisenhower were fairly vague, not surprisingly. This could be due to the apparent lack of advance work that went into preparing the proposal.[2] It may well be, however, as in many cases with top-level initiatives, that it was intentionally ill defined leaving the details to be worked out later in lower level exchanges. As well, there was the importance of the other side's reaction. After all, why bother to outline a detailed proposal if it cannot be assumed realistically that it will be accepted? President Eisenhower actually stated the following:

> Surprise attack has a capacity for destruction far beyond anything which man has yet known. So each of us deems it vital that there should be means to deter such attack. Perhaps, therefore we should consider whether the problem of limitation of armament may not best be approached by seeking—as a first step—dependable ways to supervise and inspect military establishments, so that there can be no frightful surprises, whether by sudden attack or by secret violation of agreed restrictions. In this field nothing is more important than that we explore together the challenging and central problem of effective mutual inspection. Such a system is the foundation for real disarmament.[3]

Looking closely at the idea set forth by President Eisenhower it is clear that it was conceived as a verification measure intended to contribute to future disarmament. Thus, it may be said that it aimed to provide the transparency necessary for the verification of arms control measures to be agreed upon later. This manner of approaching matters, that is, transparency before arms control, is in fact the opposite of how arms control initiatives were conceived later in the Cold War, when information exchange and verification were conjured as supplementary to arms reductions or limitations.

Aerial observation can, of course, serve multiple objectives. As President Eisenhower noted not much after the Geneva meeting in his radio and television address:

> Our proposal suggested aerial photography, as between the Soviets and ourselves by unarmed peaceful planes, and to make this inspection just as thorough as this kind of reconnaissance can do. The principal purpose, of course, is to convince every one of Western sincerity in seeking peace. But another idea was this: if we could go ahead and establish this kind of an inspection as initiation of an inspection system we could possibly develop it into a broader one, and especially build on it an effective and durable disarmament system.[4]

The opportunity to use aerial photography for reconnaissance purposes was there, as was the potential to apply it as part of an inspection system to monitor disarmament. However, as at the time the disarmament system to be monitored was non-existent, the two purported uses of aerial monitoring could hardly assume equal status. A third possible justification for Open Skies was the building of confidence. This aspect appeared only on the margins of the initiative, as evident in the comment made by Secretary of State John Foster Dulles at his after summit news conference:

> President Eisenhower's dramatic proposal that the United States and the Soviet Union should agree that peaceful planes would fly over each other's territory to take photographs so that each could be sure that the other was not planning a massive surprise attack.[5]

In the absence of any concrete measures to be monitored the notions of disarmament and confidence building provided relatively weak rationales for Open Skies. On the other hand, there was a lot to do on the reconnaissance side. As it was noted:

> … in 1955 the United States possessed all the necessary weapons for a counter-force nuclear attack against the Soviet Union. The major obstacle to confidence that such an attack could be carried out without a massive Soviet counter-attack was the lack of accurate and complete targeting data. The US Strategic Air Command was faced with a rapidly expanding target list. … In this context the Open Skies plan can be seen as a military intelligence measure of the highest importance, one which would strengthen the weakest link in US nuclear war-fighting plans.[6]

It is open to doubt whether any American politician planned a nuclear attack, not to mention a first strike, against the Soviet Union. It is certain, however, that a US-Soviet Open Skies could be used to acquire more knowledge about the Soviet Union, in particular about its military. Unlike the United States, the Soviet Union was a closed society, little accessible from the outside. Open Skies was bound to be more beneficial to the US than to the Soviet Union. As such, it was understandable for the United States to propose the idea, and for the Soviet Union, which emphasized disarmament rather than transparency, to reject it. Transparency, moreover, could well be a "double-edged sword". According to the historian John Lewis Gaddis, President Eisenhower's concern about surprise attack was genuine, yet his Open Skies proposal, which he claimed would help reduce the mutual fear of an attack, was actually a part of an American political campaign to discredit Soviet peace overtures.[7] Arms control is necessarily shaped by prevailing circumstances. Hence, Open Skies, was not envisioned as a possible exit from the confrontation between the two states, but rather was a reflection or manifestation of this competition.[8]

In the light of the above, it certainly is plausible to assume that "the Open Skies proposal was made with the knowledge that it would be rejected by the Soviet Union."[9] Nevertheless, even with such an assumption, it is interesting to note how Premier Nikolai Bulganin reasoned at the session of the Supreme Soviet:

> At the Geneva meeting US President, Mr D. Eisenhower put forward a proposal to organize an exchange of military information between the Soviet Union and the United States and to carry out mutual aerial photography of both countries' territory. When giving the necessary attention to the initiative that has tried to find a solution to the fairly complex problem of international control, it has to be said at the same time that the real effect of similar measures would not be great. In the

> unofficial exchanges with the leaders of the US government we noted directly that aerial photography cannot give the expected result as our countries are both located on immense territory on which everything can be hidden away as necessary. It has to be taken into account that the initiated plan affects only the territory of the two countries leaving aside military forces and their armaments located on the territory of other states.[10]

Bulganin's remarks make it clear that for the Soviet Union the US proposal was unacceptable. The territory of the two countries was too large for Open Skies to be put into practice, and besides, in view of the developing network of American bases abroad, limiting the regime to national territory would have placed the USSR at a greater disadvantage still. An alternative might have been to ask for a global Open Skies regime, but that would have been even more impractical and, again, of little net benefit to the Soviet Union. The shooting down of a spying American U-2 surveillance plane over Soviet territory in the spring of 1960,[11] only increased Soviet hostility towards the idea of Open Skies, and the coming to power of Leonid Brezhnev in 1964, who was even less inclined towards military transparency than his immediate predecessor, spelled the end of the idea at least until the latter's demise.

In the 1960s and 1970s two major developments affected the scope of monitoring arms control arrangements, respectively. First, was the emergence of satellite technology. As it was put: "The information collected by satellites ultimately became an essential element of bipolar stability, in much the same way that Open Skies information could have done earlier, had it been available."[12] Second, the United States and the Soviet Union concluded bilateral arms control agreements followed by several European accords whose adequate verification had to be ensured. The appearance of these two factors had a profound impact on Open Skies. The technology that could, at least partially, replace aerial monitoring was available, at least to the two superpowers. The arms control arrangements that made verification necessary existed as well. It was open to question whether in the light of these aerial monitoring, or more precisely Open Skies, would find application. The rigidity of the Cold War order, which was dominated by those states that had the most extensive and for some time nearly exclusive access to national technical means, which alone could provide for the necessary monitoring, did not bode well for Open Skies. It is not a coincidence, thus, that serious consideration of Open Skies had to await the beginning of the demise of the Cold War and the turn of the Soviet Union toward a more favourable view of transparency effected by Gorbachev.

During the Brezhnev years the idea of aerial monitoring was mentioned only once. In 1978, France proposed the "establishment of an aerial or satellite surveillance system" in Europe, as a means of stabilization.[13] It is interesting to note that the initiative was formulated alternatively. Stabilization could either rely on aerial *or* satellite surveillance. Of course, satellite monitoring on a European scale would have required a significant expansion of access to satellite information both within NATO and the Warsaw Treaty or an internationalization of monitoring by national technical means on the continent. Even though the proposal was not taken up it was the only reference to aerial surveillance on a multilateral basis before the mid-1980s.

The issue of aerial monitoring next emerged at the Stockholm meeting on CSBMs in 1984-86 in the context of monitoring limitations on ground forces training exercises. The matter remained highly controversial throughout most of the talks. The United States indicated that the most effective way of checking compliance would be through on-site inspection. Aerial inspection, involving suitable short take-off-and-landing aircraft (such as the US C-130, Soviet AN-12, or Canadian DHC Dash-7) that permitted to overfly the entire exercise area, "could be the optimum method of checking compliance".[14] The Soviet response until fairly late in the discussions demonstrated continuity: "… we are categorically opposed to such measures which, under the guise of verification, serve as a legalized means of collecting intelligence data and constitute direct interference in the internal affairs of another state…" (Tatarnikov). In other words, the traditional Soviet military concern with secrecy still dominated the Soviet diplomatic position. This stance prevailed until 20 days before the close of the conference, when the newly arrived Marshal Akhromeyev, Chief of the General Staff, announced that the Soviet Union agreed to aerial as well as ground on-site inspection.[15] Although the exact sources of the shift in the Soviet position are difficult to identify with accuracy, a likely explanation may lay in the inner struggles taking place within the Soviet leadership at the time and the eventual triumph of Gorbachev and his programme, which aimed at a political rapprochement with the West.

Examining the first international document that introduced aerial monitoring in a politically binding manner, the following can be noted.

Inspection was permitted on the ground, from the air, or both, meaning that aerial inspection was regarded as a form of on-site inspection. As under international law airspace is considered to be part of a country's territory, this is quite normal. The document, however, was vague insofar as the equipment to be used for such purposes was concerned. Accordingly, aerial monitoring could be conducted by airplane, helicopter, or both. This left the question of the ownership of the plane or helicopter to be used during inspection undecided. The ambiguity reflected the division of the participating states on the matter. The Soviet Union had insisted that the aircraft and aircrew of the *inspected* state would have to be used, whereas NATO countries had preferred that the *inspecting* state's own planes and pilots be employed. The neutral and non-aligned states had presented their compromise according to which the planes of states belonging to their group would be used. The Soviet Union had rejected this on the grounds that if the inspecting state's aircraft were used this could "be equipped with the appropriate intelligence gear that can check not only the actions of troops in this region, but also be capable of reconnoitering any installation that is not the object of monitoring. This would be unlawful intelligence activity and a violation of a state's sovereignty."[16] In the light of the history of aerial reconnaissance this complaint was understandable and remained an issue for later Open Skies discussions. Eventually compromise was reached so that aircraft "for inspection will be chosen by mutual agreement between the inspecting and receiving states".[17] It remained to be seen what to do if the inspecting and the inspected state could not agree upon whose aircraft to use.

Further measures guaranteed that the observation could not be used for espionage. Among them, beyond the selection of the observation aircraft, was the provision that directions "to the crew will be given through a representative of the receiving State on board the aircraft involved in the inspection."[18] Moreover, one member of the receiving state's inspection team was to be permitted at any time to observe data on the navigational equipment of the aircraft and to have access to the maps and charts used by the flight crew for the purpose of determining the exact location of the aircraft during the inspection flight.[19] The two provisions above clearly indicate that the inspecting and the inspected (or, more precisely, the receiving) party were obliged to cooperate throughout the inspection. This was certainly a major advantage of the regime. Bearing in mind the limited number of inspections carried out under the Stockholm regime and the even more limited reliance on aerial inspections one could hardly speak about an established practice before the end of the Cold War, however. The regulation of the Stockholm regime proved nonetheless useful during the drafting of the Open Skies Treaty in indicating both the limits of the parties' flexibility and their readiness to cooperate.

After the Stockholm conference the notion of aerial inspection remained constantly on the agenda. When the Bush administration came to office in the United States at the end of 1988 the National Security Council staff was ordered to prepare a wide-ranging review of arms control and confidence-building initiatives. Both for historical and actual reasons, Open Skies was among the initiatives considered. It was a genuine American idea whose time, as the Stockholm regime had demonstrated, might have come. It was moreover a transparency measure which the Soviet leadership with its claims of "glasnost'" could hardly find justification to reject.

The re-launch of Open Skies was initially conceived as a bilateral US-Soviet measure. This reflected the essentially status quo orientation of the United States. Such an approach, however, overlooked many of the side benefits, which a multilateralization of Open Skies could offer in the fluid context of a faltering Soviet Union, like encouraging the emancipation of the smaller members of the Warsaw Treaty or providing access to monitoring information to states which had none. Such benefits, however, were recognized by at least one US ally. In consultation with the US President, the Canadian Prime Minister Brian Mulroney called attention to the importance of a multilateral Open Skies.[20] Grasping the opportunities to be seized, President Bush presented the new US Open Skies initiative in his speech at Texas A&M University on 12 May 1989, as follows:

> Now let us again explore that proposal, but on a broader, more intrusive and radical basis—one which I hope would include allies on both sides. We suggest that those countries that wish to examine this proposal meet soon to work out the necessary operational details, separately from other arms control negotiations. Such surveillance flights, complementing satellites, would provide regular scrutiny for both sides. Such unprecedented territorial access would show the world the true meaning of the concept of openness. The very Soviet willingness to embrace such a concept would reveal their commitment to change.[21]

The Bush proposal differed from his predecessor's in two important respects. First, the proposal aimed to initiate multilateral negotiations with the involvement of all the members of NATO and of the Warsaw Treaty. Second, Bush proposed to begin separate negotiations, thus de-linking Open Skies from other forums, primarily the CFE talks, which had started two months before the speech.

Unlike the Eisenhower initiative, Bush's proposal was positively received both in the East and in the West. A conference was convened to the capital of Canada between 12 and 28 February 1990 to discuss the idea.

2.2 The Ottawa, Budapest and Vienna Rounds of Negotiations in the Light of Circumstances

The nine months that passed between President Bush’s address at A&M University (12 May 1989) and the opening of the first round of negotiations in Ottawa (12 February 1990) was one of the most tumultuous periods of 20th century European history. Consequently, the underlying conditions upon which Open Skies was premised, both in its original form of 1955 and the renewed version of 1989, were no longer valid. This, however, was not immediately apparent. Primarily, the United States still perceived the Soviet Union as a hostile, though certainly more cooperative than earlier, force. Forward deployed Soviet troops were still present in Central Europe, the USSR still enjoyed some conventional superiority and had far more armaments and military equipment than necessary under the doctrine of reasonable sufficiency. Even though Soviet political intentions seemed to be different and one strategic advantage, namely loyal allies willing to host forward deployed troops, was gone, the military capabilities of the Soviet Union remained comparable to those of earlier times. Western strategic planners were in many cases reluctant to notice the depth of the transpiring change. It is for this reason that the fundamental rearrangement of European security conditions had no immediate bearing upon Open Skies in that the expectations set for the regime did not change.

The goals of the Bush initiative thus remained: “to increase mutual confidence through increased scrutiny of each other’s activities, and to test President Gorbachev’s commitment to *glasnost*.”[22] Neither objective was sufficiently specific to answer those questions that were pertinent to the establishment of the Open Skies regime, however. It was not clear what flights would have had to be carried out and what they would have had to monitor in order for confidence building to occur. Moreover, it was fairly difficult to discern exactly what Soviet concessions would have been compatible with glasnost.

As in the case of its predecessors, the new multilateral Open Skies proposal contained few details to speak of. Even Washington had little clue as to what to expect. In fact, the US initiative hardly went beyond the words pronounced by President Bush. Moreover, NATO allies had not been briefed prior to the 12 May 1989 speech. Following the speech, the surprised NATO heads of state and government issued the following reserved reaction:

> We consider as an important initiative President Bush's call for an open skies regime intended to improve confidence among States through reconnaissance flights, and to contribute to the transparency of military activity, to arms control and to public awareness. It will be the subject of careful study and wide-ranging consultations.[23]

The second sentence clearly indicated the dissatisfaction of the NATO allies with the lack of consultation prior to the 12 May 1989 announcement. This factor contributed to the ensuing hasty preparation of a more detailed notion of the regime, primarily in Washington. For the United States, though, the more pressing concern had to do with the fact that Open Skies was going to subject the US homeland territory to extensive aerial monitoring for the first time, and the attending strategic consequences of this.[24]

In view of the above, the main US concern in preparing for the negotiations on Open Skies related to the intrusiveness of the future regime. The United States intended to create a balance between "maximizing openness and minimizing any harm to US national security that might result from Warsaw Pact overflights".[25] The cautious estimates of the Pentagon and of the US intelligence community suggested that one Warsaw Treaty overflight per week (carried out with sufficient advance notice) would not pose an unacceptable security risk to sensitive US programmes and installations. By August 1989, thus, the US position had settled on a moderately intrusive Open Skies regime.

NATO consultations began later that month. The Senior Political Committee of the organization established a drafting group that prepared a paper laying out the basic elements of an Open Skies regime. It was approved by the North Atlantic Council in December 1989 as an Annex to the document of the Council meeting.[26] The draft played an important role for two reasons. First, the drafting required that major internal differences in NATO be sorted out. Second, it proved to be a document of lasting relevance. Due to the severe difficulties of reaching a compromise within the Alliance, NATO states were subsequently unwilling to depart much from what had been achieved, and thus insisted that a final agreement on Open Skies closely follow the principles set out in the document.

The fundamental difference within NATO occurred between the United States and some European allies, most vocally represented by France. It would be premature to enter into details concerning the points of disagreement.[27] Broadly put, the United States emphasized the importance of a bloc-to-bloc approach, which France rejected.[28] This time France had persuasive arguments, however. Whereas Washington kept seeing the Open Skies process through the framework of its strategic relationship with Moscow, Paris—increasingly accompanied by other Western European countries—intended to redefine that framework. France argued that the regime should be organized strictly on the basis of individual states noting that "the westward-leaning members of the Warsaw Treaty might be more interested in overflying the Soviet Union than Western Europe".[29] Likewise, the United States, again seeing Open Skies through the prism of US-Soviet relations, was reluctant to involve the non-aligned states in an eventual arrangement. France, eager to break the preponderance of US-Soviet relations in European security matters, was in favour.

The NATO consultations ended with compromise that reflected mostly the US position. As it was stated following the first NATO-Soviet consultations:

> Because of the complexity of establishing such a regime, it would initially be limited to interested members of NATO and the Warsaw Pact. … Next steps: Further consultations are to be held within the Atlantic Alliance. We anticipate a multilateral conference of interested NATO and Warsaw Pact nations.[30]

The US-Soviet consultations seem to have been easier than those carried out inside NATO. For different reasons the positions of the two superpowers were closer to each other than to those of their respective allies. The Soviet Union wanted to maintain the bloc-to-bloc framework in order to shore up its status within the Warsaw Treaty. In September 1989, when the bilateral consultations took place, it was not at all evident that the process of change active beneath the surface in Central and Eastern Europe would result in the collapse of the Cold War order in such a short period of time. The US felt it important not to challenge the Soviet Union unnecessarily and prematurely. Furthermore, both countries felt more comfortable with their well-established bilateral negotiation framework, which they were understandably reluctant to discard in favour an untried new one.

Before the fall of the Berlin wall, Canadian Prime Minister Brian Mulroney offered to host an Open Skies conference in Ottawa in January or February 1990. By the time the foreign ministers and the diplomats met in the capital of Canada on 12 February 1990, the fundamental change in European politics could no longer be ignored. The agenda of the meeting, particularly in its initial foreign ministerial phase, was overshadowed by the two major issues of German reunification and the stationing of foreign troops in Europe under the CFE Treaty negotiated in Vienna, neither of which had much to do with the professed purpose of the conference. In terms of Open Skies discussions, the difference between the NATO and the Soviet positions were and remained fundamental. In view of the wide gap between the two sides it would be too fanciful to conclude which side "won" in Ottawa.

Irrespective of their purported bloc-to-bloc arrangement, the Ottawa talks signalled clearly for the first time that a new structure of international relations was taking shape. On the one hand, the Soviet Union began to represent strictly itself, and no longer even claimed to speak on behalf of its Warsaw Treaty allies. Coming to the conference, the Soviets had sought to present a unified Warsaw Treaty proposal. Such a proposal, however, had been wrought only at the expense of concessions made in the course of one full month of negotiations with its allies, something that the Soviets feverishly resented. Hence, after presenting the common position, the USSR reverted to its earlier stance on some of the substantive, controversial issues. With the Warsaw Treaty clearly moribund, Moscow no longer felt the need to pay heed to the views of its ostensible allies,[31] and instead concentrated on countering the NATO position. On the other hand, some Eastern European countries began to regard themselves more as mediators between the Soviet Union and the US than as Soviet allies. Moreover, many smaller members of the Warsaw Treaty started to emphasize the need to draft an agreement of 23 sovereign states rather than two alliances. The European political order of the Cold War had passed into history.

The Ottawa conference ended with the result that the parties agreed to differ on all of the major issues. Talks at the conference had been divided into working expert groups covering a range of topics: a) Aircraft and sensors, inspection of aircraft and sensors, the role and status of inspectors on board of observation aircraft; b) Quotas, geographical scope and limitations; c) The conduct of observation flights, flight safety, transit above third states; and d) The nature of the agreement, Consultative Commission, liability, status of personnel, further measures. After the two weeks of deliberations only the latter working group could present some results on fairly simple issues such as depositories, entry into force and authentic texts, while the others all faced major problems.

The Ottawa conference showed that it is extremely difficult to negotiate an arms control arrangement when relations between the parties are in great flux. By the time the conference was convened political relations in Europe were well on their way to being radically revised. Under the circumstances the parties could either continue their talks as if nothing had changed at the risk of drawing an agreement that no longer corresponded to any perceivable reality[32] or they could postpone decisions until the contours of the emerging political relations had become more clearly defined and seek to obtain a treaty that in fact reflected the changed circumstances. In view of the results of the conference, the latter possibility prevailed.

With little agreement achieved at the Ottawa conference, the discussions continued at Budapest[33] two months later between 23 April and 10 May 1990. In the light of the experience at Ottawa there was little hope of arriving at an agreement in time for the close of the meeting, although, foreign ministers had already been asked to reserve the dates of 11-12 May for a signing ceremony. Despite the subdued expectations the meeting did witness some cautious advances and slight shifts of positions. To begin with, the United States began to modify its stance and to apply increasing pressure on the USSR. The revised US policy was a mixture of sticks and carrots. The United States consolidated East-Central European support behind NATO positions and made it plain to the Soviet Union that it was isolated, while at the same time it showed itself accommodating towards Soviet concerns over the technological superiority of the West and the advantages which this might bestow.[34] On the Soviet side flexibility began to creep in. The USSR accepted that synthetic aperture radar (SAR) would be permitted on observation aircraft, though with strictly limited resolution capability the exact definition of which remained undecided, and differences were somewhat reduced over flight quotas, although the issue remained unresolved especially that now it had become clear that every party, including Warsaw Treaty members, was primarily interested in overflying the Soviet Union.[35]

The Budapest conference was a necessary if not particularly successful stage in the evolution of Open Skies. Its most notable feature was the shift in the US position away from a bloc-to-bloc perspective. The source of this change is too complex to be untangled, although, two factors may be cited. One, the European members of NATO had placed a lot of emphasis in intra-alliance discussions on the irrevocably changed conditions of political relations emerging in Europe and the consequent need for a commensurate shift in the approach to relations between East and West. Two, direct contact by US officials with Eastern European personalities such as Vaclav Havel or Lech Walesa as well as the actual orientation favourable to NATO evident in the policies of Eastern European countries at the negotiating table, particularly in the concomitant CFE Treaty negotiations, combined with their declared unwillingness to continue to host Soviet troops and armaments on their territories, helped convince the Americans that the time had come to push for the emancipation of the Warsaw Treaty countries from the Soviet grip. Subsequently, the US position may also have been influenced by the failure to include aerial observation in the monitoring means specified in the CFE Treaty, which increased the importance of an eventual Open Skies accord, and which may have induced the US to adopt a somewhat more concessionary stance on certain issues.[36]

When the Budapest conference came to an end it was clear that talks would not resume any time soon. German unification dominated high politics in Europe, and the CFE talks kept the arms control community sufficiently busy. Still, aerial monitoring of conventional arms limitations, one of the foreseen functions of Open Skies, constituted an important link between CFE and Open Skies. As it turned out, progress on Open Skies became inextricably linked with the proceedings and outcome of the CFE negotiations, namely the attempt and ultimate inability to include aerial monitoring under the CFE verification framework.

In the wake of the Budapest conference, attempts to make aerial inspection part of the CFE Treaty intensified. On 14 June 1990 the so-called group of 16, member states of NATO, tabled its aerial inspection protocol. This move was urged by the United States and Canada, which considered that aerial monitoring could contribute to a cost-effective verification system that could reduce the number of on-site inspections by 25 to 30%. Other Western delegations, notably Germany and the United Kingdom, had doubts about the wisdom of starting discussions about such a complicated matter as aerial inspection at such a late stage in the CFE negotiations, and feared that the attempt could delay the reaching of an accord. Their concerns were justified by the experience of two rounds of the Open Skies negotiations. It would have been immensely difficult to bridge the gap between the Western and the Soviet positions even if the NATO proposal focused on technical details and made no mention of the two issues where the most disagreement was likely, namely the ownership of the aircraft used for carrying out inspections and the types of sensors those aircraft were permitted to carry. The group of 7, the member states of the Warsaw Treaty, tabled its own document on aerial inspection on 7 August 1990. The document did not address any of the fundamental issues, like ownership of inspection aircraft, type of applicable sensors, inspection quotas or information sharing.[37] With little scope for agreement, and with growing concerns over the needless delay of reaching an accord or worse, the attempt to incorporate aerial monitoring within the CFE framework was abandoned.

The day before the signature of the CFE Treaty in Paris the states parties exchanged information on their military deployments, as required. The Soviet Union, which had redeployed thousands of pieces of armaments outside of the treaty-covered area and had reassigned three army divisions to naval infantry effectively placing them outside the scope of the Treaty, notified a surprisingly small total number of treaty-limited armaments and equipment and failed to give any account of the armaments and equipment of the reassigned units. As the Dutch ambassador to the talks put it later: "… on the eve of those euphoric days of the Paris Summit … the countries which had participated in the Treaty negotiations were in for a cold shower."[38]

The Soviets' withdrawal of the more than 55,000 pieces of armaments out of the geographical area covered by the CFE Treaty had placed 16,400 battle tanks, 15,900 armoured combat vehicles and 25,000 pieces of artillery out of the reach of the Treaty's inspection regime, and as such susceptible only to monitoring by national technical means, which were unavailable to most parties to the accord. For obvious reasons, this situation was unacceptable, and an obstacle to the Treaty's entry into force. More than half a year was needed to straighten out the problem. Finally, the US and the USSR struck a compromise whereby the Soviet Union pledged that the withdrawn armaments would "not be used to create a strategic reserve of operational groupings, and will not be stored in a way permitting their rapid return to the area of application"[39] and committed itself to provide information about the locations and quantity of withdrawn equipment as of 1 July 1991.

The Soviet antics of redeploying what should have been equipment subject to limitations and inspection under the CFE Treaty and the subsequent compromise on this issue had created a peculiar situation. Although the withdrawn equipment was now subject to the exchange of information, it still remained beyond the reach of verification. Open Skies, however, with its broader territorial scope, held the potential to remedy this condition, hence its increased importance from the point of view of both NATO and Eastern European countries. But how about from the viewpoint of the Soviet Union? Did the prevailing circumstances not militate against opening the Soviet Far East to aerial overflight, and thus against Open Skies? Ultimately, from the negotiating history of Open Skies it is clear that the opening of the Soviet Far East to aerial monitoring was balanced against by the opening to aerial monitoring of the territories of the United States and Canada. Soviet strategists attributed great importance to the possibility of overflying the United States, and Open Skies offered the only means of achieving this. The Soviet Union also demanded that military bases of the parties on the territory of third countries, like those of the US in the Philippines, be subject to overflight as well, but the request proved both unacceptable to the US and unworkable, and so had to be dropped at a late stage of the talks.[40]

Besides a reinforced strategic importance, Open Skies also benefited from the exchanges around the ill-fated effort to endow the CFE Treaty with an aerial monitoring regime. Namely, the positions of the parties on the issue continued to soften. Unsurprisingly, given what had transpired, but also due to a diminution of the estimated Soviet threat, the softening was most evident on NATO's side. As such, the draft inspection protocol tabled by NATO now adopted the following vague formulation: "Within the area of application, each Party concerned shall be obliged to receive, and have the right to conduct a specified number of aerial inspection overflights as an essential component of Treaty monitoring and verification." The modalities of these obligations remained to be worked out later: "(Details of the aerial inspection regime will be developed.)"[41] Moreover, the Alliance revised its earlier stance concerning the sharing of raw data, the performance of sensors and the ownership of observation aircraft.

Although the summer of 1991 had not been the most conducive to dealing with Open Skies, four events had reconfirmed the need to achieve an agreement. One, there was the firm commitment of the parties to continue the negotiations until the process was completed by the adoption of a multilateral Open Skies agreement. Two, Hungary and Romania signed a bilateral Open Skies agreement during the recess of the multilateral talks in May 1991. This was the first breakthrough for an Open Skies approach on the practical level.[42] Three, despite the failure to include aerial monitoring in the CFE Treaty, the commitment to eventually agree on aerial monitoring was clearly there. As such, the Treaty stipulated that after the end of the completion of the 40 months reduction phase "each State Party shall have the right to conduct, and each State Party with territory within the area of application shall have the obligation to accept, an agreed number of aerial inspections within the area of application. Such agreed numbers and other applicable provisions shall be developed during" follow-on negotiations.[43] Four, the already noted 57,300 pieces of heavy armaments redeployed by the Soviet Union outside the zone of application of the CFE Treaty, demanded some form of monitoring.

In sum, the critical mass for completing the Open Skies negotiations was present by the summer of 1991. What remained to be seen was how the deadlock was going to be broken. As it turned out, the impetus came from Germany. Little after the Soviets had agreed to partially regularize the situation of the pieces of equipment withdrawn from the CFE Treaty zone of application, German Foreign Minister Hans-Dietrich Genscher, in taking over the presidency of the Western European Union (WEU), sent a letter on behalf of the WEU to his Soviet counterpart proposing that the Open Skies talks recommence.[44] The initiative was skillfully conceived in two senses. One, it managed Soviet sensitivities—formally, the proposal was coming from an organization more palatable to the Soviets than NATO. Two, being launched by Genscher, who, as a result of the German reunification negotiations, had acquired a certain personal credibility in Moscow, the initiative was bound to be better received than otherwise.

The renewed impetus toward Open Skies, notwithstanding, in some areas, the positions of NATO and the Soviet Union continued to remain so far apart that the differences between them seemed unbridgeable. In situations such as this the skill of diplomats is of little use in overcoming the blockage. This was the case here as well. It took an event of world political importance to help move out of the stalemate. The abortive coup of August 1991 changed everything.

When the negotiating teams reassembled in Vienna in early September for an exploratory session, the USSR delegation had no new instructions, but was so confident of their imminent arrival that it predicated its entire behaviour during the ensuing negotiations on the assumption that it would soon have the flexibility needed to end the talks successfully. Informal discussions focused almost exclusively on possible compromises in the Soviet position. At the end of that week in September, the Soviet Union's representative did not demur in the proposal to set the beginning of the Helsinki follow-up meeting in March 1992 as the target for the end of the Open Skies negotiation.[45]

It would be incorrect to assume, however, that the remaining months that led to the signature of the Open Skies Treaty represented a simple technical exercise. The on going shifts in political circumstances continued to take their toll. Then there was also the fact that multilateral negotiations are generally more complicated than bilateral ones. In all, by the time the parties reconvened at Vienna in November to try to bring the discussions to a close, a lot of work still remained to be done. A determined push did result in the drafting of approximately one third of the Treaty text including the appendices by Christmas, however. Issues such as the designation of aircraft, transit procedures and deviations from the flight plan, among others, were successfully resolved, whereas others such as sensors, their resolution and processing, and the sharing of information, remained outstanding.

The final months of the talks, that is, the first months of 1992, brought a host of new problems that stemmed from the dissolution of the Soviet

Union. The question of succession created a situation where it was no longer clear which successor states should rightfully assume the USSR's place in the discussions. Russia, as in other fora, such as the United Nations and the CSCE, was immediately regarded as a successor state. Belarus and Ukraine were accepted in a somewhat lesser status until they became members of the CSCE. This raised the peculiar question of the participation of the European neutrals, however. Countries like Switzerland, Sweden and others, which had initially been left out of the negotiation process, now tried to join the talks on the ground that with the dissolution of the bloc-to-bloc approach engendered by the formal collapse of the Warsaw Treaty, the justification for their initial exclusion had now vanished.[46] Still, no difficulty could derail the process at this stage. With Russia willing to cooperate and with little appetite on anyone's part to reverse the process, the successful outcome of the negotiations was assured.

The Open Skies Treaty was signed on 24 March 1992 by the foreign ministers of the states parties. However, as the past decade has shown, the signing of the Treaty was certainly not to be the end of the story. In order to understand the main achievements and the pending problems of the Open Skies Treaty it is necessary to analyze the main issues that dominated the two years of negotiations, their resolution and the Treaty's subsequent evolution from signature to the completion of the ratification process.

2.3 NEGOTIATION OF THE TREATY SUBSTANCE AND ANALYSIS OF THE RESULTS

The radical political transformations of the 1980s and the 1990s represented the background against which the Open Skies Treaty negotiations took place. So far we have shown how those transformation impacted upon the negotiations. Now we turn to how the negotiations were actually conducted and how compromise was reached on some of the major issues. We do not attempt a comprehensive analysis of the entirety of the discussions for two reasons. Due to the huge complexity and often the clearly technical character of the talks, it is neither possible nor necessary to do so.[47] Nevertheless, in some of the instances presented here the story of the talks is intriguing. It tells a lot about national interests, their rearrangement and the cohesion of alliance(s) or the lack thereof. Whereas heretofore we have focused on the broad picture and how structural change in the political relations of the Cold War impacted upon Open Skies, now we delve into the intricacies of the negotiations themselves, which in turn also tell a lot about the large picture.

2.3.1 Definitions

Definitions are an inherent part of every major arms control agreement. In case of the Open Skies Treaty, 35 terms are listed under Article II.[48] They deal with the status of the parties, the area of application of the Treaty, the equipment used in the observation flights, the status and role of the personnel and so on. Some of them are linked with other complex matters or mask the controversial issues behind the compromise.[49]

2.3.1.1 The Status of the States Parties

With the decision to shift Open Skies negotiations onto a multilateral basis, the question of states parties was bound to come up. Initially the multilateralization of the talks posed little difficulty. Although it was evident that the negotiations would involve NATO and Warsaw Treaty members, the eventual participation of neutral and non-aligned countries remained open to question. Despite disagreement on granting them a full status at the talks, a compromise was worked out to minimize the sharp distinction between alliance members and non-aligned states so that the latter could still take part in the discussions in one form or another. The participation of non-aligned states in the Open Skies discussions did not translate into their inclusion in the Treaty, however.

At the Ottawa conference, NATO's position on the participation of non-aligned states in the Open Skies discussions, outlined in the Basic Elements paper,[50] was that "Open Skies is initially open to all members of the Atlantic Alliance and the Warsaw Treaty Organization", but that NATO "will be ready to consider at an appropriate time the wish of any other European country to participate in the Open Skies regime". This guarded position reflected the synthesis of different considerations. For the United States, the extension of the talks to involve alliance members already constituted a radical step. As well, though the Warsaw Treaty was clearly faltering, the alliance divide in Europe was still in place, and its imminent collapse was hardly foreseeable. Finally, NATO countries were of the view that neutral countries would not be in favour of joining Open Skies, due to the expenses of aerial inspections.

Despite further evidence of Warsaw Treaty decay, the alliance framework of the talks remained intact at Budapest. As a prelude to events still to come, many of the Eastern European countries sought to diminish this constraint[51] so as to further lessen the sway of the Warsaw Treaty. However, since the discussions ended without result and with little hope of continuation, the matter of states parties lost its relevance together with other issues.

The issue of Treaty participation next re-emerged in 1991 under severely different circumstances. By the middle of that year the Warsaw Treaty had been formally dissolved and the Soviet Union was coming undone. The legitimacy of formal differentiation between allied and non-aligned countries was thus gone, as the former members of the Warsaw Treaty had become non-aligned. Furthermore, two other complications now affected the states parties question. One had to do with how to handle the matter of Soviet successor states, the other related to the quarrel between Greece and Turkey that had erupted over the participation of Cyprus in the Treaty. The ensuing debate made it clear that the issue of Treaty membership had become a delicate matter.

The question of Soviet succession turned politically delicate the day the Russian Federation took up the seat of the Soviet Union at the talks. At the Almaty meeting of 21 December 1991 an agreement was achieved which stipulated that Russia would take the seat of the Soviet Union in international organizations, including the United Nations. This arrangement, however, did not extend to on-going negotiations. The problem stemmed furthermore from the fact that the involvement of Belarus and Ukraine in the Treaty was seen as essential. Beyond important political reasons, namely the early and symbolic recognition of Belarussian and Ukrainian sovereignty, there were also geo-strategic considerations. It suffices to look at the map of Europe to understand that the airspace of Belarus and Ukraine represents a nearly indispensable connection between Russia and the rest of Europe. The absence of these two countries from the Treaty would have clearly left a crucial gap. The negotiating states were thus agreed that Belarus and Ukraine too had to be involved in the talks; however, a complication arose from the fact that Belarus and Ukraine, contrary to Russia, due to the above-mentioned arrangement, were not parties to the CSCE. As the Open Skies negotiations unfolded outside the CSCE framework, it would have been possible to admit Belarus and Ukraine without them being members of the CSCE, save for the opposition of one party. A procedural way out of the impasse was found by the Canadian delegation chairing the plenary session, which recommended that the formal plenary session be suspended and that it continue informally until the upcoming Prague meeting of the CSCE Council, at which time Belarus and Ukraine could join the CSCE. Belarus and Ukraine, thus, formally entered the Open Skies talks in January 1992.[52]

The remaining nine Soviet successor states were granted preferential status with respect to accession. As such, they could either sign the Treaty before it entered into force and ratify it according to the provisions provided, or "accede to it at any time by depositing an instrument of accession" (Art. XVII, para. 3). This certainly represented a privileged treatment, as the nine states could unilaterally decide their accession without the need for approval by the other Treaty state parties. Since the signature of the Treaty, only two of the nine successor states, Georgia and Kyrgyzstan, have taken advantage of this privilege. This leaves the possibility of a further seven countries acceding to the Treaty.

The Open Skies Treaty also makes it possible for states other than the original signatories and the remaining Soviet successor states to join. The Treaty stipulates that "For six months after entry into force of Treaty" potential parties "may apply for accession by submitting a written request"... "The matter shall be considered at the next regular meeting of the Open Skies Consultative Commission and decided in due course." (Art. XVII, para. 4) Two constraints are placed on accession, however. One, only states belonging to the OSCE may accede to the Treaty according to this rule.[53] In view of the regional character of Open Skies, this is understandable. Two, an application for accession to the Treaty is subject to the approval of the OSCC. The Treaty does not set a deadline for such an approval; it merely states that an accession request "shall be considered at the next regular meeting" of the OSCC, which "shall take decisions or make recommendations by consensus". This implies both that the OSCC may decide on an eventual application for accession on its own time, and that any state already party to the Treaty may block the request. The latter may not pose any difficulties in most cases, as has already been demonstrated,[54] but it could conceivably lead to deadlock, as in the case of the request for accession by Republic of Cyprus, which was vetoed by

Turkey. Needless to add that acceding countries may later on also block further accessions, which perhaps suggests that in practice the sequence in which new member states join the Treaty may have some consequence for the possibility of other interested parties to accede at a later date.

In addition to OSCE states, the Open Skies Treaty also makes allowance for accession by non-European countries. Non-European countries may request to join the Treaty six months after its entry into force. Once again, prospective applications require the endorsement of the OSCC, although, the OSCC is not actually obliged to consider such applications.[55] During the Open Skies negotiations, Japan expressed its interest to join the emerging regime. As Open Skies is a particularly valuable instrument in the regional context there is no reason to assume that there would be requests for accession from other continents. It is also conceivable, however, that countries of other regions would opt for establishing their own regional regimes without attempting to accede the 1992 Treaty on Open Skies. Open Skies may in fact set an example for other regions, which may follow suit and draft a similar agreement. Japan, in view of its strategic challenge and technological capabilities, may well be the initiator of a similar process in its neighbourhood.

In sum, the Open Skies Treaty established a semi-open accession regime with three different categories of parties in mind: the NATO and former Warsaw Treaty members including Belarus, Russia and Ukraine, which had the right to sign the Treaty before it entered into force, the other nine Soviet successors which enjoyed the possibilities outlined above, and other states that may eventually want to join the Treaty, namely other OSCE member states or other non-European countries, whose accession was to be subject to approval by the OSCC.

In terms of the legal requirements of the Treaty, each member state party is obliged to fulfill them on its own. To become a member party, each country must sign and ratify the Treaty and deposit its instrument of ratification with one of the depositaries. In addition, states parties can form two sorts of "associations". They can form groups of parties or they can—as requested by the Benelux countries—establish a special entity, which to some extent resembles a group.

The idea of setting up special rules for the *Benelux countries* was present since an early stage of the Open Skies talks. Initially, the three countries sought to form a so-called "combined party" under the Treaty. The NATO position presented at Budapest reflected this intention, as it put forth the concept of a combined party modeled on the Benelux case: no more than three parties shall belong to a combined party and the territory of neither party shall exceed 100,000 square kilometres. Here, a concern to avoid the (re-)emergence of alliances under the guise of a combined party is evident. Finally, the formulation gave a certain preference to small countries, which as will be elaborated later, could be expected to meet certain difficulties in the course of Treaty implementation.

Despite interest in forming an association of some sorts, the Benelux countries initially disagreed on whether they preferred to be considered as a case apart or to be treated as an ordinary "group of parties". Belgium and Luxembourg preferred the former, whereas the Netherlands was in favour of the latter. Eventually, Dutch opinion prevailed so that "the three States Parties have agreed to be considered a single state party for the purposes of specified Articles and Annexes, in all other cases, they are considered to be individual states parties."[56] Later in the negotiations, the Benelux countries also suggested that groups of countries might also be able to share the equipment used for the purposes of the Treaty and to share the burden of carrying out and receiving observation flights as a means of reducing expenses.

Although the Benelux countries eventually decided against it, the Open Skies Treaty does permit states parties to form groups either when they enter the Treaty or at any time thereafter. During the negotiation of the Treaty, the French delegation developed a concept according to which each state party, which holds quotas, can form a group of parties. Group members can redistribute their active quotas, but not their passive quotas (Art. III, Section II, para. 2). The rationale for this is clear: since some parties are more capable of carrying out inspections than others, the formation of groups of states able to redistribute amongst themselves their active quotas but not their passive quotas can result in significant economies without impinging on the basic rights of each state party to be able to inspect any other party. A group of parties has been formed by the member states of the *Western European Union*.

The German delegation developed another approach to the issue of groups of states during the Open Skies talks. Under the German formula parties forming a group are allowed to hold active and passive quotas together, thus resembling a single entity. Under the German method, for instance, an observation flight over any member(s) of the group is counted as one flight irrespective of the number of group members overflown. The *Russian Federation and Belarus* formed a group according to this scheme. They unified their passive quota and, by implication, their total active quota, although the distribution of this remained unchanged. As such, all observation flights conducted by either Russia or Belarus are conducted on behalf of the group and charged against their total active group quota. On the other hand, an observing party may decide to overfly one or the other country or both of them, for that matter. An overflight over the airspace of both countries would count as one flight against the active quota of the observing party (Art. III, Section II, para. 3).

Beyond this fundamental difference in the two modalities of dealing with groups of states parties, there are also some commonalities (see Art. III, Section II, para. 6). Specifically, the Treaty grants permission to the parties forming a group to shift their status from one format to another. This means that parties, which formed a group under the looser format (Art. III, Section II, para. 2), may decide to deepen cooperation and move to the tighter one (Art. III, Section II, para. 3). The shift may also happen the other way around. In addition, under both formats, parties are also granted the right to withdraw from a group. Interestingly, the Treaty does not provide for the right of accession to a group. It makes such accession conditional on the consent of the group when it declares that a group of states parties "may admit further States Parties which hold quotas". Since there is reason to assume that such decisions would be taken by consensus, it means that admittance to a group is contingent on the agreement of all the members of the group. All decisions taken under this regulation are to enter into force no earlier than six months after all the other states parties have been notified. This requirement guarantees that shifts in the membership of status of group parties are clear to all other states, which may undertake appropriate preparations to take account of the new developments.

It is premature to predict how these rules will be applied, although, it seems unlikely that any additional groups will be formed in the near future. Instead, it is far more probable that parties will engage in technical cooperation without actually establishing groups of states parties.

2.3.1.2 The Area of Application

Although the term "area of application" is not part of the definitions outlined in the Treaty, the issue was subject to debate during the Open Skies negotiations. The most important decision with regard to the scope of the Treaty's area of application had in fact been taken prior to the beginning of negotiations. The US decision to launch Open Skies as a bloc-to-bloc initiative including all the members of NATO and the Warsaw Treaty to a large extent predetermined the eventual area of application of the Treaty. The starting positions of both NATO and the Warsaw Treaty shared the view that "All territories of the participants in North America and Asia, as well as in Europe will be included".[57] The draft of the Soviet Union prepared for the Ottawa conference stated that the "Open Skies regime will extend to the territory of all states parties, including the island territories that belong to them".[58] This meant that unlike other European arrangements, such as those on CSBMs or the CFE Treaty, the territory of the United States and Canada on the one hand and that of the extra-European part of those successor states of the Soviet Union, which are parties to the Treaty (most importantly the Russian far East), were going to be subject to Open Skies observation flights.[59] The importance of this is that the United States mainland, Canada and Siberia all became subject to a regional arms control regime for the first time.

Nevertheless, the broad agreement of the two sides on the Treaty area of application contained one significant difference, namely the Soviet desire that the Treaty zone of application include the territories of non-parties hosting military bases of Open Skies states.[60] Evidently, the Soviet position could hardly be acceptable to the United States, which unlike the Soviet Union, was not contiguous to its allies and was hence dependent on extra-territorial bases. Moreover, it would have been practically impossible to guarantee the consent of some of the non-participating states for a variety of reasons not necessarily related to European security matters. The transparency acceptable in Europe at the end of the 1980s was in fact unacceptable elsewhere. In view of the impracticability of this position, which may well have been put forth by those inside the USSR who opposed Open Skies, the idea was gradually abandoned.

Another issue related to the Treaty's area of application was the delimitation of observation flights. While the original NATO proposal contained no provisions in this respect, the Soviet one went into details.

Most controversially, the Soviets proposed that areas of a country could be excluded from observation on the grounds of “national security”. Furthermore, the Soviets also advanced the notion of temporarily closed areas, including training areas, launch areas of space objects, etc., for safety reasons.[61] Later they also demanded that overflights keep a minimum altitude of 10,000 metres above nuclear power plants, chemical plants and densely populated areas.[62] Although the Soviet suggestion that certain areas be excluded from observation found no support even among its allies, a compromise on special regulation for the overflight of objects such as nuclear power stations, large chemical factories and some others was eventually agreed in the final stages of the negotiations at Vienna. The compromise entailed referring the Open Skies Treaty to the “hazardous airspace” regulation of the International Civil Aviation Organization (ICAO), which made the demarcation of prohibited, restricted and dangerous areas possible on the grounds of flight safety, public safety and environmental protection. The reference to prohibiting overflight on the basis of national security was given up *de facto*. This was apparently the single most important matter for many.[63]

2.3.2 Sensors

Initially the Western states tried to negotiate a sizeable and diverse set of allowable sensors.[64] In contrast, the Soviet Union would accept only optical framing and panoramic cameras and SAR with a coarse resolution of 10 metres. A compromise reached by the US and Soviet Foreign Ministers, James Baker and Eduard Shevardnadse, in August 1990 established the criterion of all-weather capability. This capability is provided in principle by radar (SAR) sensors. Such sensors can take images through cloud cover and at night. However, the finally agreed radar resolution of 3 metres is too coarse to allow the reliable detection of individual objects such as land vehicles. This made it clear that the backbone of the sensor set would be optical framing and panoramic cameras with an agreed resolution of 30 centimetres. The images from such cameras, when analyzed in stereo pairs, enable the recognition of different types of land vehicles, which are relevant in a verification and military confidence-building context.

Upon the insistence of Western states, Russia also agreed to include infrared line scanners with a resolution of 50 centimetres. These sensors can provide temperature images at day and night. The scanners are obstructed by clouds but can image through light haze. The sensors were introduced in order to support data taking during winter in northern regions when illumination by sunlight is short and faint.[65]

Video cameras were introduced as a separate class since Russia objected to the more general category of electro-optical sensors.[66] The Western states accepted this solution since it kept the door open for a future introduction of electro-optical sensors. This will become an issue in the OSCC later on because electro-optical sensors with enhanced capabilities are in the process of revolutionizing the civilian airborne remote sensing market.[67] The OSCC can agree by consensus on the subsequent introduction of additional sensor categories and on improvements of sensor capabilities (Art. IV, para. 3).

In short, the agreed *full sensor set* comprised:

- one vertical and two oblique optical framing cameras at 30 centimetres resolution;
- one optical panorama camera at 30 centimetres resolution;
- video cameras at 30 centimetres resolution;
- a thermal infrared line scanner at 50 centimetres resolution at a radiant temperature differential of 3 degrees Celsius; and
- a sideward looking synthetic aperture radar (one side only) at 3 metres resolution capable of recording a strip of up to 25 kilometres within a sideward corridor of 50 kilometres.

The full sensor capability is to be introduced stepwise. If the *observed* state provides the observation aircraft (taxi option), the full sensor set at the nominal resolution has to be operative by the beginning of the fourth year after the Treaty's entry into force (i.e., 1 January 2006). If the observing state provides the aircraft, the SAR resolution shall not be worse than 6 metres. In the first three years after entry into force a reduced capability is allowed (incomplete sensor set, higher than nominal resolution). Infrared line scanners can only be used *during the first three years* if agreed by both the observing and observed parties (Art. XVIII).

Resolution was defined in Article II as "the minimum distance on the ground between two closely located objects distinguishable as separate objects." This is the traditional photogrammetric definition of ground resolved distance.[68] The negotiators encountered considerable difficulties when trying to specify procedures for verifying the sensor resolution.

Existing photogrammetric practices were discussed. However, the fear that a sensor might underpass the nominal resolution complicated the negotiations. In consequence, the discussions were not completed before the Treaty's signature in March 1992. The issue was handed over to the OSCC and its sensor commission for completion.

The OSCC took two relevant decisions (Nr. 3 on 29 June 1992 and Nr. 7 on 10 December 1992). To the surprise of many observers the OSCC adopted a different definition of sensor resolution, which—for optical cameras—corresponds to approximately 60 centimetres ground resolved distance.[69] This performance still allows detection of vehicles and general identification of the vehicle type (e.g., car, truck, tank).[70]

Two more regulations on sensors are worth mentioning. First, no data taking is permitted during *transit flights*. Hence, each sensor has to have a cover or other means which prevents data taking during transit flights. Sensor covers or inhibiting devices must be removable or operable only from outside the aircraft (Art. IV). Second, *real-time* data processing and display is permitted for checking sensor functionality in flight, whereas real-time data transmission via satellite or directly to a ground station is strictly forbidden. This regulation is meant to prevent misuse of data taking for targeting quasi real-time attacks. The time flow of an observation mission leaves at least one day between the taking of data and the handing over of the developed film or other image data to the observing party.

2.3.3 Flight Quotas

According to the Treaty each state party has the right to conduct a certain number of observation flights using unarmed fixed-wing aircraft (active quota) and is obliged to accept observation flights by other state parties over its territory (passive quota).[71] No state party is obliged to accept more than one observation flight within 96 hours (Art. II, para. 1). The total active quota of a party can equal its passive quota but the possibilities for overflight are limited by the passive quotas of parties to be overflown. The allocation of passive quotas amongst the different state parties is given in Table 2.1.[72] As an example, Germany and Italy have to receive up to 12 overflights each per year, while the Russia-Belarus group and the United States are obliged to receive up to 42 overflights each. The active quota of a state is usually equal to its passive quota. For the first three years of Treaty implementation (i.e., 2002-2005) all quotas are capped at 75%.

Table 2.1: Flight Quotas and Maximum Distances[73]
The table includes also states which acceded to the Treaty after its entry into force (status as of 1 April 2004).

Country	Quotas[a]	Maximum Flight distance (km)[b]
Russia-Belarus Group	42	5,000-7,200
United States	42	3,750-4,900
Canada	12	5,100-6,150
France	12	2,078-2,715
Germany	12	1,300
Italy	12	2,015
Turkey	12	1,500
Ukraine	12	2,100
United Kingdom	12	1,500
Norway	7	1,700
Sweden	7	1,700
Benelux Group[c]	6	945
Denmark[d]	6	250-5,800[d]
Poland	6	1,400
Romania	6	900
Finland	5	1,400
Bosnia and Herzegovina	4	t.b.d.
Bulgaria	4	660
Czech & Slovak Republic[e]	4	800
Georgia	4	1,255
Greece	4	910-1,170
Hungary	4	860
Iceland	4	1,500
Latvia	4	800
Spain	4	750-2,000
Portugal	2	1,030-1,700
Kyrgyzstan	-	-

Notes:

a These numbers apply to the period of full implementation. Signatories are only obliged to receive 75% of their passive quota in the first three years of the operation of the Treaty.

b As of 1 April 2004. Some of the distance values set in the Treaty where changed by Decisions of the OSCC.

c Belgium, the Netherlands and Luxembourg.

d Including Greenland.

e At Treaty signature Czechoslovakia was still one state.

The allocation of active quota entitlements proved difficult in the negotiations of the Treaty because almost every party wanted to overfly Russia and the Ukraine. Finally the parties agreed to an initial distribution of active quotas, shown in Table 2.2, which is considerably below the 75% mark. In case of Russia and Belarus only 28 out of 31 possible flights were assigned. Two flights were reserved for Sweden and one for Finland in view of their anticipated accession to the Treaty after its entry into force. This quota could also be used for flights over newly acceding successor republics of the Soviet Union.[74] The distribution shown in Table 2.2 is applicable for the first year of the Treaty (1 August 2002-31 December 2003). The distribution for 2004 and 2005 has to be negotiated (within the 75% limit). If no new agreement can be reached the distribution of Table 2.2 will continue to apply. The member states of the WEU have already agreed to refrain from 5 (in 2004) and 4 (in 2005) flights over Russia, to which they would be entitled.

2.3.4 Time Sequence of Overflights

The time sequence of overflights follows the procedures developed for on-site inspections in the CFE Treaty. The party requesting an overflight must inform the party to be overflown of its intention at least 72 hours before the arrival of its aircraft at a designated point of entry; it shall make every effort to avoid using the minimum pre-notification period over weekends (Art. II, Section I). The party to be overflown must acknowledge receipt within 24 hours and state whether it will allow the overflying country to bring its own aircraft or would exercise its right to provide an aircraft. In deviation from this short notice procedure, Appendix H allows for advance notice of intended flights and for advance coordination of the sequence of flights.[75] In that case the observed party can opt for the taxi option well in advance. After arrival, the aircraft and sensors can be inspected, and the proposed *mission plan* is to be handed to the host country.[76] The observed party has very limited scope for requesting changes to the mission plan. After acceptance or agreement on eventual changes, the mission plan forms the basis for working out a flight course, which is prepared by the state that provides the observation aircraft while following ICAO rules and taking into account existing national flight regulations. Due to the time sequence, the observed state has a minimum of 24 hours advance notice between learning about the mission plan and the commencement of the observation flight. This gives sufficient time for hide-away operations of moveable equipment, but still comprises a certain surprise element.

Each overflight may vary in actual flight path and timing. Flight paths may be unique for every overflight and may follow any course from a straight line to a zigzag or a loop pattern. The observing party is, however, restricted from loitering over one point, except on take-off and landing, and from crossing its own flight path more than once at a certain point. The amount of time the observing party allocates to execute the flight plan is largely at its discretion. Observing parties have a total of 96 hours from the earlier of notified arrival time or actual arrival time to complete their observation overflight. Rest and refueling stops can be made as identified in the mission plan (any airfield is eligible to be designated as a weather or emergency alternative). Thus, the actual time spent collecting data during an Open Skies observation overflight will vary with each occurrence.[77] In practice, 72 hours or less will be available for the observation flight including stopovers.

A typical observation event might proceed as follows:

Day 1:	- arrival
	- point of entry procedure
	- pre-flight inspection
Day 2:	- demonstration flight, if necessary[78]
	- handing over of the mission plan
	- negotiation and agreement on the mission plan
Day 3:	- observation flight
Day 4:	- continuation of observation flight, if required
	- processing of film
	- duplication of film and magnetic tapes
Day 5:	- continuation of film processing and duplication, if necessary
	- completion of mission report
	- departure

Figure 2.1 gives an accurate account of the time sequences to be observed according to Article VI of the Treaty (Figure 1.2 of the Sensor Guidance Document). Article VI of the Treaty rules that the observing state can include the personnel of other states parties in its observation team. This facilitates the formation of multinational observer teams—in the cooperative spirit of the Treaty.

Table 2.2: Initial Distribution of Active Quotas

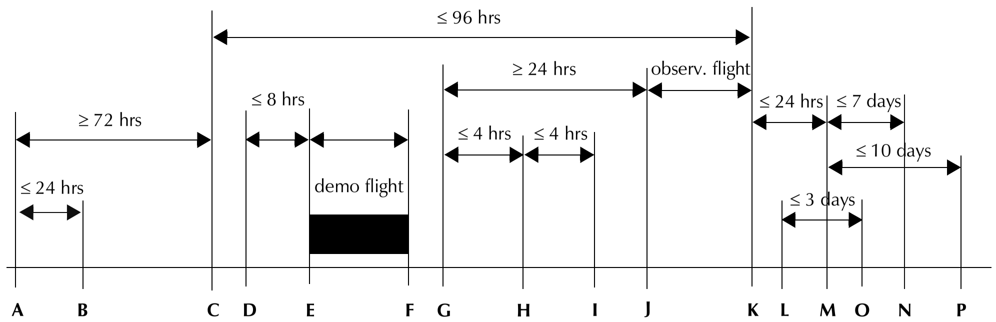
Observing State Party	Observed State Party																						
	Benelux	Bulgaria	Canada	Czechoslovakia	Denmark	France	Georgia	Germany	Greece	Hungary	Iceland	Italy	Kyrgyzstan	Norway	Poland	Portugal	Romania	Russia*	Spain	Turkey	Ukraine	UK	USA
Benelux	v														1			1					
Bulgaria		v							1			1								1			
Canada			v	1											1			2			1[2]		
Czechoslovakia				v				1													1		
Denmark					v										1			1					
France						v											1	3					
Georgia[5]							v																
Germany								v										3			1		
Greece		1							v								1						
Hungary										v							1				1		
Iceland											v												
Italy										1		v						2			1[4]		
Kyrgyzstan[5]													v										
Norway														v	1			2					

Poland								1							v			1			1		
Portugal																v							
Romania		1							1	1							v				1		
Russia*	2		2		2	3		3	1			2		2				v		2		3	4
Spain				1															v				
Turkey		1																2		v	2[3]		
Ukraine				1						1					1		1			2	v		
UK																		3			1	v	
USA																		8			1[1]		v
	BX	BU	CA	CZ	DK	FR		GE	GR	HU	IC	IT		NO	PO	PL	RO	RU	SP	TY	UE	UK	US
Active quota	6	4	12	4	6	12		12	4	4	4	12		7	6	2	6	42	4	12	12	12	42
(75% quota)	4	3	9	3	4	9		9	3	3	3	9		5	4	1	4	30	3	9	9	9	30

* Includes Belarus; [1] Shared with Canada; [2] Shared with USA; [3] One of which is shared with Italy; [4] Shared with Turkey; [5] No quota assigned.

Note: The active quota of the former Czechoslovakia has been divided as follows: one flight by the Czech Republic over Germany and one flight of Slovakia over Ukraine. It was also agreed that Canada, Spain and the Ukraine would have one quota each over both the Czech Republic and the Slovak Republic. Georgia, Iceland and Portugal did not ask for assignment of an active quota during the negotiations, nor was any quota for overflying Georgia, Iceland and Portugal assigned to any party.
Source: P. Jones, "Open Skies: Events in 1992", in J. B. Poole and R. Guthrie (eds), *Verification Report 1993*, VERTIC, London and New York: The Apex Press, 1993, p. 152.

Figure 2.1: Open Skies observation flight line



A: Notify intent to conduct the observation flight.
B: Confirm receipt of the notification of intent to conduct the observation flight.
C: Arrive at point of entry (POE).
C-D: Arrival procedures, inspect covers, get latest weather forecast and information on air traffic and air navigation safety.
D: Conduct pre-flight inspection (to be completed not later than 4 hours before observation flight).
E-F: Time period to conduct demonstration flight. Duration of demo flight not to exceed two hours over the calibration target. If demo flight requested by observed party an additional 24 hours (beyond the 96 hour period) is provided to the observing party to complete observation flight.
F-G: Transfer to the Open Skies airfield (if different from the POE).
G: Submit mission plan, at any time after arrival (C).
H: Complete examination of the mission plan and modifications thereto.
I: Agree on mission plan or cancel mission.
J: Begin observation flight.
K: Complete observation flight.
K-L: Transfer to the point of exit (if different from the last Open Skies airfield). Time for film processing by the observed party shall not exceed 3 days after the arrival of the aircraft at the point of exit.
K-M: Prepare and sign mission report.
M: Depart from the point of exit. Time for film processing by the observing party shall not exceed 10 days after departure from the territory of the observed party.
N: Distribute mission report to all states parties.
O: Film processing time if film is processed as arranged by the observed state party.
P: Film processing time if film is processed as arranged by observing state party.

2.3.5 Technical Requirements of Overflights: Whose Aircraft to Use?

Upon insistence by Russia, each state to be overflown has the choice of either receiving the aircraft of the observing state or of providing an aircraft with full sensor equipment of its own for the use of the observing state. This provision reflects the initial Soviet hesitation about fully opening its airspace to foreigners. A compromise worked out by James Baker and Eduard Shevardnadze at Irkutsk in early October 1990 paved the way for the future success of the negotiations. The Soviets conceded to open their entire territory, including prohibited airspace, for observation flights. In return, the observed state party was granted the right to exercise the so-called *taxi option*, that is, the right to provide its own aircraft for an observation flight.[79] The taxi option was decisive in obtaining the consent of the Soviet military, which feared that other states would install hidden prohibited sensors on their aircraft. Since Russia insisted on the taxi option, the US and others insisted that a taxi aircraft would have to be equipped with all permitted sensors operating at Treaty resolution. Demonstration of that capability became an issue. Should the observed state decide not to provide a taxi aircraft of its own, the observing state can also use the aircraft of a third state party. This regulation is important for states which do not operate an Open Skies aircraft of their own. The regulation is also applicable for groups of states parties.

2.3.6 Territorial Restrictions

One important provision of the Treaty (Art. VI, Section II, para. 2) is that the full territory of each state party may be overflown, except for a 10-kilometre zone next to the state's borders with non-state parties.[80] This implies that the vast territories of North America and Siberia, which were hitherto off limits to inspections under the CFE Treaty, are now accessible to Open Skies flights. For example, sensitive sites like the White House in Washington, the Space Shuttle launch sites at Cape Canaveral and Russian missile silos have been overflown in trial flights. As another example, a test flight over Frankfurt airport resulted in a shutdown of all other flight operations for some one and a half hours. This created a major traffic jam and probably will not be repeated. But it was a point in case. Only sites that affect the safety of flight could be excluded. Each flight over a particular country, however, will be restricted to a maximum flight distance, as specified in Table 2.1.

Open Skies observation flights have priority over any regular civilian and military air traffic. According to ICAO rules, three exceptions are permitted: missions for aircraft emergency relief, air defence and medical evacuation.

2.3.7 Dissemination of Information and Openness of Data

According to Article VI, Section I, paragraph 21 the mission report from each observation flight shall be accessible to all member states. Based on this report the states parties may decide to request a copy of the flight image data (at an agreed cost). It was the Soviet Union that from the beginning insisted on "equality in acquiring and in access to information". Although this proposal was not greeted with enthusiasm by all, after considerable maneuvering the parties finally agreed on the sharing of image data. As such, after an Open Skies observation flight any states party is entitled to request to receive a first generation copy of the image data taken.[81] In the case of photographic film, the image data can be easily analyzed through inspection by image analysts. Digitalized and SAR images data, however, require a greater technological effort and sensor knowledge to interpret.

The option and right of data sharing is one of the most innovative features of the Treaty, which emphasizes its cooperative character. However, although unclassified, data will be available only to state agencies for purposes in accord with the intentions of the Treaty. Hence, there are limits to openness. These limits, which date back to 1990, appear somewhat outdated in view of the new generation of commercial high-resolution photo-satellites, which provide black and white pictures with 1-metre or even 0.6 metres ground (pixel) resolution worldwide.[82]

Notes

1 Forty-five years after it had been tabled the proposal was still on its way to becoming an active treaty.

2 There is no record of any major preparation of the proposal or any indication that it had been thoroughly considered by the US government prior to its announcement.

[3] "Statement by President Eisenhower", in *The Geneva Conference of Heads of Government, July 18-23, 1955*, Washington, DC: US Government Printing Office, 1955, p. 21.

[4] "Radio-Television Address by President Eisenhower", Washington, July 25, 1955, in *The Geneva Conference of Heads of Government, July 18-23, 1955*, p. 86.

[5] "News Conference Statement by Secretary of State Dulles", Washington, 26 July 1955, in *The Geneva Conference of Heads of Government, July 18-23, 1955*, p. 87.

[6] A. S. Krass, *Verification: How Much Is Enough?*, London and Philadelphia: Taylor and Francis, 1985, p. 118.

[7] J. L. Gaddis, *Strategies of Containment: A Critical Appraisal of Postwar American National Security Policy*, Oxford: Oxford University Press, 1982, pp. 156-57.

[8] The authors gratefully acknowledge the support of Mr James Marquardt in developing this idea.

[9] A. S. Krass, p. 118.

[10] "Itogi Zhenevskovo Soobsheniya Glav Pravitelstv Cheteryekh Derzhav: Doklad Predsedatelya Soveta Ministrov SSSR tovarishcha N. A. Bulganina 4 avgusta 1955 na tretey sessii Verhovnovo Soveta SSSR", *Pravda*, 5 August 1955, p. 3.

[11] US documents show that Eisenhower had been informed about the coming breakthrough in surveillance capabilities by a high-altitude aircraft (U-2) that would "open" skies with or without Soviet acceptance, and gave approval to the U-2 programme. When the Soviet Union shot down a U-2 aircraft in spring 1960 near Sverdlovsk (now Ekaterinburg) the first phase of Open Skies history was over. The US denied the existence of the U-2 until faced with solid Soviet evidence to the contrary.

[12] J. A. Hawes, *Open Skies: Beyond "Vancouver to Vladivostok"*, Occasional Paper No. 10, Washington, DC: The Henry L. Stimson Center, December 1992, p. 2.

[13] J. Borawski, *From the Atlantic to the Urals: Negotiating Arms Control at the Stockholm Conference*, Washington: Pergamon-Brassey's, 1988, p. 21.

[14] Mentioned by J. Borawski, op. cit., p. 68.

[15] It was learned much later that Akhromeyev adamantly opposed on-site inspection.

[16] Quoted by J. Borawski, op. cit., p. 98.

[17] *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*, para. 89, http://www.osce.org/docs/english/1973-1990/csbms1/stock86e.htm.

[18] Ibid., para. 90.

[19] Ibid., para. 91.

[20] J. Clark, "Foreword: Open Skies", in Slack, M. and H. Chestnutt (eds), Open Skies—Technical, Organizational, Operational, Legal and Political Aspects, Toronto: Centre for International and Strategic Studies, York University, 1990, pp. vi-vii.

[21] G. Bush, "Notes for an Address to the Graduating Class of Texas A&M University", 12 May 1989, quoted in P. Jones, "Open Skies: A Review of Events at Ottawa and Budapest", J. B. Poole (ed.), *Verification Report 1991*, VERTIC, London and New York: The Apex Press, 1991, p. 73.

[22] Ibid., p. 73.

[23] "Declaration of the Heads of State and Government Participating in the Meeting of the North Atlantic Council in Brussels, 29-30 May 1989", para.18, in *NATO Final Communiques 1986-1990*, Brussels: NATO Office of Information and Press, 1990, p. 35.

[24] The US mainland had heretofore been a "sanctuary". On-site inspections under the Stockholm regime did not extend to extra-European territories and the still pending CFE Treaty, which was being negotiated concomitantly, would not allow them either. The only—not multi-, but bilateral—regime that permitted on-site inspections, and Soviet inspectors, to enter the territory of the United States was the Intermediate Nuclear Forces (INF) Treaty. Under the INF Treaty access by Soviet inspectors was confined to a very limited number of areas, however.

[25] J. B. Tucker, "Back to the Future: The Open Skies Talks", *Arms Control Today*, Vol. 20, October 1990, p. 21.

[26] "Annex to the Communique of the North Atlantic Council meeting in Ministerial Session on 14th and 15th December 1989—Open Skies Basic Elements", in *NATO Final Communiques 1986-1990*, pp. 128-32. See Appendix G.

[27] See section 2.3 below.

[28] The French opposition to bloc-to-bloc arms control was well known. France, as a "semi-member" of the Atlantic Alliance since 1966, had expressed its disagreement with arms control negotiations based on

two blocs, NATO and the Warsaw Treaty, since the beginning of conventional arms control in the early 1970s.

29 J. B. Tucker, op. cit., p. 21.

30 *Arms Control Reporter*, Cambridge, MA.: Institute for Defence & Disarmament Studies, 1990, p. 409.B.3.

31 It is a fact that the Soviet Union was practically never obliged to seek compromise in the Warsaw Treaty on arms control until the early 1980s. Major compromise efforts were necessary, however, at the end of the 1980s and the beginning of the 1990s, the period between the *de facto* and the *de jure* disappearance of the Warsaw Treaty.

32 According to our impression this was the case of the CFE Treaty signed in November 1990.

33 Canada and Hungary, in particular, played a pioneering role as facilitators of the process. Apart from hosting the first two Open Skies conferences they performed two joint demonstration flights over Hungary and Canada, using Canadian aircraft (4-6 January 1990 and 15-16 January 1992, respectively). Canada commissioned a number of technical background papers for the benefit of all participating states (see, e.g., A. V. Banner, A. J. Young, K. W. Hall, *Aerial Reconnaissance for Verification of Arms Limitation Agreements*, United Nations Institute for Disarmament Research (UNIDIR), Geneva: United Nations, 1990). Canada, as was mentioned earlier, also played a "midwife" role at the very beginning of the Open Skies process.

34 As the matter is specifically related to sensor performance it is addressed in section 2.3 below.

35 S. Koulik and R. Kokoski, *Conventional Arms Control—Perspectives on Verification*, SIPRI: Oxford University Press, 1994, pp. 174-75. This latter issue, has persisted in a somewhat modified form ever since.

36 As one scholar has put it: "Events in Europe between May 1990 and the summer of 1991 fundamentally changed the Open Skies dynamic but in a very complex manner. While it was clear that NATO no longer faced the same threat from the USSR, the failure to obtain an aerial inspection regime in the CFE Treaty and the Soviet decision to move large numbers of forces and CFE treaty-limited equipment out of the 'Atlantic to the Urals' zone, made an Open Skies agreement appear more urgent to many in the Alliance. As a result, it became possible for NATO countries to offer serious concessions …" See R. J. Lysyshyn, "Open Skies Ahead", *NATO Review*, Vol. 40, February 1992, p. 24.

37 For all these matters see section 2.3 below.

[38] L. W. Veenendaal, “Conventional Stability in Europe in 1991: Problems and Solutions”, *NATO Review*, Vol. 39, August 1991, p. 21.

[39] “Statement of the Representative of the Union of Soviet Socialist Republics in the Joint Consultative Group, Vienna, 14 June 1991”, point 3, in *Treaty on Conventional Armed Forces in Europe and Related Documents*, The Hague: The Netherlands Ministry of Foreign Affairs, May 1996, pp. 182-83.

[40] P. Jones, “Open Skies: A Review of Events at Ottawa and Budapest”, op., cit., p. 80.

[41] Group of 16 (NATO), “Draft Protocol on Inspections Relating to the Treaty Between the Parties Art. XII”, in *BASIC Reports from Vienna*, No. 7, 11 April 1990, p. 11.

[42] For more details see section 8.1 below.

[43] Treaty on Conventional Armed Forces in Europe, Art. XIV, para. 6 in *Treaty on Conventional Armed Forces in Europe and Related Documents*, p. 35.

[44] R. Hartmann and W. Heydrich, *Der Vertrag über den Offenen Himmel,* Baden-Baden: Nomos Verlagsgesellschaft, 2000, p. 19.

[45] R. J. Lysyshyn, op. cit., p. 24.

[46] P. Jones, “Open Skies: Events in 1992”, op. cit., pp. 146-47.

[47] For more details see the book (in German) of R. Hartmann and W. Heydrich. R. Hartmann was the head of the German delegation at the negotiations.

[48] The full text of the Treaty can be found at http://www.osmpf.wpafb.af.mil.

[49] For this reason, several terms are clarified in the part where the respective matters are addressed in detail.

[50] See it as Appendix G in this volume.

[51] See, for example, the opening speech of the Hungarian Foreign Minister, which emphasized the importance of the “national approach” in order to go beyond the “bloc approach”.

[52] P. Jones, “Open Skies: Events in 1992”, op. cit., p. 146.

[53] This constraint is no longer relevant for the remaining Soviet successor states, since by 24 March 1992, the day the Open Skies Treaty was signed at Helsinki, all Soviet successor states had joined the CSCE (now OSCE).

[54] See section 5.6 below for the details of the accession process.

[55] According to the Treaty, the OSCC “may consider the accession” (Art. XVII, para. 5) of non-European states. Of course, the possibility to consider does not imply an obligation to do so.

[56] *Treaty on Open Skies: Message from the President of the United States Transmitting the Treaty on Open Skies with Twelve Annexes, Signed at Helsinki on March 24, 1992*, Washington, DC: US Government Printing Office, 1992, p. 165.

[57] Open Skies "Basic Elements" Document, Appendix G in this volume.

[58] Osnovnye polozheniya dogovorennosti o rezhime "otkrytovo nebo", Art. IV, para. 2.

[59] The possibility that the Open Skies Treaty would be applicable to extra-European territories of European states has not played any role. It was evident that this would not happen and would not be requested. France, a country that would have been affected by such a broad interpretation did not even raise the matter. The only country that reflected upon it at a plenary meeting a week before Treaty signature was the United Kingdom. The UK declared that the Treaty would not apply to Hong Kong in the light of its transfer to the People's Republic of China in 1997. See R. Hartmann and W. Heydrich, op. cit., p. 38. For the German translation of the text of the UK declaration see ibid., p. 551.

[60] The initial Soviet proposal stated the following: "Bearing in mind military activity beyond national territory those states parties of the regime, which have military bases abroad would if possible already during the process of negotiation include the consent of those third parties, which do not participate in the regime". Osnovnye polozhenia… Art. IV, para. 2.

[61] Ibid., Art. XI.

[62] J. B. Tucker, op. cit., p. 22.

[63] The importance of this matter can best be illustrated by that the "Article-by-Article analysis of the treaty on Open Skies" submitted by the US Department of State to the Senate. It mentions four times that "the term does not permit the closure of areas for national security purposes". See *Treaty on Open Skies: Message from the President of the United States Transmitting the Treaty on Open Skies, with Twelve Annexes, Signed at Helsinki on March 24, 1992*, Washington, DC: US Government Printing Office, 1992, pp. 172-73.

[64] For example, in the Budapest draft Treaty of May 1990 the Western states had proposed the following sensor types: air sampling devices, optical cameras, electro-optical cameras, infrared sensors including video, gravity metres, magnetometres, forward looking infrared sensors, infrared line scanners, multispectral imaging scanners, spectrometres and SAR.

65 R. Hartmann and W. Heydrich, op. cit., p. 49.

66 Electro-optical sensors record radiation by many small radiation sensitive solid-state elements (like photo cells). The image information is rendered in digital format. The reason behind the Russian objection was its inferiority in sensor technology vis-à-vis the West. While US reconnaissance and civilian satellites were equipped with electro-optical sensors already in the 1970s, the Soviet Union and then Russia were still using optical film cameras on most of their imaging satellites in the 1990s.

67 In 2000 new commercial electro-optical cameras were presented, which feature both stereo and multispectral (colour) capability at resolutions between 10-100 centimetres.

68 A ground resolved distance of 30 centimetres was envisaged at the Vienna talks on Mutual and Balanced Force Reductions (MBFR) in 1984/85 as an adequate resolution limit for aerial inspections. Lt.Col. Lars Olof Johansson, Stockholm, private communication.

69 The ground resolution of 30 centimetres according to Decision 3 corresponds to the width of an image element (pixel) of an electro-optical sensor. This width is usually quoted as the resolution property of electro-optic satellite sensors. Apparently, the negotiators—when drafting the resolution definition of Article II—already had a coarser resolution in mind (as specified in Decision III). F. Badstöber and P. Harandt, IABG, D 85521-Ottobrunn, private communication, 2002. F. Badstöber was a member of the German Open Skies delegation 1990-92. P. Harandt was technical advisor in the Sensor Working Group from 1992 to 1994.

70 The issue of resolution and its certification is further discussed in section 4.4.

71 This text reflects the wording of the Treaty. According to the Treaty, a state is obliged to open its territory to overflights. This is reflected in the passive quota. The number of passive quota for each state party is specified in the Treaty. The active quota may well be the same but it has to be set by the OSCC yearly (Art. III, Section I, para. 7).

72 P. Jones, "Open Skies: Events in 1992", op. cit., pp. 146-47.

73 Table 2.1 gives the maximum flight distance of observation flights counted from the agreed Open Skies airports (Appendix A of the Treaty). After the Treaty's entry into force in 2002 the Open Skies airfields and the resulting maximum flight distances were revised and some changes were introduced.

74 R. Hartmann and W. Heydrich, op. cit., p. 97.

75 The sequence of flights has to be notified by the observing state by 15 November, 15 February, 15 May and 15 August, respectively for the following quarter of the year. The observed state has to state within seven days for which of the flights it wants to exert its right of providing a "taxi-aircraft".

76 A mission plan details the requested route, altitude and speed to be flown by the observing party. Coordination with any other state is not required, but it is recommended if the route of flight passes close to the border of any other state. Flying within ten kilometres of the border of a state non-party to the Treaty is prohibited. The final mission plan must be accepted and signed by senior officials of both parties and this is usually done after the mission has been coordinated with Air Traffic Control Services. The general rule is that Open Skies aircraft fly the agreed mission plan as long as safety of flight is not compromised.

77 M. Heric, C. Lucas and C. Devine, "The Open Skies Treaty: Qualitative Utility, Evaluations of Aircraft Reconnaissance and Commercial Satellite Imagery", *Photogrammetric Engineering & Remote Sensing*, Vol. LXII, No. 3, 1996, pp. 279-84.

78 A demonstration flight of maximum 2 hours over a calibration target can be requested in order to verify the sensor resolution (Appendix F, III). A demonstration flight will not occur very often; if the aircraft to be inspected has successfully passed a certification and no modification to the aircraft or to the sensors has taken place since, a demonstration flight will not be necessary.

79 R. Hartmann, "Treaty on Open Skies, Historical Overview", address to an Information Seminar on the Open Skies Treaty, Vienna, OSCC DEL/21/01, 1 October 2001.

80 Since the Treaty allows the use of side looking cameras, it is still possible to observe areas of dangerous airspace and border areas, without directly overflying them.

81 Radar data can be exchanged either as raw data or as processed image data.

82 See section 9.1.

CHAPTER 3

THE OPEN SKIES TREATY POST-SIGNATURE

Pál Dunay and Hartwig Spitzer

3.1 THE RATIFICATION PROCESS

To enter into force, the Open Skies Treaty required that it be ratified by at least 20 countries, including those with large passive (and hence active) quotas and the two depositories (Art. XVII, para. 2). In practice this meant that the Treaty could not enter into force unless ratified by the following countries: Canada, France, Germany, Hungary, Italy, Russia and Belarus (the latter two as a group of parties), Turkey, Ukraine, the United Kingdom, and the United States.[1] Most signatories found ratification unobjectionable. The number of instruments of ratification deposited reached 22 by mid-1995 (see Table 3.1). Thus, just over three years after the Treaty's signature the only question remaining was whether the three Slavic successor states of the Soviet Union, namely Belarus, Russia and Ukraine, would ratify the Treaty—and if so, when. Ultimately, it took another six years before the Open Skies Treaty could enter into force due to problems with the ratification process in Russia and the Ukraine.

After two failed attempts, Ukraine eventually ratified the Treaty on 2 March 2000. Although some Ukrainian officials had reservations about Open Skies out of traditional fears such as espionage, essentially these reservations were minor. The two previous attempts to ratify the Treaty in 1996 and 1998 had failed due to the poor planning of the vote or to particular concerns.[2] Ukraine was worried about the cost of preparing its airfields to host observation flights and fretted over not being able to fully use its active quota because of the high costs of observation flights. Whereas the former concern was founded, the latter was not. No country is obliged to exhaust its active quota, which is an entitlement. It is up to the country to decide how many flights it intends to carry out depending on circumstances such as the assessment of the military importance of observation flights, the state of the international environment and, last but not least, the resources available for the implementation of the Treaty. Nevertheless, Ukraine's delay in ratifying Open Skies was bound to remain largely inconspicuous so long as Russia and Belarus had not done so either.[3]

In case of Russia, important obstacles to the ratification of the Treaty came from several quarters. To begin with, strong opposition to ratification existed within the Russian military, which vividly remembered the US use of aerial observation for espionage, and clearly feared more of the same.[4] Second, this resistance within the military was accompanied by the actually much more important deadlock between the Russian Parliament, the Duma, and President Boris Yeltsin. This institutional stalemate explains why the Open Skies Treaty, submitted by President Yeltsin for ratification on 13 September 1994, was actually ratified only on 18 April 2001, well after Yeltsin had resigned. Finally, these domestic tribulations surrounding Russia's ratification of the Treaty were complemented by the fact that the United States gave little priority to the bringing of Open Skies into force, Washington being rather more concerned with Russia's ratification of the Strategic Arms Reductions Treaty (START), which in turn served to diminish the political importance of Open Skies in Moscow, and to further reduce its urgency.

With ratification still pending, Russia's attitude toward Open Skies shifted to become far more cooperative after 1997. This was reflected in Russia's more frequent participation in trial inspections (see Figure 4.4). Here, it is interesting to look at the analytical note on the Open Skies Treaty prepared for the Duma.[5] The document takes up two important points. First, the volume of information collected on other countries, both directly through observation flights and indirectly due to access to information gathered by other states parties and shared among others with Russia. On this count the document states that the "Treaty entering into force … will allow Russia to increase its volume of information on the USA and NATO" … "the additional volume of information, just in the 0.3-0.6 micrometer spectrum (information which Russia essentially does not possess) will comprise 6-7% of the total Russian information volume and complement space observation resources Russia is in a position to 'obtain'…" In "summary, we can conclude that the Treaty on Open Skies is advantageous to Russia, and allows for some compensation of Western superiority in obtaining information with minimal expenditures."[6]

Table 3.1: Status of Open Skies Treaty Ratification as of 1 April 2004
The table includes states that have successfully applied for accession after entry into force of the Treaty, as discussed in section 5.6.

Open Skies Treaty Ratification					
Country	**Signature**	**Application for Accession Approved by the OSCC**	**Ratification**	**Deposition of Instruments of Ratification**	**Entry into Force**
Belgium	24.03.1992		19.05.1995	28.06.1995	01.01.2002
Belarus	24.03.1992		20.05.2001	02.11.2001	01.01.2002
Bulgaria	24.03.1992		01.03.1994	15.04.1994	01.01.2002
Canada*	24.03.1992		04.06.1992	21.07.1992	01.01.2002
Czech Republic	24.03.1992		25.10.1993	21.12.1992	01.01.2002
Denmark	24.03.1992		19.12.1992	21.01.1993	01.01.2002
France	24.03.1992		21.07.1993	30.07.1993	01.01.2002
Georgia	24.03.1992		12.06.1998	31.08.1998	01.01.2002
Germany	24.03.1992		03.12.1993	27.01.1994	01.01.2002
Greece	24.03.1992		25.08.1993	09.09.1993	01.01.2002
Hungary*	24.03.1992		18.06.1993	11.08.1993	01.01.2002
Iceland	24.03.1992		15.08.1994	25.08.1994	01.01.2002
Italy	24.03.1992		20.09.1994	31.10.1994	01.01.2002
Kyrgyzstan	15.12.1998				
Luxembourg	24.03.1992		20.12.1994	28.06.1995	01.01.2002
Norway	24.03.1992		18.05.1993	14.07.1993	01.01.2002
Poland	24.03.1992		22.03.1995	29.05.1995	01.01.2002
Portugal	24.03.1992		17.09.1994	22.11.1994	01.01.2002
Romania	24.03.1992		16.05.1994	27.06.1994	01.01.2002
Russia	24.03.1992		26.05.2001	02.11.2001	01.01.2002
Slovak Republic	24.03.1992		26.11.1992	21.12.1992	01.01.2002
Spain	24.03.1992		25.10.1993	18.11.1993	01.01.2002
The Netherlands	24.03.1992		15.01.1994	28.06.1995	01.01.2002
Turkey	24.03.1992		18.05.1994	30.11.1994	01.01.2002
Ukraine	24.03.1992		02.03.2000	20.04.2000	01.01.2002
United Kingdom	24.03.1992		27.10.1993	08.12.1993	01.01.2002
United States	24.03.1992		02.11.1993	03.12.1993	01.01.2002
Bosnia and Herzegovina		22.07.2002	17.08.2003	21.08.2003	20.10.2003
Croatia		22.07.2002			
Estonia		05.05.2003			
Finland		04.02.2002	30.11.2002	12.12.2002	10.02.2003
Latvia		22.07.2002	31.10.2002	13.12.2002	11.02.2003
Lithuania		22.07.2002			
Slovenia		24.02.2003			
Sweden		04.02.2002	04.06.2002	28.06.2002	27.08.2002

* Depository State

Second, the attention paid to the issue of cost shows that the Russian military was well aware of the constraints it faced. The costs of the implementation of Open Skies, according to the document, could be significantly reduced through the leasing of Russian observation aircraft to countries, which did not possess such planes, and the selling of Open Skies aeronautical, special and ground technical nomenclature externally.[7] Russia, thus, calculated the costs and benefits of the Treaty and ratified it when political conditions were ripe. Whether Belarus' ratification was actually indispensable for the Treaty's entry into force is open to debate. Bearing in mind, however, that Russia had formed a group of states parties with Belarus and that neither country had a passive quota of its own, in retrospect, Belarus' ratification of the Treaty was most likely also indispensable.[8] On 1 January 2002, 60 days after Russia and Belarus deposited their instruments of ratification the Open Skies Treaty finally entered into force.

The nearly ten years that lapsed between the Treaty's signature and its entry into force did not pass in vain. While diplomatic officials were working on bringing the Treaty into force military professionals prepared for its implementation. Their activities encompassed the following areas: the establishment of operational units dealing with the implementation of Open Skies,[9] the selection and preparation of national or foreign observation aircraft, trial certification of observation aircraft and trial inspections (see Chapter 4).

Most signatories established Open Skies units under the auspices of their Ministries of Defence, usually as part of their on-site inspection agencies, which most parties already possessed to deal with verification under the Vienna CSBM regime and the CFE Treaty.

In the ten years before the Treaty's entry into force more than 350 international trial inspection missions were carried out. It is interesting to note that all signatories, except for two (Iceland and Kyrgyzstan), participated in such flights.[10] Furthermore, several demonstrations were made in order to show the advantages of Open Skies to countries, which are not parties to the Treaty, in particular, Bosnia and Herzegovina. These demonstrations have shown that Open Skies can be used for post-conflict monitoring and that its modification to encompass conflict and post-conflict monitoring may well be a variant worth considering.[11] They also showed that Open Skies could be used for non-military activities such as the monitoring of floods, as on the Oder in 1997, or of the damages caused by hurricane "Mitch" in Central America in late 1998.[12] In the latter case, the US OC-135B aircraft took over 15,000 aerial photographs in Honduras, Nicaragua and Guatemala to follow in detail the evolution of the storm.

In sum, the ten years period that passed between the Treaty's signature and its entry into force was used advantageously by the parties to prepare for implementation and also to explore some new avenues where Open Skies or the observation methods regulated and used by it, could be applicable. It remains an open question, however, whether these are going to be sufficient to sustain interest in Open Skies in the light of the fundamentally changed security relations in the Euro-Atlantic area.

3.2 Establishment and Activity of the OSCC: Decisions and Guidance Documents to the Treaty

The Open Skies Treaty mandated the establishment of a consultative body, the Open Skies Consultative Committee (OSCC). This body is responsible for the reallocation of active quotas on an annual basis. It will also discuss any proposals for the upgrade of existing sensor types and the introduction of new sensor categories. As called for in Article X, the OSCC provides a forum within which disputes related to the Treaty may be discussed if bilateral talks fail. The OSCC will discuss any technical questions arising from the accession to the regime of new states. The OSCC is also the forum to which bodies of the CSCE (now OSCE) or any other relevant international organization would address requests for extraordinary observation flights in times of tension.[13] The OSCC is mandated to meet at least four times a year in Vienna. Its offices are next to the headquarters of the Organization for Security and Cooperation in Europe in Vienna. The OSCC has established four *working groups* around the following themes: costs, sensors and calibration rules, notification procedures and formats, flight rules and procedures. Based on the results of the working groups the OSCC has established from 1992 to 2000 24 legally binding *Decisions* to the Treaty. Some of the decisions were further elaborated by a *Sensor Guidance Document*.[14]

The OSCC and its working groups began their deliberations already on 2 April 1992. A sizeable number of questions related to sensor calibration, aircraft certification and other procedures had to be addressed. The OSCC also had to resolve the matter of Czech and Slovak flight quotas after the dissolution of Czechoslovakia. As a result of these discussions several decisions were taken concerning: (a) how to calculate the minimum permissible flight altitude (H_{min}) when using optical and video cameras; (b) how to calculate the minimum flight height (H_{max}) above ground level at which each video camera with real-time display and each infrared line-scanning device installed on an observation aircraft may be operated during an observation flight; (c) calibration activities; (d) the format in which data are to be recorded and exchanged on recording media other than photographic film; and (e) the mandatory time period for sorting and sharing data recorded during an observation flight. These decisions were considered important milestones in the technical and procedural elaboration of the Treaty provisions.[15]

The OSCC also held two seminars on the possible use of the Open Skies regime for environmental monitoring on 3-4 December 1992 and on 11-12 July 1994. The seminars underlined the potential of Open Skies in the environmental area. In 1995 the work of the OSCC slowed down somewhat due to outstanding Treaty ratifications, which prevented its entering into force. Work on drafting a Guidance Document for aircraft and sensor certification continued, however. After 1997 the activity of the OSCC slowed down even more. The working groups stopped their meetings, after settling many but not all pending questions. On the other hand, after 1996 the negotiating climate within the OSCC improved, partially due to a more accommodating Russian stance. This allowed the OSCC to reach agreement on a more flexible certification procedure than would have been possible theretofore. In particular—as practiced in the trial certification of 2001—states parties were hence allowed to submit a set of previously established H_{min}-values for photographic cameras, which then would have to be confirmed during the certification. This procedure facilitated the certification activities of 2002 considerably. In 2001, after Russia's ratification, the OSCC resumed its more high profile activities by addressing remaining certification questions and accession issues (for details see Chapter 5).

In summary, the OSCC has proven to be a useful body when it comes to resolving outstanding technical and procedural questions. It is also a sounding board for potential future extensions of the Treaty.

Notes

1 Canada and Hungary being the two depositories. Canada was equally a "large quota" country.

2 An account of the dates and the division of the votes in the Narodna Rada of the two failed attempts to ratify the Treaty is given in Istoriya Parlamentskikh slukhan' Dogovoru z Vydkritovo Neba, 2 March 2000. Interestingly, the report does not mention the reasons why these ratification attempts failed.

3 As Belarus was widely expected to follow Russia's example, all international attention was in fact focused on Russia.

4 The Russian military could point out that Eisenhower's initial Open Skies proposal had been closely followed by the U-2 incident. On the other hand, the advent of satellite technology had by this time largely displaced the use of aerial surveillance in the collection of intelligence.

5 *Council Meeting of the State Duma with Attachments*, Excerpts from the Minutes No. 5, Federal Assembly of the Russian Federation, 10 February 2001.

6 See ibid., pp. 4 and 7. It is interesting to note that Russia, due to the lower resolution of its satellites, considers that Open Skies provides particularly valuable information in the 30 to 60 centimetres resolution range. An US assessment, due to its more developed reconnaissance technology, would be different.

7 Ibid., p. 6.

8 See R. Hartmann and W. Heydrich, *Der Vertrag über den Offenen Himmel*, Baden-Baden: Nomos Verlag, 2000, p. 123.

9 For further details see section 4.1.

10 See E. Britting and H. Spitzer, "The Open Skies Treaty", in Poole, J. B. and R. Guthrie (eds), Verification Report 1992, VERTIC, London and New York: The Apex Press, 1992, pp. 223-38.

11 See sections 7.2 and 8.2.

12 R. Hartmann,"Inkrafttreten des Vertrags über den Offenen Himmel", *SWP-Aktuell 25*, Berlin, December 2001, p. 25. For more details see F. Korkisch, "Open Skies: Die Entstehung eines Vertrages und die Darstellung der Interessengegensätze zwischen Staaten", Referatsmanuskript, Europäisches Forum Alpbach 2000, p. 11.

13 P. Jones, "Open Skies: Events in 1993", in Poole, J. B. and R. Guthrie (eds), Verification Report 1993, VERTIC, London and New York: Brassey's, 1993, p. 155.

[14] The text of Decisions 1-22 and of the full Sensor Guidance Document can be found at http://www.osmpf.wpafb.mil. A German translation of Decisions 1-22 and the English version of the Sensor Guidance Document are reproduced in R. Hartmann and W. Heydrich, op. cit., pp. 247-550.

[15] Appendix J gives a full list of the Decisions of the OSCC as of April 2003.

CHAPTER 4

TECHNICAL PREPARATIONS FOR TREATY IMPLEMENTATION

Hartwig Spitzer and Rafael Wiemker

4.1 ESTABLISHMENT OF OPERATIONAL UNITS

Subsequent to the Treaty's signature in March 1992, most states parties established operational units which are in charge of technical preparations and actual observation flights. It is the task of such units to prepare and carry out Treaty-related activities, like observation mission planning, pre-flight inspections of Open Skies aircraft and sensors, operating imaging sensors during overflights and escorting foreign teams flying over national territory. Aircraft, aircrews and mission specialists are usually provided by the armed forces, to a large extent by the air force of the respective country, whereas image analysis is carried out by intelligence units.

In most countries the Open Skies units operate under the Ministry of Defence.[1] In some countries, like Turkey, the units are joint establishments of the Ministry of Foreign Affairs and the Ministry of Defence. Appendix A gives the addresses of the arms control and verification centres of the states parties which are in charge of implementing the Open Skies Treaty. States with dedicated Open-Skies aircraft and states with larger flight quota employ sizeable staff for Treaty matters. As an example, the Open Skies units of the German Verification Center and the Federal Armed Forces Intelligence Office comprise 38 full time employees (as of March 2003), not counting translators and other service personnel.[2]

It can be said that through continued training and practice a considerable amount of professional expertise and corps d'esprit has been built up both within the national units and in areas of cross-national cooperation.

4.2 AIRCRAFT

One important step of preparation for Treaty implementation was the selection and retrofitting of suitable aircraft for Open Skies applications. Several criteria had to be satisfied by the states parties in particular:

- type and size;
- range;
- ability to operate at quite different altitudes;
- availability.

Type: According to the Treaty, observation aircraft have to be unarmed fixed wing types, with sufficient carrying capacity for sensors, as well as flight crew, mission team and escort team. The aircraft need to have down-looking windows (camera bays).

Range: The Treaty foresees (maximum) flight distances that range from 660 kilometres for Bulgaria to 7,200 kilometres for the Russian Federation with Belarus (see Table 2.1). Although refuelling is allowed during an observation flight, it is advantageous to execute the flight in one go. In particular Germany opted for a medium to long-range aircraft, a Tupolev 154 M, which could be flown over Siberia with only one refuelling. The German aircraft was lost in an accident in September 1997 and was not replaced. The US chose Boeing OC-135 B aircraft of even longer range (6,500 kilometres), which are well suited for transatlantic flights.

Ability to operate at different altitudes: Due to weather conditions in the Northern hemisphere an ability to underfly clouds at altitudes of 800 to 1,000 metres is highly desirable. This is no problem for turboprop aircraft, but extremely fuel-consuming for heavy jet aircraft. On the other hand, operation altitudes above 5,000 metres and beyond are mandatory for future flights over crisis areas, in order to stay out of the range of hand-held anti-aircraft weapons.

Availability: Most States Parties decided to use existing observation aircraft (Bulgaria, Czech Republic, Hungary, Romania, Russia, Ukraine, the United Kingdom) or to retrofit existing aircraft for Open Skies use (Germany, Sweden, the United States). The "Pod Group" (Belgium, Canada, France, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain) uses existing Lockheed C-130 Hercules transport aircraft, which can carry a sensor container (the "pod") under one of the wings. Turkey has acquired one CASA Airtech CN 235 aircraft for Open Skies purposes.

Table 4.1 shows a list of existing Open Skies aircraft. The aircraft are adequate choices. In particular the Boeing, Lockheed and Tupolev types have ample space for escorts and observers, at the expense of rather high operation costs. Several states parties decided not to equip an Open Skies aircraft of their own. Still, each of these countries can participate in the Open Skies missions by leasing an aircraft from another state party or by making arrangements with the state party to be overflown. Belgium, Luxembourg and the Netherlands operate jointly and act as a single state party (Art. XIV), as discussed in section 2.3.1.1. Kyrgyzstan has acceded to the Treaty but has not yet ratified it. It did not participate in trial flights.

It should be kept in mind that most sensors are operated at considerably lower altitudes than the maximum cruising altitude. Fuel consumption is higher at lower altitudes resulting in reduced range. This is illustrated by the range values given in Table 4.1 for flight altitudes of 1,000 and 6,000 metres. The table shows also the sensor operation altitudes and the ground swath covered by existing vertical framing and panoramic cameras. Some of the parties have more than two sensor configurations and related operation altitudes. The table gives the minimum and maximum altitude.[3] The values are subject to change. More details on aircraft are given in Appendix B.

The costs of purchasing and equipping an Open Skies aircraft and keeping it in service are considerable, particularly in view of the small active quota most states parties have. Not to mention that one group of countries with the highest passive quota, the Russia-Belarus group, is opting—with some exceptions—to be flown over only by its own aircraft, which will further limit the use of the observation aircraft of many other states parties. Due to the rearrangement of security relations in Europe most states parties are not interested in carrying out observation flights in the airspace of most other states parties. In case the purposes for which Open Skies observation flights could be used are not broadened the dilemma of whether or not to purchase observation aircraft nationally to fly a small quota of missions should grow further. Consequently, this is an area where cooperation among the parties may result in all-around gains: reduced national expenses without incurring any disadvantages. The EU, which has embarked upon the building of a European Security and Defence Policy, has not addressed this issue, yet. Addressing it would make perfect sense, however. The several EU members which do not plan to purchase observation aircraft should certainly be receptive to a pooling of resources.[4]

Table 4.1: Open Skies Aircraft

State	Type	Range at different flight altitudes (km)		Sensor operation altitude (m)		Ground swath (km)		Seats including crew
		1,000m	6,000m	Vertical camera	Panorama camera	Vertical camera	Panorama camera	
Bulgaria	1xAntonov 30	1,500	2,650	2,950 3,150	1,200	4.4 4.7	6.6	14
Czech Rep.	1xAntonov 30	1,500	2,650	1,803 2,047	-	4.6 5.2	-	16
Hungary	1xAntonov 26	1,500	2,650	1,972 2,993	-	3.0 4.4	-	30
Pod Group	Hercules C-130	2,500	5,000	1,210 1,950	3,810 5,050	1.8 2.9	20.9 28.0	20
Romania	1xAntonov 30	1,500	2,650	t.b.d. t.b.d.	-	1.7 1.9	t.b.d. t.b.d.	24
Russia	3xAntonov 30	1,500	2,650	1,210 3,103	-	2.8 5.5	-	20
	1xTu 154	2,500	5,000	t.b.d.	t.b.d.	t.b.d.	t.b.d.	ca.30
Sweden	1xSaab 340	1,500	2,500	1,009 5,215	-	1.5 7.9	-	21
Turkey	1xCN 235 Casa	2,000	4,000	t.b.d.	t.b.d.	t.b.d.	t.b.d.	ca. 25
Ukraine	1xAntonov 30	1,500	2,650	1,073 2,993	-	2.5 7.1	-	16
UK	1xAndover MK1*	1,300	-	-	854	-	12.2	16
USA	2xOC 135	3,000	6,000	1,456 2,104	4,698 11,101	2.2 3.1	9.9 23.4	39

* The UK aircraft was decommissioned in April 2003.
Source: German Verification Center, Geilenkirchen.

4.3 SENSORS

The Treaty foresees the use of four types of imaging sensors:

1. optical panoramic and framing cameras with a ground resolution of 30 centimetres (panchromatic) at a modulation (contrast) of the image of 0.4;
2. video cameras with real-time display and a ground resolution of 30 centimetres (panchromatic);
3. thermal infrared imaging sensors with a ground resolution of 50 centimetres at $\Delta T = 3°K$ (temperature differential)[5]; and
4. imaging radar (SAR) with ground resolution of 300 centimetres.

With regard to photographic cameras the Treaty allows for one panoramic camera, one vertically mounted framing camera and two obliquely mounted framing cameras. The ground coverage of these cameras is limited to 50 kilometres on each side of the flight path.[6] Radar coverage will be limited to a ground swath of 25 kilometres on one side of the aircraft. The transverse ground distance of this swath from the flight track can be chosen freely within a sideward corridor of 50 kilometres.
The *recording media* will be:

(a) black and white film for photographic cameras;
(b) magnetic tape for video cameras;
(c) black and white photographic film or magnetic tape for thermal infrared sensors; and
(d) magnetic tape for radar.

The agreed-on tape format for the digital data recording is that of an AMPEX tape machine. It should be noted that the specified resolution of 30 centimetres for photographic cameras is not defined as the standard photographic resolution but rather as a kind of pixel resolution, as discussed in section 4.4. Table 4.2 shows the sensors that have been installed on Open Skies aircraft or in the sensor pod of the Pod Group. Most states are using vertical framing cameras. The Pod Group, Turkey and the United States are also using oblique framing cameras. Ukraine has oblique framing cameras, which are not yet certified. The United Kingdom has relied solely on a panoramic camera with a very wide field of view of 164 degrees. The radar and infrared sensors of Russia and the US are under development. More details on sensors and image examples are given in section 6.2 and Appendix C.

Table 4.2: Open Skies Sensors as of May 2004[7]

Country	Vertical framing camera	Oblique framing camera	Pano-ramic camera	Video camera	Infra-red line scanner	Radar (SAR)
Pod Group: Belgium, Canada, France, Greece, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain	x	left/right	x	x	–	–
Bulgaria	x	–	x	–	–	–
Czech Republic	x	–	–	?	–	–
Germany	–	–	x	x	x	–
Hungary	x	–	–	x	–	–
Romania	x	–	–	x	–	–
Russia	2	–	planned	planned	planned	2006
Sweden	x	–	–	–	planned	–
Turkey	x	left/right	x	3	planned	?
Ukraine	x	–	–	?	–	–
United Kingdom	–	–	x	x	–	–
USA	x	left/right	x	x	planned	planned

4.4 The Ground Resolution Limits and Their Verification

Article IV of the Treaty limits the ground resolution of optical cameras to 30 centimetres. Ground resolution is defined in Article II of the Treaty as "... the minimum distance on the ground between two closely located objects distinguishable as separate objects." This is a traditional definition. However, when describing that resolution in Decision 3, the Treaty deviates from traditional photogrammetric practice and specifies that the "... value of the ground resolution shall be equal to the width of a single bar in the smallest group of bars [in a calibration target as shown in Figure 4.2] which can be distinguished as separate bars, in centimetres." Since ground resolution is most often explained in terms of Ground Resolved Distance (GRD), or the sum of the width of a (black) bar *and* a (white) space in a calibration target, 30 centimetres ground resolution as per Decision 3 is in reality 60 centimetres GRD. Figure 4.1 illustrates this situation. Many participants in Open Skies were disappointed to learn that the potential image quality will be significantly less than what had been expected.[8] A detailed discussion on resolution questions is presented in Appendix E.

However, this resolution will still allow for the detection of standard military vehicles from their dimensions. Photo 4.1 shows as an example an image of a military site at approximately 100-centimetre pixel resolution (a factor 3 times worse than the ground resolution as defined in the Treaty). Military trucks (some with towed artillery) and other vehicles can be recognized.

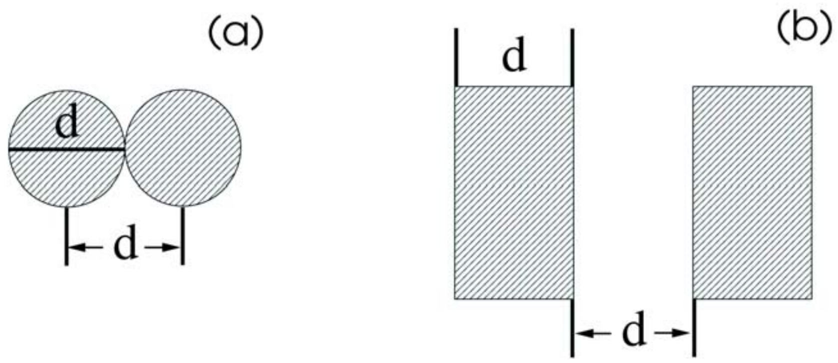


Figure 4.1:
(a) Photogrammetric definition of resolution: Two objects of diameter *d* can be resolved (given adequate contrast) at a distance *d*.
(b) Treaty definition of resolution: Two black bars of width *d* and centre distance 2*d* can be resolved.

Photo 4.1: Detail of a military vehicle depot at Tiraspol, Moldova. The image was taken by the Ikonos-2 satellite with a ground pixel size of 1 metre, corresponding to a GRD of about 2 metres. Open Skies pictures have superior resolution and recognition potential. *Source*: H. Spitzer, University of Hamburg.

For *optical cameras*, Decision 3 to the Treaty is the foundation for establishing the flight altitude $\boldsymbol{H}_{\text{min}}$ at which the cameras achieve exactly a 30-centimetre resolution. $\boldsymbol{H}_{\text{min}}$ is derived from analysis of aerial images taken over a calibration target. The target consists of black and white bars of different width as shown in Figure 4.2. Decision 3 defines $\boldsymbol{H}_{\text{min}}$ as the average of several measurements using at least five pictures ($n \geq 5$) taken by the sensor flying over the ground resolution calibration target according to the following equation:[9]

$$H_{\min} = \frac{1}{n}\sum_{i=1}^{n} H_i \left[\frac{L_a}{L_i}\right]\left[\frac{K_a}{K_i}\right]^m$$

Where n is the number of images being analyzed;

H_i is the height of the aircraft, in meters, at the moment that the target was photographed;

L_a is the agreed ground resolution of 30 centimetres;

L_i is the measured ground resolution, in centimetres from image *i;*

K_a is the agreed modulation contrast of 0.4 of the calibration target at which the ground resolution is defined corresponding to a contrast ratio of 2.3:1;

K_i is the effective modulation contrast (see definition below);

m is the agreed corrected exponent value of $m = 0.45$ as derived from laboratory examinations of several different camera lenses;

and

K_i $= \dfrac{C-1}{C+1}$ (normalized contrast, as determined from image *i*);

C $10^{\Delta \log E} = 10^{\log E_1 - \log E_2} = E_1 / E_2$

E exposure response of the film, or pixel intensity (gray value), with E_1 and E_2 being measured on the white and black contrast panel of the calibration target.

i.e. Δlog E is the difference in the logarithm of the exposures between the black and the white bars of the calibration target.

One of the main tasks of certification and demonstration flights is to determine the minimum allowable flight altitude for each of the sensors. It has been pointed out that the above formula might be insufficient since the actual ground resolution depends also on atmospheric conditions (mean visibility and aerosol content).[10] A more recent evaluation claims that the above equation performs well under set conditions (clear weather). Data taken by the United States Open Skies team shows that the above equation does model US camera resolutions.[11]

Furthermore, the determination of flight altitude based on air pressure also is affected by uncertainties. In practice, it was agreed to tolerate a resolution range of 25 to 35 centimetres.

The determination of $\boldsymbol{H}_{\mathrm{min}}$ for SAR, video and infrared sensors is specified in Decisions 7, 14 and 15, respectively and in the Sensor Guidance Document. Ongoing tests will probably lead to a simplification and clarification of the certification procedure for infrared line scanners.

4.4.1 Determination of Contrast and Resolution for Optical Cameras

The formula provided by Decision 3 to the Treaty for determining the proper minimum flight altitude requires two measurements: contrast *ratio* and *spatial* resolution. The necessary measurements are carried out on test photographs, by means of a ground calibration target. Its design is based on Appendix D of the Treaty as well as on Decisions 12 and 14 (see also section 2.6 of the OSCC Sensor Guidance Document). For example, the German calibration target is spray-painted on collapsible aluminium sheets (Figure 4.2).

Contrast

The calibration target contains two large rectangular panels, one black and one white, for contrast measurement (arrows in Figure 4.2). By means of a microdensitometer or a microphotometer, the density value on film for both the black and the white panel is measured as the average of several measurement squares, which are taken across the black and the white calibration panel. Then the contrast is determined as the ratio between the average “white” and “black” values. Determination of the contrast allows the effective modulation K_i to be calculated and then inserted into the $\boldsymbol{H}_{\mathrm{min}}$ calculation. Prior to the flight a so-called D log E-curve is produced for the film, using a densitometer to measure the densities of a 21-step densitometric strip exposed on the film.[12] Figure 4.3 shows an example.

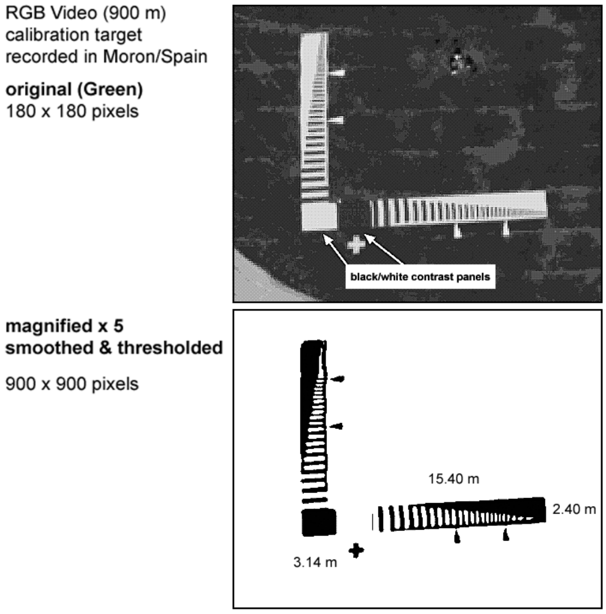


Figure 4.2: Top: German calibration target from 900 metres. The image was taken by the RGB video camera (green channel) on the former German Open Skies aircraft. Bottom: top image after data processing. The last resolved bar can clearly be recognized.

Resolution

In terms of the Treaty, the resolution is defined as the smallest width between a pair of black bars which can just be discerned on a white background, where "black" and "white" are the same as used for the contrast measurement. Nineteen pairs of black bars of decreasing width and separation are grouped on the calibration target (Figure 4.2). The decision as to which of the bar pairs are just resolved is made on the basis of the eye appraisal of the analysts assisted by an optical magnifier directly on the negative that is lit from below.

The calibration target contains 19 pairs of black bars. The separation between each pair of bars decreases in the pattern of a geometric series: each separation is smaller than the foregoing by a factor $1/\sqrt[6]{2} = 0.891$. Thus, after a succession of six pairs the separation is down by one half, after 12 pairs down by one fourth, after 18 pairs by one eighth. The largest bars are 50 centimetres wide, the smallest 6.25 centimetres.

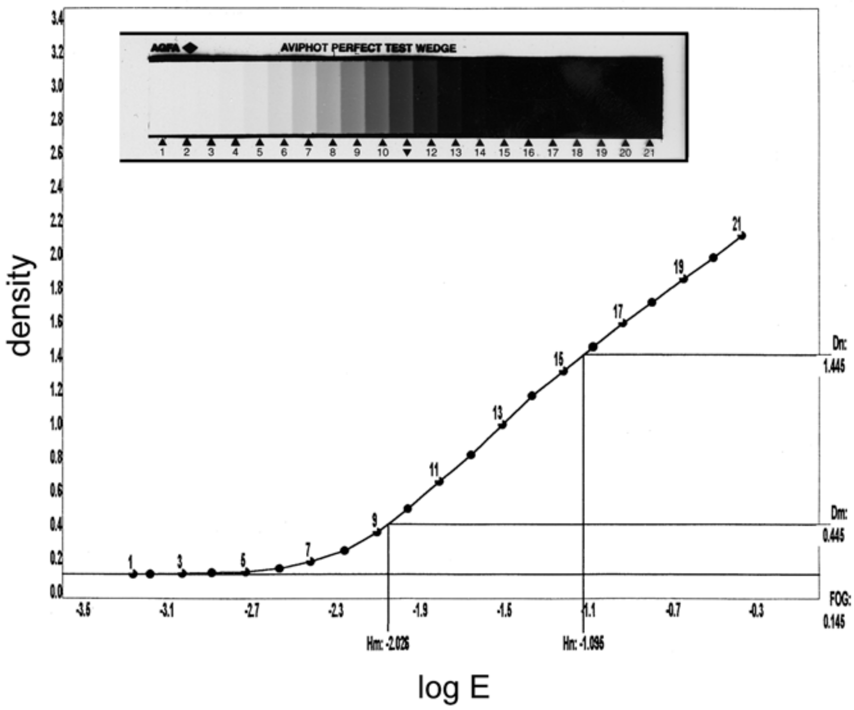


Figure 4.3: Top: Densitometric strip with 21 different grey values. Bottom: Sample D log E curve for Agfa Pan 200 film. Such curves are used to determine the optimum film processing conditions. *Source*: German Verification Center, Geilenkirchen, August 2000.

During the certification procedure, the photographic negatives of the calibration target are visually analyzed by ten inspectors from different countries. Each analyst casts an opinion on which pair of bars he can just resolve. Then the highest and the lowest resolution estimate are eliminated in order to neutralize outliers, and the final result is computed as the average of the remaining eight resolution estimates.

Contrast and resolution results are then entered into the above $\boldsymbol{H}_{\min}$-formula for calculation of the minimum flight altitude.

4.5 Trial Flights and Lessons

After the signing of the Treaty in 1992 a growing number of training and trial flights were performed. These flights had three purposes:

- *Training* of personnel and test of equipment and procedures on the *national level*;
- *Bilateral or multilateral* (border crossing) trial flights for training and testing under conditions that corresponded (in most cases) to the provisions of the Treaty;
- *Data gathering*, which—although on a trial basis—in effect contributed to capturing the aims of the Treaty.

National training is mandatory in order to prepare for full participation and to maintain capabilities and skills. International trial flights are agreed upon bilaterally or multilaterally on a voluntary basis. Partners of test flights followed most of the Treaty provisions. Two important exceptions were made. One, due to the voluntary character of the flights, image data were just shared between the states involved in a particular flight and not among all members states. Two, some airspace was excluded for various reasons.

Initial test flights aimed particularly at testing the procedures mandated by the Treaty. As an example, in October and November 1992 three aircraft, provided by Denmark, Russia and Canada, tested synthetic-aperture radars over specially designed targets in Hungary in order to demonstrate calibration of three very different SAR sensors. This successful experiment was hailed as “a milestone in technical cooperation among parties to the Open Skies Treaty” and it was noted that the “monumental task of negotiating such complicated issues as SAR parameters was a vivid example of the confidence-building intent of the Treaty at work”.[13] Based on this experience the OSCC was able to agree on decisions, which specified such procedures in more detail.

The early test flights revealed also some of the limitations of the Treaty. One, that it is particularly difficult to underfly (low) cloud covers, when adhering to the 30-centimetre resolution limit of optical cameras. An operating flight altitude of 800 to 1,000 metres above ground turned out to be a lower limit. Two, 3-metre resolution on SAR imagery produces a limited amount of information, which may be insufficient to justify the high costs involved.[14]

In subsequent years the character of test flights changed from an exploratory to a more routine nature. Figure 4.4 and Appendix D show the development of the annual bilateral and multilateral trial flights. From 1992 to the end of 2001 some 350 missions were flown involving all member states except Iceland and Kyrgyzstan. In addition, 42 test flights involving both non-signatory and signatory states were undertaken as shown in Table 4.3. Germany played a particularly active role taking part in 38% of all flights. The lower bars in Figure 4.4 indicate the flights involving the Russian Federation and Germany, respectively. Russia has shown an increased involvement in test flights since 1996.

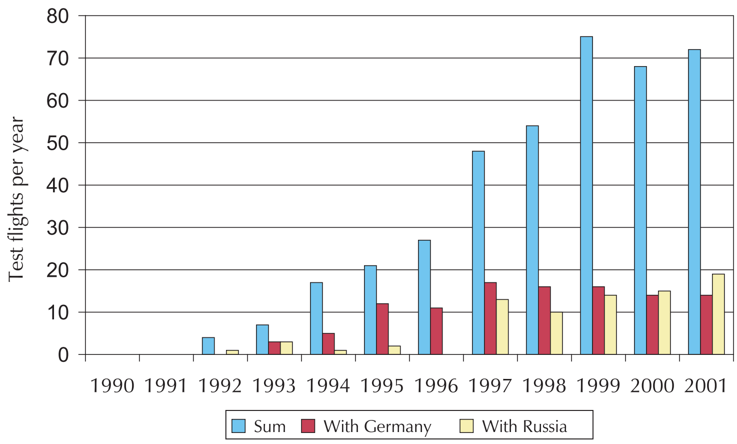


Figure 4.4: Open Skies test flights, including flights that involved non-signatory states, as of 31 December 2001. *Sources*: Zentrum für Verifikationsaufgaben der Bundeswehr, D-52503 Geilenkirchen; *SIPRI Yearbooks 1993-1995*.

Some of the test flights covered the vast territories in North America and Siberia, which are not accessible to on-site inspections under the CFE Treaty or the Vienna Documents. As an example, Figure 4.5 shows the flight route of a German-Russian flight over Siberia using the German Open Skies aircraft (9-17 October 1995). Similarly, a Russian test flight to the US made its way from Washington, DC to Alaska and the US part of the Aleutian Islands (22-30 July 2000).

Table 4.3: Open Skies Flights Involving Non-Signatory States as of 31 December 2001
The flights were carried out upon bilateral or multilateral agreement as demonstration or data gathering flights.

Date	Mission	Observing State	Observed States	Additional Observers	Observation Aircraft
14.08-23.08.96	Training flight for Finland	Germany	Germany		TU-154M
12.05-16.05.97	Test flight	Germany	Finland		TU-154M
17.06-19.06.97	Observation flight	Hungary/ Romania	Bosnia and Herzegovina	CND, D, F, GB, US, KR, YU, UKR	AN-26
18.08-22.08.97	Test flight	Finland	Germany		TU-154M
25.08-29.08.97	Observation flight	Germany	Bosnia and Herzegovina	Yes	TU-154M
03.11-07.11.97	Observation flight	Russia, USA	Bosnia and Herzegovina	Yes	AN-30
13.07-17.07.98	Observation flight	Germany, Russia	Bosnia and Herzegovina	Yes	AN-30
14.09-18.09.98	Test flight	Finland	UK		Andover (?)
04.12-19.12.98	Post-disaster monitoring	USA	Central America (El Salvador, Honduras, Nicaragua)		OC-135B
14.03-20.03.99	Test flight	Finland	USA		OC-135B
23.05-28.05.99	Test flight	USA	Finland		OC-135B
05.07-16.07.99	Test flight	Germany, UK, USA	Estonia, Latvia, Lithuania		OC-135B
July 1999	Test flight	USA, 3 Baltic States	UK		OC-135B
12.07-16.07.99	Test flight	Russia	Finland		AN-30
20.09-24.09.99	Test flight	Finland	Russia		AN-30
21.09-23.09.99	Test flight	France	Bosnia and Herzegovina		C-130H
25.10-29.10.99	Test flight	Slovenia	UK		Andover

22.11-26.11.99	Test flight	UK	Slovenia		Andover
14.02-18.02.00	Test flight	Finland	France	Germany	C-130H
20.03-24.03.00	Test flight	Slovenia	USA	Germany, UK	OC-135B
25.03-03.04.00	Static display	USA	Chile	Germany	OC-135B
10.04-20.04.00	"Pre-disas-ter" mission	USA	Caribbean States	Germany	OC-135B
24.04-28.04.00	Test flight	Sweden	UK		Andover
22.05-26.05.00	Test flight	Finland	Russian		AN-30B
07.08-12.08.00	Test flight	USA	Slovenia	Germany	OC-135B
09.10-13.10.00	Test flight	Sweden	Russia	Finland, Latvia	AN-30
09.10-13.10.00	Test flight	Czech Republic	Bosnia and Herzegovina	Denmark	AN-30
13.11-17.11.00	Test flight	UK	Croatia		OC-135B
09.04-13.04.01	Test flight	Finland	Russia		AN-30
23.04-27.04.01	Test flight	Norway/ Benelux	Finland		C-130H
26.04-02.05.01	Test flight	Norway/ Benelux	Sweden		C-130H
14.05-18.05.01	Test flight	Czech Republic	Slovenia		AN-30
28.05-01.06.01	Test flight	Czech Republic	Bosnia and Herzegovina	Germany, Denmark	AN-30
04.06-07.06.01	Test flight	Russia	Sweden		AN-30B
11.06-15.06.01	Test flight	Russia	Finland		AN-30B
11.06-15.06.01	Test flight	UK	Croatia		Andover CMK1
09.07-13.07.01	Test flight	USA	Latvia	Germany, UK	OC-135B
21.07-28.07.01	Test flight	Sweden	USA	Germany	OC-135B
04.08-07.08.01	Test flight	USA	Sweden		OC-135B
07.08-10.08.01	Test flight	USA	Finland	Germany	OC-135B
04.09-07.09.01	Test flight	Norway	Latvia	Greece	C-130H
15.10-19.10.01	Test flight	Sweden	Russia		AN-30B

Source: Zentrum für Verifikationsaufgaben der Bundeswehr, OH, D-52503 Geilenkirchen.

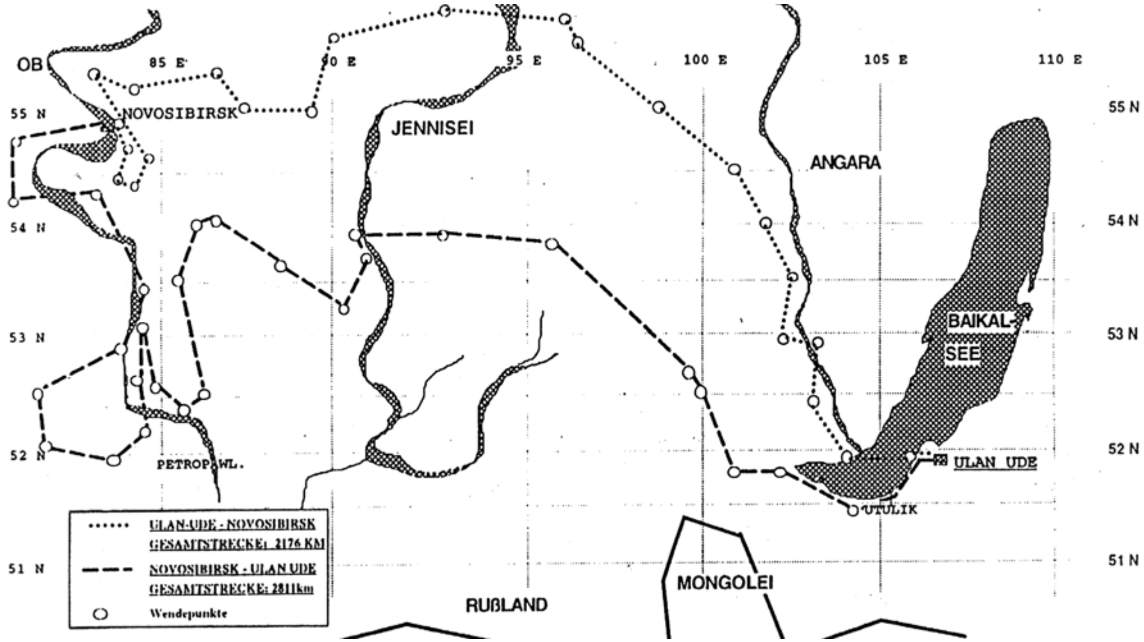


Figure 4.5: Flight route of a German-Russian test flight over Siberia using the German Open Skies aircraft (9-17 October 1995). Source: Götz Sperling, Erfahrungen aus der Praxis der militärischen luftgestützten Verifikation, Vortrag beim ISSC Seminar "Satellitengestützte Erdbeobachtung für Sicherheitspolitik, Wirtschaft und Ökologie" (25-26.03.1996, Oberpfaffenhofen), unpublished, Zentrum für Verifikationsaufgaben der Bundeswehr, D-52503 Geilenkirchen.

It is remarkable to note that the total number of missions (64) flown in 1999 represents 39% of the initial quotas.[15] Thus, in the absence of entry into force, the prolonged test phase that followed the signing of the Treaty may well be seen as some form of quasi-implementation below the full ratification level. Although part of the test operations were of purely technical nature (including training), the test flights clearly demonstrated the potential of the Treaty with regard to *monitoring* for enhancing military transparency, and to *confidence building* through cooperative flights, sharing of equipment and data sharing.

In particular, German flights over Russia and the Ukraine yielded valuable insights from an arms control and transparency point of view, by assessing sites which are not covered by other arms control treaties (e.g., CFE weapon reduction sites behind the Urals, Black Sea fleet). Russia has permitted overflights of sensitive sites, such as Intercontinental Ballistic Missiles (ICBM) silos.[16] Similarly, Russia performed a test flight over US bases in Germany (7-11 June 1999) during the formation of the US Kosovo task force. The flight followed on Russian inspections under the Vienna Documents in Macedonia (7-9 May 1999) and Albania (16-19 May 1999) as well as on an inspection of the US airbase at Aviano, Italy, under the CFE Treaty (May 1999). *This combined approach has demonstrated the value and applicability of both treaties under crisis conditions*.

The active test practice also led to opportunities for involving *non-signatory states*. A total of 42 of such flights were carried out from mid-1996 to December 2001 as shown in Table 4.3. The partner states fell into three categories:

- *Candidates for accession* to the Treaty after its entry into force. Here Croatia, Finland, Slovenia, Sweden and the three Baltic States participated in joint exercises with signatory states;
- *Demonstration flights* in areas where Open Skies agreements of their own might be established (Bosnia and Herzegovina, Chile);[17]
- *Data gathering* flights for pre- and post-disaster monitoring (Central America, Caribbean Islands, Germany).[18]

In summary, the trial implementation of the Treaty can be considered as a success:

- It involved virtually all states parties to the Treaty (except for Iceland and Kyrgyzstan);
- It proved the *functionality* of the equipment and of the Treaty provisions;
- It demonstrated that Treaty *objectives* could be obtained through cooperative observation flights;
- It showed that even *small states* with modest resources could play a distinctive role;
- As example, Bulgaria has now—due to a prudent investment policy—the most advanced camera equipment among all the parties to the Open Skies Treaty;[19]
- It created opportunities to *demonstrate the Open Skies approach* to countries that are not parties to the Open Skies Treaty, yet.

The trial implementation also revealed a number of weaker points:

- Some of the Treaty provisions (like accurate $\boldsymbol{H}_{\mathrm{min}}$ determination) require relatively complicated procedures and extensive training;
- The particular solution of the sensor pod of the Pod Group proved to be less than optimal.[20]

4.6 Trial Certifications of Open Skies Aircraft

Aircraft certification is a major Open Skies event. It is intended to assure participants that a designated aircraft and sensor combination, an observation system, can and will perform within the parameters of the Treaty specified limits. The certification event consists of a ground examination and of data taking flights over calibration targets with subsequent analysis of the collected in-flight data. The purpose of the flights is to establish the minimum sensor operation altitude $\boldsymbol{H}_{\mathrm{min}}$ for each camera/lens/film/filter combination, as discussed above (section 4.4).

Under Treaty conditions notification is given to all Open Skies states parties at least 60 days prior to the scheduled date of the *Certification Event*. Beyond the certifying state other states parties to the Treaty are allowed to participate with a maximum of four persons per state party but the total number of participants can be restricted by the certifying state to a total of no more than 40. During the ground examination, the participants will be briefed fully on the sensors and related equipment in the aircraft. They shall also be briefed on the safety requirements around the aircraft and will receive complete familiarization with the entire aircraft. During the in-flight examination, the aircraft will be flown at the expected minimum height for each sensor configuration for a minimum of five passes over the calibration target to establish the verified minimum height for each sensor configuration. The certification event is limited to a period totalling seven days per aircraft to be certified.

As part of the trial implementation phase several test certifications have been conducted. We refer here to the test certification of the former German Open Skies aircraft, as well as to a joint test certification of six Open Skies aircraft in August 2001.

The German Test Certification at Köln-Wahn, June 1997

The certification was held from 16-22 June 1997, at the Köln-Wahn airfield and was organized by the German Verification Center, Geilenkirchen. The certification was conducted under true Treaty conditions, although the Treaty had not entered into force by then.

The response to the invitation for the test certification of the German Open Skies aircraft was overwhelming; therefore, 40 observers—the maximum number allowed by the Treaty text—had to be selected from 20 interested countries according to their respective flight quota.[21] Due to their large number, the observers were split into three groups, which were dispatched daily to the three locations of interest: the aircraft itself (stationed at the airfield Köln-Wahn), the ground calibration target (at Mendig airfield, approximately 80 kilometres from Köln-Wahn), and the image processing and evaluation lab (then also at the airfield Köln-Wahn).

On two days the aircraft took off to the calibration target laid out at Mendig airfield. For about five hours each the aircraft circled over the target in order to take images using various sensor configurations at varying flight altitudes. The different configurations were realized by changing combinations of cameras (left oblique, vertical, right oblique), of photographic films (a Kodak film for high altitudes, an Agfa film for low altitudes), colour filters according to atmospheric conditions and resolution degradation filters according to flight altitude. Fortunately, all necessary image flights could be concluded before the weather conditions prohibited further test flights.

The photographic films were processed at Köln-Wahn overnight following the test flights, in the presence of the observers. Then, for each sensor/altitude combination, the contrast and resolution of the images were determined in the presence of the observers. The contrast was measured on the photographic negatives as exhibited by the large rectangular contrast fields of the calibration target. The resolution was determined on both the negatives and on video data independently by ten observers, for each. From these measurements the minimum flight altitude $\boldsymbol{H}_{\min}$ was determined and compared to the expected and actual altitude of the respective image flight. Numerous discussions between the observers helped to clarify even remote aspects of the Treaty's certification regulations.

At the ground calibration target at Mendig airfield, the observers inspected the make of the target and witnessed the ground measurement of the photometric contrast. The measurements on the target panels were sampled from a number of points by means of a hand-held photometer. These measurements are meant to verify that the contrast on the ground target is compatible with the agreed modulation contrast $K_a = 0.4$ in the $\boldsymbol{H}_{\min}$ formula. The aircraft itself could be inspected by all non-destructive means. Representatives of the maintenance team and the refitting-contractor company were present in order to answer all questions. All technical reports required for the certification had been assembled previously by the German Verification Center at Geilenkirchen, as demanded by Treaty regulations. The course of the certification procedure was certainly eased by the complementary English and Russian translation of the documents, which were shipped to the participating observers four weeks ahead of the certification.

The test certification was finally declared successful on all of the 24 tested sensor/film/filter/altitude configurations. Following two earlier test certifications of US Open Skies aircraft, and one other test certification of the Ukraine, this was probably the first really comprehensive certification of the Open Skies test phase, which observed the Treaty regulations strictly.

The German aircraft was expected to be retrofitted again during 1998 in order to mount the video cameras on stabilized platforms and to accommodate SAR and the infrared line scanner, requiring a new certification afterwards. However, the aircraft crashed three months after its test certification in September 1997.

Multilateral Data Gathering and Test Certification, Fürstenfeldbruck, August 2000 and 2001

In August 2000 the German Verification Center organized a major data gathering exercise at Fürstenfeldbruck near Munich. Two hundred and fifty participants and observers from 31 countries were present. The Open Skies aircraft of Bulgaria, the Czech Republic, Hungary, Romania and the Ukraine participated in the exercise. The event demonstrated the high professional standard and expertise of the Open Skies teams.

Based on the success of the event another multilateral certification exercise was held at Fürstenfeldbruck from 30 July to 13 August 2001. The aircraft of Canada (with sensor pod), Hungary, Russia, Ukraine and the United Kingdom performed an extensive flight programme over two calibration targets. Photo 4.2 shows a display of the five aircraft. For each sensor configuration five overflights were made, at the nominal height (expected $\boldsymbol{H}_{min}$).[22] All tested sensor configurations met the expectations. Hence, it was to be expected that the real certifications after entry into force of the Treaty would proceed without major problems. Nevertheless, it turned out that a German and a French calibration target yielded $\boldsymbol{H}_{min}$ values differing by 20%, due to different spacing of the bars. It is recommendable to agree on one type of target in the future.

In addition, some standards in the area of film processing had to be clarified. Some minor provisions of the Sensor Guidance Document turned out to be impracticable. It is likely that the film developing facilities of some states parties might not conform to the strict requirements of the Sensor Guidance Document. However, the cooperative practice and the spirit of the Treaty leave sufficient room for overcoming these problems. Photo 4.3 shows as an illustration international experts and observers on board of the Ukrainian Open Skies aircraft during a calibration flight.

Photo 4.2: Display of Open Skies aircraft during the test certification at Fürstenfeldbruck, August 2001. Photograph: A. Rothkirch, University of Hamburg.

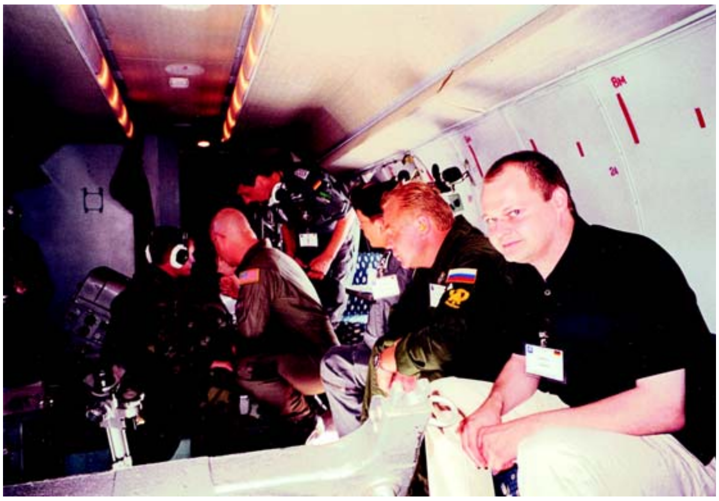


Photo 4.3: Sensor operators, international experts and observers on board of the Ukrainian Open Skies aircraft, August 2001. Photograph: A. Rothkirch, University of Hamburg.

Notes

1 Treaty-relevant policies are coordinated with the Ministry of Foreign Affairs, which is in charge of the diplomatic representation towards the co-signatories.

2 For details on the US Open Skies Unit see http://www.osmpf.wpafb.af.mil and www.dtra.mil/os/ops/os/os_os.html.

3 The data of Bulgaria, Hungary, the Pod Group, Russia, Ukraine, the United Kingdom, and the United States correspond to their certification in 2002. The sensor operation altitudes of the Swedish aircraft are expected estimates, which have to be confirmed. Some of the parties have more than two sensor configurations and related operation altitudes. The table gives the minimum and maximum altitude. The Pod Group panorama camera with reduction filter has an $\boldsymbol{H}_{min}$ of 786 metres at ground swath 4.3 kilometres. The data for Romania are expected to be the same as for Hungary (same camera/film).

4 Probably to the amazement of many, the list of countries which do not intend to acquire their own observation aircraft include large countries as well. The Federal Republic of Germany, after losing its observation aircraft in September 1997, decided not to replace the plane. For more details and an apparent argument for Germany having its own national observation aircraft see Klaus Arnhold, "Der Vertrag über den Offenen Himmel: Ein Konzept zur Aktualisierung des Vertrages", *SWP-Studie*, Berlin, June 2002, particularly pp. 15-16.

5 That is, an alternating pattern of warm and cold bars, with a width of 50 centimetres each, shall be resolved, if the (radiative) temperature difference of two adjacent bars is 3°K.

6 In practice, the ground swath covered by photographic cameras will be smaller. For example, the panoramic camera of the Pod Group covers at present a maximum ground swath of 14.5 kilometres on either side, when flying at sensor operation altitude ($\boldsymbol{H}_{min}$).

7 The German and British sensors are in storage.

8 D. G. Armstrong, "Technical Challenges Under Open Skies", *Proceedings of the Second International Airborne Remote Sensing Conference and Exhibition, Strasbourg*, Environmental Research Institute of Michigan, Ann Arbor, Vol. I, 1994, pp. 49-60.

9 Decision 3 uses a slightly different notation: L_2 for L_i and K_2 for K_i. We prefer the running index i because the values L_i and K_i refer to results from different overflights of the calibration target.

[10] D. G. Armstrong, op. cit., pp. 49-60.

[11] S. P. Simmons, "When Better Resolution Is Not Good: The Treaty on Open Skies", *Proceedings of the Second International Airborne Remote Sensing Conference and Exhibition, San Francisco*, Environmental Research Institute of Michigan, Ann Arbor, Vol. I, 1996, pp. 403-10. This paper discusses also the limits of the above formula if non-linear effects occur (resolution not proportional to flight altitude).

[12] Here D is the density of the film and E is the exposure time. For more details see ibid.

[13] *Disarmament Bulletin*, No. 19, Winter 1992/93, p. 15. More details on the test flights performed within years 1992-94 can be found in SIPRI Yearbooks 1993-95.

[14] *Open Skies Backgrounder No. 5*: *Second Trial Overflight*, Department of External Affairs, Ottawa: Government of Canada, January 1992.

[15] See Table 2.2.

[16] R. Hartmann and W. Heydrich, *Der Vertrag über den Offenen Himmel*, Baden-Baden: Nomos Verlag, 2000, p. 134.

[17] See sections 8.2 and 8.4.

[18] See section 7.3.2.

[19] The cameras are also frequently used for civilian cartographic and monitoring missions.

[20] The present pod is shared between ten states, thus reducing the flexibility of the members in scheduling flights. After each flight mission the pod is dismounted from the aircraft and stored at Brussels. The mounting procedure has impeded the flow of post-mission events. Other shortcomings include: no possibility of film replenishment during flight; in the event of camera malfunction, the camera failure cannot be observed and corrected; film might have to be changed on the airfield, i.e., in the open.

[21] In the meantime the OSCC has decided that it can agree on admitting more than 40 participants to a certification (see section 5.3).

[22] The Hungarian and Ukrainian aircraft had to make also overflights each at 0.85 x $\boldsymbol{H}_{\mathrm{min}}$ and 1.15 x $\boldsymbol{H}_{\mathrm{min}}$. The Pod Group, Russia and the United Kingdom had established the corresponding data prior to the event, thus easing the workload during the certification exercise.

CHAPTER 5

POST-RATIFICATION PHASE AND ENTRY INTO FORCE

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5.1 POST-RATIFICATION EVENTS

In May 2001 the Russian Federation and Belarus informed the OSCC that their respective national parliaments had ratified the Treaty on Open Skies. Taking into consideration these statements, the OSCC started a discussion on the resumption of activity in its informal working groups. This was initiated by the joint proposal of the Ukrainian and Russian delegations. The proposal had a dual aim: to begin the consideration of any remaining unresolved questions before the initiation of observation flights, and to commence preparations for the certification of observation aircraft.

On 25 June 2001, the OSCC adopted a Decision to resume the informal working groups once the Russian Federation and Belarus had deposited their instruments of ratification. Following this, the provisional application of the Treaty was extended for the last time. The French Chairmanship of the Commission put forward a suggestion to hold an information seminar on the Treaty on Open Skies for all OSCE participating states. It was agreed to hold the seminar at the beginning of October 2001 and the preparatory work started accordingly.

The seminar was held on 1-2 October 2001. The objectives of this event were the following:

- revitalizing the spirit of the Treaty and reviewing the history preceding its signing;
- achieving a deeper understanding of the main Treaty provisions;
- informing about the work that had been done by previous OSCC working groups;
- recalling the Decisions taken by the OSCC;

- formulating some conclusions based on the provisional application of the Treaty;
- exchanging views regarding further activities, in particular, certification of the observation aircraft and sensors.

Once the seminar was over, the OSCC took a Decision, on 29 October 2001, to establish three Informal Working Groups (IWG) on *Certification*, *Sensors*, and *Rules and Procedures*.

5.2 Entry into Force of the Treaty, 1 January 2002

On 2 November 2001, the Russian Federation and Belarus deposited their instruments of ratification with the depository states Canada and Hungary, thereby completing the ratification process by all states parties with a passive quota of eight flights or more. The number of ratifications now stood at 26 of the 27 signatory States (Kyrgyzstan had still not ratified the Treaty). Hence, according to its provisions, the Treaty could enter into force in 60 days, or in other words, on 1 January 2002.

At the OSCC plenary meeting of 5 November 2001, the delegations of the depository states informed the delegations of the other states parties that they had received the Russian and Belarussian instruments of ratification. This was the signal to begin discussion in the IWGs on Certification and Rules and Procedures.

5.3 Certification of Aircraft

The main goal of the IWG on Certification was to enable states parties to begin observation flights in a quick and comprehensive manner. To complete this task, the OSCC began by clarifying the intention of states parties with respect to the certification of their observation aircraft in 2002, the desirable time and place of such certification, and finally their willingness to conduct *joint certification*. To this end, the German Delegation stated its government's readiness to arrange a joint certification on its territory.

The first results were apparent within one month, when the OSCC, at its plenary meeting of 17 December 2001, adopted a Decision regarding the provisions for the initial certification period and a Chairperson's Statement on issues related to the certification of observation aircraft and sensors.

According to the above-mentioned Decision the initial certification period was designated to last from 1 January to 31 July 2002. During this period, the observation flights were to be conducted on an agreed bilateral basis only, and in accordance with the Treaty provisions. The utilization of states parties' active quotas for the calendar year 2002 would take place during the period of 1 August 2002 to 31 December 2003. The Decision also established the initial certification schedule as follows:

- A joint certification of the Republic of Hungary, Ukraine and of the group of states parties formed by the Republic of Belarus and the Russian Federation from 15-29 April 2002 at the Naval Air Station Nordholz, Germany;
- A separate certification of the US aircraft from 8-15 May 2002 at Wright-Patterson Air Force Base in the United States;
- A unique certification of the Pod Group's pod-system from 19-26 June 2002 at Orleans Bercy airbase in France;
- A joint certification of the United Kingdom and Bulgaria from 8-16 July 2002 at RAF Brize Norton airbase in the United Kingdom.

The OSCC Chairperson's Statement established *six arrangements* to facilitate the certification process. While doing so experts took into consideration the previous discussions and agreements achieved in the OSCC, as well as the experience gained during the period of provisional application. The arrangements deal with both organizational and purely technical matters, as follows:

- **The methodology for the determination of the number of individuals participating in a certification**. It provides a common interpretation of the relevant Treaty provisions aiming to find a compromise between the limited number of participants (40) set forth in the Treaty and the number of notified participation applications in the event these exceed 40 persons;
- **The principles for the conduct of the C-130H/pod-system certification**. This unique sensors system will be used by the Benelux

countries, Canada, France, Greece, Italy, Norway, Portugal and Spain, referred to as the Pod Group, with their own aircraft C-130H. According to the agreed principles, the certification results for one C-130H and its pod-system will be valid for all the above-mentioned states parties. In order to facilitate this, the Pod Group were obliged to take additional steps while testing their pod-system prior to certification and to provide information on their aircraft;

- **The principles for joint certification**. The definition of joint certification, as well as its aims and the responsibilities of states parties wishing to participate in a joint certification while preparing and conducting this event, were spelt out in this document;
- **A common understanding** was reached on the relevant provisions of the Treaty and the Guidance Document on Certification regarding the *determination of* H_{min}*-cert* in the course of a certification for sensors whose ground resolution is dependent upon a height above ground level;
- **The use of CD-ROMs** was accepted as the desired medium *for the distribution of data relevant to an observation aircraft and its associated sensors certification*. In order to enhance the effective use of CD-ROMs containing this data, certain technical standards were agreed;
- **The principle giving states parties a right to identify the calibration target** it will use in the course of flight examination during the certification was established.

Meanwhile, the OSCC IWG on Certification continued its work on the preparation of the certification of observation aircraft and observation flights. In February and March 2002, the OSCC adopted Decision 4/02 on “Provisions for the Use of a Standard Signature Page to the Certification Report” and Decision 7/02 revising the maximum level of per diem for states parties representatives during a certification. With the adoption of these decisions, the IWG on Certification had addressed all the issues that were to be resolved prior to certification and thus the initial certification process was able to commence.

By July 2002 the scheduled certifications had been concluded successfully. Hence, Bulgaria, Hungary, Russia, the Pod Group, Ukraine, the United Kingdom and the United States had certified aircraft ready to start regular observation flights. Table 4.1 shows the certified sensor operation altitudes ($\boldsymbol{H}_{\mathrm{min}}$) for vertical cameras. The certification of the Czech and Romanian aircraft did not materialize and might take place in

2004. Sweden and Turkey have scheduled a joint certification at Nordholz Naval Air Base, Germany, which will include the certification of a Russian Tu-154 aircraft for April 2004.

5.4 Decisions on Rules and Procedures

At the 17 December 2001 plenary, the OSCC adopted a Decision on its rules of procedure and working methods that reflected the Treaty's entry into force. The Decision foresees three OSCC sessions per year from the end of one OSCE recess to the end of the following recess, which would amount to a period of about four months. Each session will be chaired by a state party in rotation. Plenary meetings will be held at least once per session, and not more than once a month. Informal meetings will be convened by the Chairmanship when needed.

In summer 2002 many tasks listed on the agenda of the IWG on Rules and Procedures were addressed, notably several difficult issues that may only be resolved by bringing in appropriate expertise. The list covers a wide range of topics, in particular those dealing with financial aspects of Open Skies missions, data collected during observation flights and their copies, mission planning in special situations and the provision of support for Treaty implementation.

Many of these issues have emerged as a result of the experience of states parties during the period of provisional application. Obviously, their proposals reflect, to a certain extent, different national practices in the conduct of observation flights. From time to time, during the discussion on such proposals, the IWG on Rules and Procedures has faced difficulties in reaching a common understanding of a particular problem and in finding an appropriate solution. As a result, the consideration of these issues can be time consuming. On occasion, consideration of such problems by states parties had to be postponed until sufficient experience has been obtained in the course of Treaty implementation.

Similarly, discussion on the suggestion of involving the OSCE Secretariat's Conflict Prevention Centre (CPC) in Treaty implementation, by tasking it to maintain an *Open Skies Central Data Bank*, has also been a slow process. Without a clear idea of the kinds of functions such a databank would perform, states parties have not been able to take a common decision on this issue. Some of the tasks which would be performed by the databank, as well as those reflected in the OSCC Decision 21 of 23 October 1995, have been already carried out by the Conference Services Unit of the OSCE Secretariat, and can often be performed by states parties themselves. Therefore, the implementation of Decision 21 could be suspended until its worth has been proven through experience gained during Treaty implementation. Ultimately, on 24 February 2003, rather than establishing a full databank, the OSCC requested the OSCE secretariat to provide support in filing and distributing information relevant to Treaty matters (Decision 2/03).[1]

Nevertheless, a number of questions were successfully resolved by the Group and subsequently approved by the OSCC as decisions or Chairperson's statements. The most important are the following:

- guidelines for accession to the Treaty on Open Skies;
- transit flights of observation or transport aircraft over territories of states non-parties to the Treaty;
- coordination of observation flights for the year 2002;[2]
- protection of data collected during observation flights.

5.5 Taxi Option

On 22 July 2002, Russia stated in the OSCC that it would not provide its own observation aircraft to conduct flights from the Open Skies airfields related to the point of entry Ulan-Ude (near Lake Baikal in Siberia) unless otherwise established by means of formal notification. The inspecting states parties would have to utilize their own aircraft or that of a third party from this point of entry. Russia's decision was motivated by financial, logistical and technical considerations. Until March 2004 the pool of certified Russian Open Skies aircraft consisted of medium range AN-30 solely. In 2002/03 Russia also refrained from exercising its taxi option on three observation flights by France, the United Kingdom and the United States, respectively, starting from the point of entry near Moscow. Thus, the Russian position on the taxi option seems to have become more flexible.[3]

5.6 Accession of Additional States Parties

The OSCC dealt also with the guidelines for accession to the Treaty and adopted Decision 8/02. The provisions laid down in Article XVII, which deal with accession, were significantly developed and clarified. This Decision is important because it provides the legal basis for accession to the Treaty by non-states parties. Early in 2002 Finland and Sweden applied for accession to the Treaty on Open Skies. The applications were deposited with Canada on 4 January and with Hungary on 7 January. In their applications, Finland and Sweden also asked to be allotted passive quotas of five and seven observation flights, respectively.[4] The OSCC adopted Decisions on 4 February 2002, which stated that the Swedish and Finnish applications were accepted.

On 12 March 2002, Spain, in its capacity as Chair of the *WEU Group of States Parties*, informed the other states parties that Finland and Sweden had applied to join this Group. According to this annoncement, their membership will take effect following their accession to the Treaty and not earlier than six months after the circulation of the above-mentioned Spanish notification. On 28 June 2002 and 12 December 2002, respectively, Sweden and Finland deposited their instruments of ratification, meaning that they became state parties 60 days thereafter.

Five additional states also applied for accession to the Treaty: Bosnia and Herzegovina, Croatia, Cyprus, Latvia and Lithuania. All of them have been accepted to join the Treaty by the OSCC on 22 July, except for Cyprus, because of the veto of Turkey. The handling of this veto is a challenge for OSCE diplomacy. Turkey had already strongly opposed that Cyprus would become a state party in 1991-92 and even more so that Cyprus would have a quota. Estonia and Slovenia applied for accession in early 2003. Latvia's accession entered into force on 12 February 2003.

The most recent applications have particular political relevance and underline the future potential of the Treaty in areas of cross-border tensions. Each of these states has some unresolved issues with one or more of its neighbours. The relation of the *Baltic states* with Russia could be eased by mutual Open Skies flights, in particular after the admission of the Baltic states to NATO. *Croatia* strongly wants to integrate itself into the network of European institutions. It has been involved in two wars from 1991 to 1995 and is a main actor in the future peaceful development on the Balkans. *Bosnia and Herzegovina* still struggles with the wounds of the war and with ethnic separation. It has been the scene of seven multilateral aerial observation demonstration flights in 1997-2001. It is thus fully aware of the potential of Open Skies. However, a number of implementation problems have to be overcome by the different entities of Bosnia and Herzegovina. The applications of Croatia and Bosnia and Herzegovina are also a reaction to the failure of establishing a separate aerial monitoring regime under Article V of the Annex to the Dayton Agreement of 1995, as discussed in section 8.3.

Outlook

At the same time, for many OSCE participating states, as well as for other countries interested in joining the Open Skies regime, the financial burden regarding participation will be an important determining factor. As the security situation in Europe improves, the question of costs moves to the forefront. Another problem the states parties will probably encounter quite soon is the constraints of the Treaty as it now stands. With this in mind, it may well be worth taking another look at the additional areas of Treaty application, namely conflict prevention and environmental monitoring, which were envisaged, but not worked out before the Treaty entered into force.

Notes

1 The support includes: maintaining a hard copy of all OSCC documents; filing of circulated national data; maintaining a central archive of Open Skies notifications; maintaining a point of contact list of Open Skies experts; posting all OSCC documents on the internal OSCE delegations web site.

2 The distribution of active quota for flights over the Russian Federation and Belarus was agreed as follows: out of 28 such observation flights to be carried out in the period 1 August 2002 to 31 December 2003 13 have been claimed for 2002 and 15 for 2003. The remaining three flights are reserved for Finland (one) and Sweden (two).

3 A state party, which exercises the taxi option, has to cover the operation cost of its taxi aircraft for the respective flight. In contrast, if the observing party provides its own aircraft, it then has the obligation to cover the aircraft operation cost for the overflight.

4 Also, a passive quota of four has been allocated to Georgia, but has not been distributed yet.

CHAPTER 6

IMAGE ANALYSIS AND DATA ASSESSMENT: WHAT CAN BE LEARNT FROM OPEN SKIES IMAGE DATA?

Hartwig Spitzer and Rafael Wiemker

Image analysis and interpretation is an art, which requires skills and experience. In this chapter we will take a look at the detection and identification potential of the Open Skies image data in different application areas. We will then discuss shortly the traditional way of photo interpretation and some of the challenges and opportunities of digital image processing.

6.1 Imaging Targets and Assessment Potential

What kind of sites will be looked at in Open Skies missions? In principle any site can be photographed in the spirit of enhancing openness and confidence. In practice the application horizon will focus primarily on the observation of military or military-industrial sites and activities, as well as on the monitoring of crisis areas. The preamble of the Treaty also mentions a possible future extension to other fields of application like the protection of the environment.

Hence, potential imaging targets under Open Skies include a wide choice of military sites and activities in particular:

- Headquarters and communication infrastructure;
- Barracks with vehicle depots and training grounds;
- Airfields;
- Naval facilities;
- Missile launch sites;
- Military production and repair facilities;
- Transport infrastructure (roads, bridges, railway lines etc.);
- Military activities, manoeuvres.

Conflict prevention and *crisis management* might call for the monitoring of irregular forces, recently laid minefields, refugee movements and camps, damage assessment of hostile actions, traffic anomalies. Applications for the protection of the *environment* will likely focus on the monitoring of environmental disasters and of emergency situations like floods, heavy storm damage, forest fires, industrial disasters, etc. (see section 7.3).

In addition, the Treaty allows for imaging of virtually all civilian, dual-use or suspect sites without territorial restriction.

In practice the amount of data taking will be limited by the agreed flight quota and the time constraints of the missions, as well as by weather conditions. The Treaty aims at enhancing openness and confidence through occasional checks rather than through regular and complete monitoring.

To what degree can Open Skies image data support the above objectives? Access to raw image data does not by itself impart useable knowledge. Image analysts need training and expertise as well as access to contextual information and reference data.[1] Depending on the spatial resolution, image analysts can use the images to address various imaging interpretation tasks.

These tasks usually begin with *detection* (i.e., determining the presence or absence of a particular feature like a vehicle) and *general identification* (i.e., specifying a feature or an object within a particular class, like identifying a vehicle as truck). *Precise identification* discriminates within a target class of known types (e.g., by identifying a tank as a heavy battle tank T 72). *Description* of an object requires much improved resolution in order to provide precise dimensions, configuration, construction of components (e.g., by specifying the calibre of the gun of a tank). Description is usually seen as part of intelligence. A resolution capability that would enable description of major land weapons systems (like tanks, artillery or combat aircraft) are clearly excluded by the Treaty for all sensor categories.

Table 6.1 gives the approximate ground resolution in meters required for target detection and identification (as well as for description and technical analysis).[2] The origins of this table date back to the 1950s when photographic film was used exclusively. Hence, we infer that the definition of resolution used in Table 6.1 is the photogrammetric one, which differs by approximately a factor of two from the definition used for Open Skies Treaty implementation. *Thus, the assessment potential of Open Skies images at the 30 centimetres Treaty resolution corresponds to the 60 centimetres resolution values in Table 6.1.*

Table 6.1: Ground Resolution (Photogrammetric Definition) Required for Target Detection, Identification, Description and Analysis

Approximate Ground Resolution in Meters for Target Detection, Identification, Description and Analysis					
Target[a]	**Detection[b]**	**General ID[c]**	**Precise ID[d]**	**Descrip-tion[e]**	**Technical Analysis[f]**
Troop units	6.0	2.0	1.20	0.30	0.150
Vehicles	1.5	0.6	0.30	0.06	0.045
Aircraft	4.5	1.5	1.00	0.15	0.045
Airfield facilities	6.0	4.5	3.00	0.30	0.150
Nuclear weapons components	2.5	1.5	0.30	0.03	0.015
Missile sites (SSM/SAM)	3.0	1.5	0.60	0.30	0.045
Rockets and artillery	1.0	0.6	0.15	0.05	0.045
Surface ships	7.5-15.0	4.5	0.60	0.30	0.045
Surfaced submarines	7.5-30.0	4.5-6.0	1.50	1.00	0.030
Roads	6.0-9.0	6.0	1.80	0.60	0.400
Bridges	6.0	4.5	1.50	1.00	0.300
Communications					
radar	3.0	1.0	0.30	0.15	0.015
radio	3.0	1.5	0.30	0.15	0.015
Command and control headquarters	3.0	1.5	1.00	0.15	0.090
Supply dumps	1.5-3.0	0.6	0.30	0.03	0.030
Land minefields	3.0-9.0	6.0	1.00	0.03	--
Urban areas	60.0	30.0	3.00	3.00	0.750
Coasts, landing beaches	15.0-30.0	4.5	3.00	1.50	0.150
Ports and harbors	30.0	15.0	6.00	3.00	0.300

Table 6.1 (continued)

Approximate Ground Resolution in Meters for Target Detection, Identification, Description and Analysis					
Target[a]	**Detection**[b]	**General ID**[c]	**Precise ID**[d]	**Description**[e]	**Technical Analysis**[f]
Railroad yards and shops	15.0-30.0	15.0	6.00	1.50	0.400
Terrain	--	90.0	4.50	1.50	0.750

Notes:
[a] The table indicates the minimum resolution in meters at which the target can be detected, identified, described or analyzed. No source specifies which definition of resolution (pixel-size or white-dot) is used, but the table is internally consistent.
[b] Detection: location of a class of units, object, or activity of military interest.
[c] General identification: determination of general target type.
[d] Precise identification: discrimination within a target type of known types.
[e] Description: size/dimension, configuration/layout, components construction, equipment count, etc.
[f] Technical analysis: detailed analysis of specific equipment.
Sources: US Senate, Committee on Commerce, Science, and Transportation, *NASA Authorization for Fiscal Year 1978*, pp. 1642-43, and *Reconnaissance Hand Book* (McDonnell Douglas Corporation 1982), p. 125. Table from Ann M. Florini, "The Opening Skies: Third Party Imaging Satellites and US Security", *International Security*, Vol. 13, No. 2 (Fall 1988), p. 98.

Source: Y. A. Dehquanzada and A. M. Florini, *Secrets for Sale: How Commercial Satellite Imagery will Change the World*, and sources quoted therein, Washington, DC: Carnergie Endowment for International Peace, 2000, p. 45.

We can infer from Table 6.1 that Open Skies panchromatic images at Treaty resolution will allow for the *general identification* of land vehicles, rockets and artillery as well as for precise identification of troop units, aircraft, airfield facilities, missile sites, surface ships and infrastructure, like roads and headquarters. In addition, test missions have verified a very good capability of monitoring the effects of environmental disasters like floods and hurricane damage.[3]

6.2 Potential of Different Sensors

6.2.1 Photographic Cameras (stereo)

Photographic framing cameras equipped with panchromatic (black and white) film have been—for a long time—the backbone of military aerial surveillance and civilian photogrammetry. Usually the images are taken in *stereo mode*. Here the images are taken in continuous succession so that each two subsequent frames show a 60% overlap. Thus, each point in the observed scene is mapped in at least two photographs. The observation angle of a given landmark is different between the two photographs (parallax) and its height can be determined from the relative displacement between the two positions.

Hence, with a 60% frame overlap it becomes possible to construct a three-dimensional model of the observed scene. The accuracy (σ_z) in determining the height of a feature is about 50% worse than the position accuracy (σ_{xy}) in the plane.[4] For example, with a photographic image scale of 1:100,000 (ground swath 23 kilometres) one can expect a positional accuracy of $\sigma_{xy} \approx 90$ centimetres and determine the height of building and rooftops with an accuracy of $\sigma_z \approx 135$ centimetres.

Image analysts view two stereo images through stereoscopes, which provide a three-dimensional impression. Looking at stereo images is like overflying the observed space. The stereo method contributes significantly to the identification potential of images, because objects can be discriminated by their extension in three dimensions. Good image analysts are trained for many months on known objects and in the use of context knowledge in order to achieve optimum identification results. Photo 6.1 shows an image detail of a military airport taken for the US Open Skies programme. The figure also indicates the annotated interpretation obtained by stereoscopic viewing. Combat aircraft and munitions vehicles can be identified.

Panoramic and oblique cameras provide the Treaty resolution only in a small angular sector (in vertical direction for panoramic cameras), and give a less sharp image in other directions. However, they allow for side views of buildings, and give a wide overview of the underlying scenery. This includes the capability to identify power transformers, and lead-ins adjacent or attached to walls or under roof overhangs. However, the masking of objects by terrain or trees can reduce the information value of oblique imagery.[5]

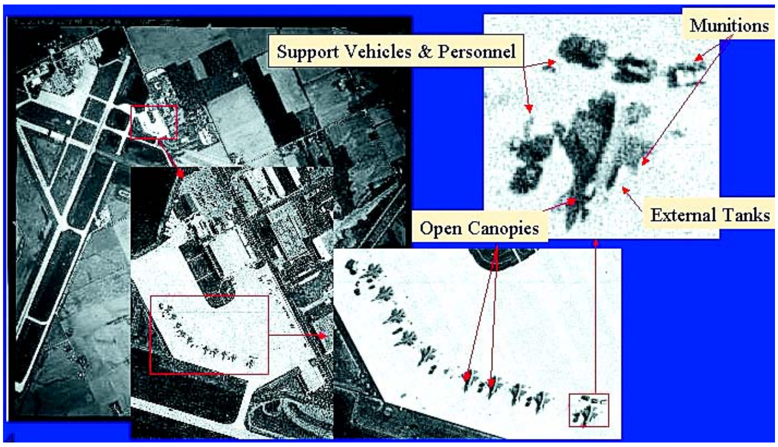


Photo 6.1: Open Skies image of a military airfield with magnified details. *Source*: US Defense Threat Reduction Agency, Washington, DC, Briefing to PPF 2000 Forum Innovations and Technology Transfer, May 11, 1999.

6.2.2 Video Images

Video cameras on Open Skies aircraft are primarily used for providing a real-time look at the scene under or ahead of the aircraft. The ground swath covered is usually restricted to smaller values than those of aerial cameras.

Video cameras can be distinguished into two different types:

- A conventional video camera forms a complete image frame in one look. The camera's lens focuses the image on a Charge Coupled Device (CCD) array from where it is converted into either an analogue or digital video signal. The full video frames come at a rate of 25 hertz[6] and can be viewed in real-time on a closed circuit TV monitor[7] or recorded by a video tape recorder.

- A digital video line camera[8] sees only one line at a time. The line is perpendicular to the flight track and the full image is formed only as the aircraft moves along its flight track and image line after line is added (so-called push broom scanner). The image lines can be recorded digitally. The image can also be viewed immediately onboard, but it has to be kept in mind that it does not show a real-time TV image but that each image line depicts the state at its recording time, that is, a couple of seconds earlier. The top lines on the display are current while the bottom lines are the “oldest”.

Both camera types can be built to yield panchromatic or colour images. Generally the video image is not as sharp as the imagery from the framing cameras. While the Treaty allows for 30 centimetres ground resolution of video cameras most systems give much coarser resolution when flown at the $\boldsymbol{H}_{\text{min}}$ of photographic cameras (850-11,000 metres). The main advantages of video systems are the immediate availability of images during the flight and the optional colour quality, which is permitted by the Treaty and allows for easier image interpretation.

The silicon, which forms the CCD detector material for both types of video cameras, is sensitive to visible light and to invisible near-infrared radiation up to a wavelength of 1,050 nanometres. The former German Open Skies video camera had a cut-off filter for wavelengths greater than 630 nanometres, since the Treaty does not permit near infrared imagery as of yet.[9] The near infrared wavelength range, however, would be very useful for all kinds of vegetation monitoring, and indirectly also for finding buried items (such as mine fields) since it is capable of showing disturbances in vegetated areas.[10]

The line camera has a substantially higher resolution. A line of a conventional video image has a resolution equivalent to 700-800 pixels[11] whereas a line camera typically contains 6,000 pixels.[12] This means that for a fixed ground resolution the line camera can cover a seven times larger ground swath, or if the ground swath is fixed the image is seven times better resolved. On the other hand, the line camera images are very sensitive to deviations from a straight flight path. Each turn or attitude change of the aircraft will cause distortions in the image, which have to be corrected during later geocoding (see section 6.3.1). Thus, the raw images resulting from conventional and line cameras are not comparable. The conventional video images are captured instantaneously and are much less distorted.

6.2.3 Thermal Infrared Images

Thermal infrared image detectors are sensitive to the thermal radiation, which each body emits. Bodies at room temperature (20 degrees) emit electromagnetic radiation primarily in the wavelength range of 8-13 micrometres, whereas the wavelength of visible light is at 0.4-0.68 micrometres. Hot objects like the afterburner of a jet fighter emit dominantly at wavelengths between 1 and 5 micrometres (depending on temperature). Thermal images can be taken during day and night, independent of illumination by the sun.

Precision imaging with thermal infrared radiation presents bigger technical problems than imaging in the visible range. Because of longer wavelengths the diffraction limit[13] is higher and has to be compensated for by larger apertures. Detectors need to be cooled in order to reduce thermal noise. Since glass does not transmit thermal infrared radiation for most of the wavelength range (≥ 3 micrometres), different lens materials such as germanium have to be used. The intensity of infrared radiation is usually smaller than that of visible-light radiation (during the day). In order to detect enough radiation and to stay clear of the diffraction limit one has to use an electro-optic image sensor with quite large pixels with dimensions of 20-100 micrometres (as compared to typical pixel sizes of 10 micrometres in CCD detectors for visible light).

The Open Skies Treaty foresees the future use of *thermal infrared line scanners* in a second phase (final concept starting on 1 January 2006). Infrared line scanners use a rotating mirror with optics to direct radiation from a small ground-surface area to a detector or detector array. The mirror rotates perpendicular to the line of flight so that, with each cycle, a strip of ground perpendicular to the flight direction is covered. The ground swath covered is quite wide, for example, 1.15 x h for the AA/AAD-5 line scanner described in Appendix C, where h is the flight altitude. The resulting image can be registered either on film or on magnetic tape.

In the context of Open Skies, thermal infrared imaging will be particularly useful for monitoring military manoeuvres and production plants at day and night. The operation state of vehicles or equipment can be deduced from their heat profile. The fuel status of aircraft and storage tanks can be determined as well as the thermal differences in effluents and cooling ponds. Photo 6.2 shows a thermal infrared aerial image of an airport. Warm objects appear white and cold objects dark. Aircraft and buildings can be clearly recognized.[14]

Photo 6.2: Thermal infrared line scanner image of an airport taken at night. Notice the "hot" buried heating lines and trees along the roadsides. Warm auxiliary power units can be seen near some of the aircraft. One aircraft in the upper left corner appears anomalously warm. It might have been parked in the nearby hangar not long before the image was taken. Photo: Courtesy of Intera-Kenting, Ottawa.

The image was taken shortly before midnight. The quality of the picture demonstrates the potential of thermal infrared imaging for night vision independent of illumination. At the Treaty resolution of 50 centimetres thermal infrared images will be an important additional source of information in addition to photographic cameras. Image analysis of digitally stored infrared images will require computer processing and display of the image data. The line scanners of type AA/AAD-5, which are prepared for Open Skies use, record the thermal images on film. This eases the analysis of the image data by human image analysts.

In summary, infrared imaging technology is available for aerial monitoring of heat profiles of hardware and buildings. The available resolution will be adequate to detect objects of interest, which are not masked by roofs. Infrared radiation also can give indications of activities in buildings of industrial production as derived from temperature profiles. Infrared sensors will be particularly useful for crisis monitoring missions by locating activities at night.

6.2.4 Synthetic Aperture Radar

Unlike other ("passive") Open Skies sensors, SAR is a so-called "active" sensor. It emits microwaves, which are scattered back from the ground and are recorded by the sensor. The most prominent feature of SAR instruments is their 24-hour/all-weather capability. Since SAR produces its own microwave "illumination", it does not need the sunlight to brighten the scene. Moreover, SAR microwaves are not obstructed by haze and clouds.

In principle, the ground resolution of a SAR sensor is independent of flight altitude. Better ground resolution requires higher microwave and computing power, however. The ground resolution limit of 3 metres harkens back to the fact that sub-meter resolution SAR has only very recently become commercially available.

Unlike other sensors, the raw data recorded by the SAR antenna are not in image-like form. The raw data, which comprise phase and amplitude of the reflected waves as well as timing information, have first to undergo sophisticated processing before the image can be seen. It has to be noted that the final image quality depends to a certain degree on advanced post-processing techniques. The Treaty foresees that copies of the original raw data can be requested by other states parties.

SAR imagery looks quite different from optical imagery and is more difficult to interpret. The signal strength of the ground reflected microwaves depends on the roughness of the scanned surface and the orientation relative to the antenna. Smooth surfaces like water bodies have a very low reflection signal. The reflection signal becomes high when the surface roughness scale is comparable to the radar wavelength (1-30 centimetres). The reflection is most pronounced for conducting materials, particularly metallic structures.

Photo 6.3 shows a SAR image of the military airport at Fürstenfeldbruck, Bavaria, Germany as an example. The image was taken by a commercial airborne SAR sensor, which operates at a nominal resolution of 50 centimetres (both in flight direction and perpendicular to the flight path). The airfield, various buildings, streets, trees and fields can be recognized. The aircraft can be identified from their dimensions as Transall transporters. A comparison with Photos 6.1 and 6.2 shows that the contours of well defined objects appear fuzzier on SAR images than on photographic or thermal infrared images of similar resolution.

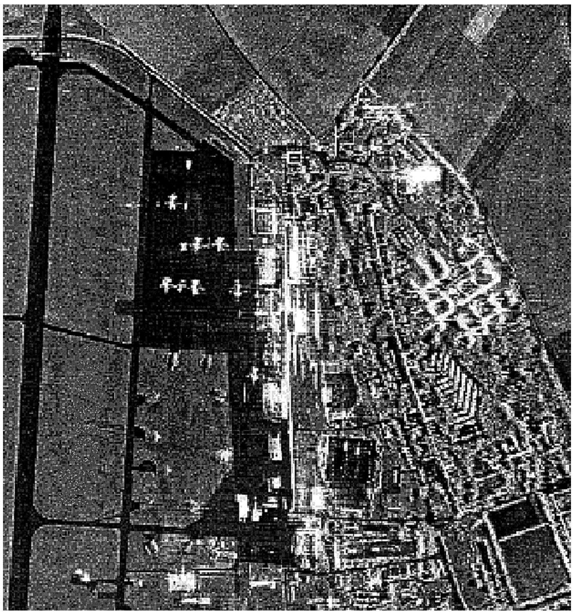


Photo 6.3: SAR image of the military airport at Fürstenfeldbruck, Bavaria, Germany at nominal resolution of 50 centimetres. Photo: Courtesy of Dr. J. Moreira, Aerosensing GmbH, Wessling.

Insiders claim that a SAR resolution of 15-20 centimetres would be required in order to provide the same sharpness of shapes as a photo of 30-50 centimetres resolution. Still, the 3-metre resolution of SAR sensors under Open Skies will provide detection and identification of infrastructure facilities like airports, streets, bridges, buildings as well as of large vehicles (e.g., aircraft, ships). Aircraft types can be determined from their dimensions. The main advantage of SAR will be its all-weather day-and-night operation capability.

6.3 THE DIGITAL REVOLUTION: COMPUTER-AIDED IMAGE ANALYSIS

For many decades the analysis and interpretation of aerial images for security purposes has been the task of well-trained human image analysts. Optical equipment and computers have been used for supporting image display and measurement. But the main information processor was the human eye and brain, assisted by the memory of a long-term experience and training.

With the advent of digital satellite and aerial image sensors the role of computers in image processing and analysis is growing continuously. We expect that a transition to the digital age will come sooner or later also in the Open Skies context. Therefore, we will sketch shortly some of the challenges and opportunities of both digital image processing and analysis.

Image processing technologies have reached a mature stage, in particular in relation to:

- *pre-processing* (geometric and radiometric calibration, geocoding, noise filtering, image restoration in the presence of sensor artifacts);
- *visualisation* (colour image display, formation of colour composite images, stereoscopic display of terrain, virtual reality, that is, visual display of a three dimensional view from a flight over a scene);
- *segmentation and feature enhancement* (edge detection, contrast sharpening, etc.).

In the field of digital image analysis computerized *land cover classification* has yielded a still growing variety of unsupervised and supervised methods, which are widely used.[15] All approaches have to deal with major *validation* problems:

- acquisition of reliable reference data (ground truth) in order to calibrate the classifying algorithms or to validate the results;
- difficulties of quantifying the classification accuracy in an objective way, even if some kind of ground truth is available.

Useful classification tools are available commercially. However, research and development is still ongoing, in particular in the area of enhancing the accuracy of classification.

Further steps towards a comprehensive computer assisted image understanding are the fields of *object recognition and knowledge-based interpretation* of scenes. These challenges are the concern of various research and development programmes. Applications to a few rather simple target configurations have reached the maturity required for commercial applications.

Another important development is the trend towards combined exploitation of image data from different sensors and different resolutions *(multi-sensor data fusion and multi-resolution analysis)*.

Below we elaborate on some of the techniques, which are most likely to be applied in the Open Skies context, once the imagery is available in digitalized form. These techniques can be applied already now, provided the analogue imagery (photographs) is properly digitalized.

6.3.1 Geocoding/Image Registration

The imagery recorded during an Open Skies flight can of course be analyzed in its original form as it comes from each sensor, for example, frame-by-frame for photographic images and SAR, and track-by-track for digital video and infrared line scanners.[16] However, for advanced archival processing and computer aided analysis a crucial pre-requisite is—after proper digitization—the *geocoding* or *geometric registration* of the imagery. Ideally, the images are geocoded, that is, each image element (pixel) is mapped onto a geographic world coordinate. Thus, the image can be embedded into a *Geographic Information System* (GIS) for archival and retrieval. From there all images available for a given coordinate range can be retrieved and displayed in synopsis. A less demanding possibility than full geocoding is the relative geometric registration of several images with respect to each other for case based studies.

For illustration, Photo 6.4 shows two images of the same scene (recorded in 1991 and 1995) registered to map. The images were recorded by a multispectral line scanner from an altitude of 1,800 metres at wavelengths of visible light. Note the distortions that stem from the slightly bent flight path of the sensor-carrying aircraft (image recording time is approximately 20 seconds). The images are resampled so that spatial correspondence is achieved.

Operational geocoding/registration is still a tedious problem for airborne imagery. Correct registration depends on the one hand on the terrain of the imaged scene, and on the other hand on the flight path of the aircraft. The position and attitude of the aircraft has to be computed for the recording time of each pixel. Since the 1990s this can be achieved at the necessary rate of about 100 hertz by combining different global positioning system (GPS) and inertial navigation system (INS) data.

An alternative—if such an automated parametric registration is not available—is the selection of landmarks or ground control points (GCPs) by photo analysts. The same control point has to be identified in the recorded image as well as on the topographic map or the other image in question. Due to flight path ambiguity, airborne images need a rather high number of hand selected GCPs.[17] By virtue of these landmarks, locally adaptive coordinate transformation functions can be computed which are then used to register the imagery.[18]

A typical problem of imagery recorded with airborne line scanners is that the registration inaccuracy can be as large as the size of one or several pixels. The elevation of scene objects displaces their position in the image. With a digital elevation model (DEM) or digital terrain model (DTM) this effect can be corrected. However, small objects such as houses and trees are usually not considered in a DEM with a common mesh width of say 50 metres. The residual displacements are much more of a problem in airborne imagery than in spaceborne one, due to the larger scan angles of sensors carried by aircraft.

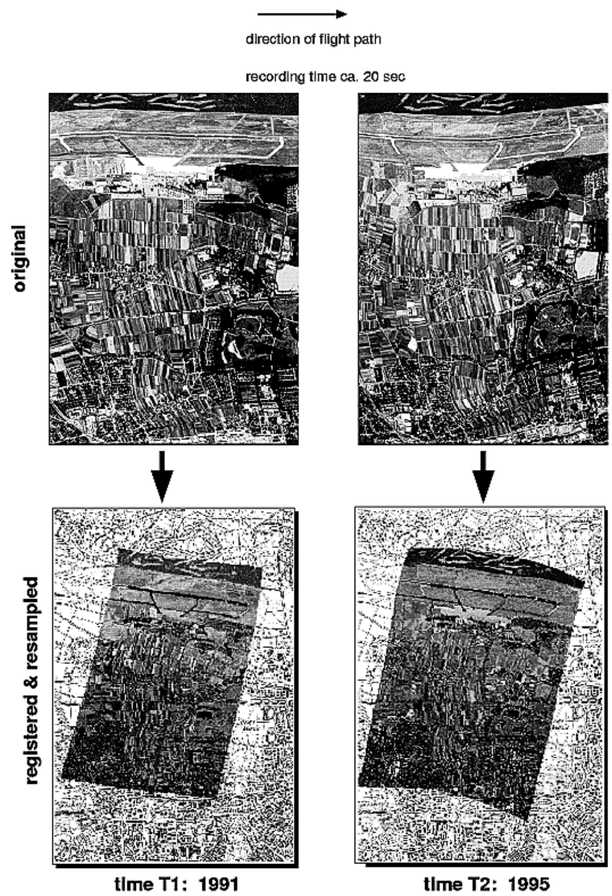


Photo 6.4: Top: Images of the airport of Nürnberg, Germany and adjacent areas taken by a line scanner in two time periods. Bottom: The same images after registration to a map. *Source*: A. Rothkirch, University of Hamburg.

The registration and geocoding problems are in principle well understood and controlled. With the advent of differential GPS the geocoding can theoretically be carried out by a fully automated procedure. However, as of yet these procedures are still quite tedious. Often not all the data is available: missing DTM, missing difference signal for the GPS, lacking GPS accuracy due to atmospheric disturbance or mountainous terrain, high frequency vibrations of the sensors relative to the platform, etc. are common problems. Large scale monitoring needs quite robust automated procedures and precludes landmark selection by hand.

6.3.2 Computer Aided Fusion of Images from Multiple Sources

Data fusion allows the merging of imagery of the same scene from multiple sources, such as images recorded by different sensors, or images from the same sensor taken at different recording times (see section 6.3.3). Often during Open Skies image flights images of the same scene are recorded simultaneously by different sensors. In this case all sensors operate from the same viewing angle and the mutual geometric registration is relatively easy. Since the various sensors have different capabilities of showing features of interest, the analysts can often benefit from fusing the imagery.

In some cases the fusion may be a simple *overlay* of complementary data sets represented in different colours (see Figure 6.1, Top). For example, the image from the infrared line scanner may be coded in a red colour with varying saturation and overlaid on a greyscale radar image for better orientation. Then the resulting image is much more instructive as to where strong thermal signatures occur and what they probably are.

Moreover, image fusion can sometimes produce a refined product of a substantially improved quality. For example, the infrared line scanner is restricted to a slightly coarser resolution (50 centimetres) than the photographic imagery (30 centimetres); by computer aided digital image fusion it is then possible to *sharpen* the coarser images by means of a finer one (see Figure 6.1, Bottom). A digital colour video image of 1-metre resolution, say, can be used with the registered 30 centimetres black and white photographs of the same scene and yields a fused colour image which appears almost as sharp as the 30 centimetres panchromatic photographs.

One can go even a step further by fusing Open Skies photos at 30 centimetres resolution with high-resolution commercial satellite images. A new generation of commercial satellites provides images in 4 colour channels (red, green, blue, near infrared) at 4-metre ground resolution. Fusion of such images with Open Skies black and white photos will provide fused multispectral or colour images, at approximately 50 centimetres resolution, a product which is well suited for multispectral change detection.[19] In order to ease the analysis both sets of images should be taken in nadir mode (vertical).

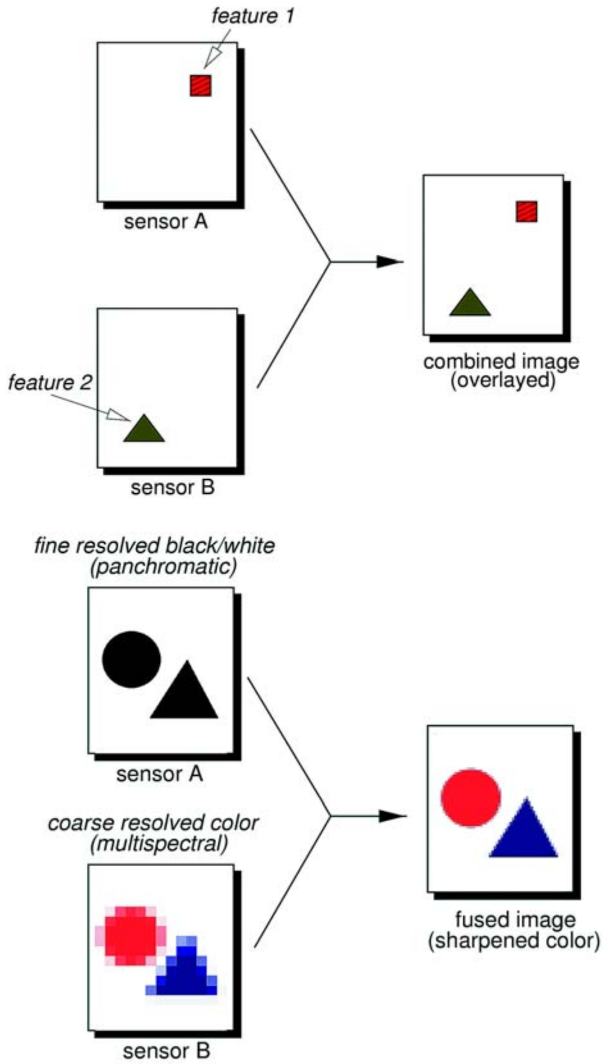


Figure 6.1: Top: Overlay of images from two different sensors, which are sensitive to different features. Bottom: Fusion sharpening of a coarsely resolved colour image.

The resulting fusion-sharpened image is not only visually more satisfactory, but it has been shown that subsequent digital image processing applications such as automated ground cover classification,[20] change detection, etc. show indeed clearly improved performance on fusion-sharpened imagery.[21]

We see that image fusion techniques are not restricted to mere overlaying. They can rather produce imagery of an improved quality. Certain objects may show features that are inconspicuous in the specific images of a single detector, and only their co-occurrence in different sensor modalities is meaningful. In these cases image fusion may allow detection of objects, which would not be found in either of the single un-fused detector specific images.

6.3.3 Computer Aided Change Detection

So far the imagery recorded during the Open Skies trial implementation phase has been analyzed mostly by eye appraisal of experienced photo analysts. Regardless as to whether the imagery is reproduced on paper or digitalized or genuinely digital (such as digital video, SAR), the analysis is done by human analysts seated at the light table or before the computer monitor.

Once the Open Skies observation flights will be carried out in full, the amount of both photographic and digital image data may become substantial. As the comparison of aerial images of the same scene taken at different recording times is a tedious and time consuming task, data processing might become one of the central technical bottlenecks, in particular if large territories are to be monitored on a regular basis. Hence, it seems natural to investigate the possibility of computer aided change detection. Can semi-automated digital image analysis give assistance to the image analysts?

The *Remote Sensing and Computer Vision* literature provides two basic approaches to computer aided change detection:

(1) Comparison of image pairs (data driven, image feature based)

Two images, I_1 and I_2, recorded by overflights over the same scene at two different time periods, T_1 and T_2, are compared. An appropriate algorithm must then check the two observed images against each other and assist the analyst by designating those areas where the ground cover has probably changed. The algorithm can base its comparison on so-called "early" features such as brightness, texture, spectral properties (for colour/ multispectral imagery), temperature (for thermal imagery), polarization properties (for SAR imagery). Other higher-level features can, for example, be object signatures and land cover classes. These methods are based on a pixel-to-pixel comparison. They can be extended to so-called scale space approaches. The comparison is performed at different levels of increasing scale, so that after single pixels have been compared local neighbourhoods of increasing size are also contrasted.

Image-to-image comparisons have been tested, and used for a number of different algorithms and geoscience applications.[22,23,24,25,26] They can successfully designate the locations of probable change areas for closer human inspection. They do not produce semantic interpretations of changes, however.

(2) Comparison of image and scene models (map) (model driven, knowledge based)

Another approach tries to match new image data with reference information extracted from a topographic map, or better a geographic information system, which represents the observed scene in a symbolic form. The scene contents are described in terms of meaningful structures (such as buildings, streets, vegetation areas, etc.). Changes should be detected where structures appearing in the image cannot be explained by the scene description and where expected scene objects cannot be verified by corresponding image structures.[27,28,29] Although concepts and description logic frameworks for this second approach have been presented, practical application is still far away. A particular hindrance is the requirement of a complete symbolic representation of all image scenes. Between "Vancouver and Vladivostok" there are large areas which have certainly never been depicted in 1:10000 topographic maps, not to mention digital geographic information systems.

Problems related to the first approach are elaborated here below.

Limitations of Change Detection by Direct Image Comparison

A fundamental problem of comparing two images of the same scene is that the recording conditions may have changed. Change detection techniques should be robust in that they should be resistant to possible variations in atmospheric parameters and imaging parameters that may have occurred between the two recordings. In particular, the direct solar illumination and the diffuse skylight, the path radiance, and the transmittance of the atmosphere may have changed. For multispectral sensors also the radiometric calibration may have changed individually for each spectral band.

If simply the difference between the intensity values from images I_1 and I_2 is considered, then all these systematic errors would cause spurious results and almost everything would appear "changed". Therefore, robust approaches find areas of probable change by their statistical "strangeness". The underlying idea is that all pairs of pixels which have not changed form a certain kind of statistical cluster, and statistical outliers with "strange" relations between their appearances in image I_1 and I_2 stick out.

Image-to-image change detection has, apart from the non-trivial computing cost, a number of further problems and limitations:

- Shadows cause false indications of change, due to their shift depending on the position of the sun at the time of recording;
- Elevated objects cause false indications of change whenever the observation angle is different between the two compared images, due to perspective displacement;
- Changes can only be detected reliably if the magnitude of their expression is greater than the registration/geocoding margin of error. If changes of smaller magnitude are not suppressed then spurious change results appear which stem from mis-registration rather than from real displacements of objects;
- Often the images contain also vast vegetational or agricultural areas. Although ecological or seasonal changes in these areas are not of interest, they will be indicated nonetheless as the algorithm cannot automatically decide on the nature of the changes;
- Statistical change detection approaches work on the basis of identifying areas that appear spectrally "strange", that is, identifying statistical outliers. If, however, changes make up for more than 50% of the whole image area (e.g., seasonal vegetation changes) then statistical change

detection approaches are mislead into designating the constant features as "changed" and vice versa;

- Direct comparison of the images (instead of statistical approaches) need a very careful radiometric calibration of the imagery and are easily deceived by changed atmospheric conditions between the two recording times.

Some of these limitations could in principle be overcome by model driven approaches (approach (**2**)); however, these require large databases and enormous computing power and are not operational as of yet.

In summary, computer based change detection can be helpful to indicate areas of potential change to the image analyst. Computerized change detection can be applied already to digitalized single channel images (e.g., black and white photos). However, the method is more potent when applied to multichannel (multispectral) images.

Notes

1 J. C. Baker, "New Users and Established Experts: Bridging the Knowledge Gap in Interpreting Commercial Satellite Imagery", in J. C. Baker, K. M. O'Connell and R. A. Williamson (eds), *Commercial Observation Satellites*, Santa Monica and Bethesda: RAND and ASPRS, 2001, pp. 533-57.

2 See, for example, Table 1 of Y. A. Dehquanzada and A. M. Florini, *Secrets for Sale: How Commercial Satellite Imagery will Change the World*, and sources quoted therein, Washington, DC: Carnergie Endowment for International Peace, 2000, p. 45.

3 See section 7.3.

4 See, for example, K. Kraus, *Photogrammetrie*, Vol.1, Bonn: Dümmler, 1994.

5 M. Heric, C. Lucas and C. Devine, "The Open Skies Treaty: Qualitative Utility Evaluations of Aircraft Reconnaissance and Commercial Satellite Imagery", *Photogrammetric Engineering and Remote Sensing*, Vol. 62, March 1996, pp. 279-84.

6 30 hertz for US and Japanese systems.

7 Like onboard the US Open Skies aircraft.

[8] Like the Zeiss VOS-60 onboard the former German Open Skies Tupolev-154.

[9] B. Uhl, "High Resolution Digital Colour EO Camera System VOS", *Proceedings of the Third International Airborne Remote Sensing Conference and Exhibition, Copenhagen*, Environmental Research Institute of Michigan, Ann Arbor, Vol. II, 1997, pp. 21-28.

[10] E. M. Winter, D. J. Fields, M. R. Carter, C. L. Benett, P. G. Lucey, J. R. Hohnson, K. A. Horton and A. P. Bowman, "Assessment of Techniques for Airborne Infrared Land Mine Detection", *Proceedings of the Third International Airborne Remote Sensing Conference and Exhibition, Copenhagen*, Environmental Research Institute of Michigan, Ann Arbor, Vol. II, 1997, pp. 44-51.

[11] A conventional video image has 625 lines (US and Japan 525 lines) and an aspect ratio of 4:3.

[12] Like the Kodak detector KLI-6003 used in the Zeiss VOS-60 (see B. Uhl).

[13] The diffraction limit of the resolution of an optical system results from the wave nature of the radiation. The larger the wavelength the larger the aperture of the system that has to be chosen in order to provide a specified resolution.

[14] The profile of an aircraft remains visible for a while since the tarmac under the aircraft stores the heat of the day longer than the metal fuselage of the aircraft and hence remains at a higher temperature.

[15] See, for example, X. Jia, J. A. Richards and D. E. Ricken (eds), *Remote Sensing Digital Image Analysis*, Heidelberg and New York: Springer, 1999.

[16] The various sensors may require an individual correction as pre-processing. Due to their respective optical system some sensors, such as line scanners, do not produce images at true scale. They can be corrected by mathematical modelling of the image formation process.

[17] The computer aided automatic selection of corresponding landmarks (GCPs) is possible only for essentially undistorted photographic or satellite imagery.

[18] See M. Ehlers, "Geometric Registration of Airborne Scanner Data Using Multiquadric Interpolation Techniques", *Proceedings of the First International Airborne Remote Sensing Conference and Exhibition, Strasbourg*, Environmental Research Institute of Michigan, Ann Arbor, Vol. II, 1994, pp. 492-502; R. Wiemker, K. Rohr, L. Binder, R. Sprengel, and H. S. Stiehl, "Application of Elastic Registration to Imagery from Airborne Scanners", *Proceedings of the XVIII Congress of ISPRS,*

Commission VII, International Archives of Photogrammetry and Remote Sensing, Vol. XXXI, No. B7, 1996, pp. 949-54; and R. Wiemker, "Registration of Airborne Scanner Imagery Using Akima Local Quintic Polynomial Interpolation", *Proceedings of the Second International Airborne Remote Sensing Conference and Exhibition, San Francisco*, Environmental Research Institute of Michigan, Ann Arbor, Vol. III, 1996, pp. 210-19.

19 See section 6.3.3.

20 Multispectral *ground cover classification, or land use classification* can be performed on e.g., red, green, blue (RGB) video data. The classification algorithms compute *thematic* maps from the imagery based on the spectral appearance (colour) of each pixel.

21 See R. Wiemker, B. Prinz, G. Meister, R. Franck and H. Spitzer, "Accuracy Assessment of Vegetation Monitoring with High Spatial Resolution Satellite Imagery", *Proceedings of the ISPRS Commission VII Symposium on Resource and Environmental Monitoring—Local, Regional, Global*, WG III, International Archives of Photogrammetry and Remote Sensing, Vol. XXXII, No. 7, 1998, available at http://kogs-www.informatik.uni-hamburg.de/PROJECTS/ censis/budapest98. fusion.pdf; B. Prinz, R. Wiemker and H. Spitzer, "Simulation of High Resolution Satellite Imagery for Accuracy Assessment of Fusion Algorithms", *Proceedings of the Joint Workshop of ISPRS WG I/I, I/3 and IV/4*, Institute for Photogrammetry and Engineering Surveys, University of Hannover, Vol. 17, pp. 223-31, 1997; and H. Spitzer, R. Franck, M. Kollewe, N. Rega, A. Rothkirch and R. Wiemker, "Change Detection with 1-Metre Resolution Satellite and Aerial Images in Urban Areas", CENSIS – Report – 37 – 01, Hamburg: Institut für Experimentalphysik, University of Hamburg, 2002.

22 See, for example, T. M. Lillesand and R. W. Kiefer, *Remote Sensing and Image Interpretation*, New York: John Wiley, 1994, pp. 621-23.

23 A. Singh, "Digital Change Detection Techniques Using Remotely-Sensed Data", *International Journal of Remote Sensing*, Vol. 10, No. 6, 1989, pp. 989-1003.

24 X. Jia, J. A. Richards and D. E. Ricken (eds), op. cit.

25 A. A. Nielsen, R. Larsen and H. Skriver, "Change Detection in Bi-Temporal EMISAR Data From Kalr, Denmark, by Means of Canonical Correlation Analysis", *Proceedings of the Third International Airborne Remote Sensing Conference and Exhibition, Copenhagen*, Environmental Research Institute of Michigan, Ann Arbor, Vol. I, 1997, pp. 281-87.

[26] R. Wiemker, "An Iterative Spectral-Spatial Bayesian Labeling Approach for Unsupervised Robust Change Detection on Remotely Sensed Multispectral Imagery", in G. Sommer, K. Daniilidis and J. Pauli (eds), *Proceedings of the 7th International Conference on Computer Analysis of Images and Patterns, Kiel 1997, CAIP'97*, Lecture Notes in Computer Science, Vol. 1296, Heidelberg and New York: Springer, 1997, pp. 263-70.

[27] See, for example, L. Dreschler-Fischer, C. Drewniok, H. Lange and C. Schröder, "A Knowledge-Based Approach to the Detection and Interpretation of Changes in Aerial Images", in S. Fujimura (ed.), *Proceedings of the International Geoscience and Remote Sensing Symposium IGARSS'93, Tokyo, August 1993,* IEEE, Vol. I, 1993, pp. 159-161.

[28] H. Lange and C. Schröder, "Analysis and Interpretation of Changes in Aerial Images", in H. Ebner, C. Heipke and K. Eder (eds), *Proceedings of the ISPRS Commission III Symposium on Spatial Information from Digital Photogrammetry and Computer Vision*, International Archives of Photogrammetry and Remote Sensing, Vol. XXX, No. 3, 1994, pp. 475-82. SPIE, Vol. 2357, 1994.

[29] C.-E. Liedtke, J. Bückner, O. Grau, S. Growe and R. Tönjes, "AIDA: A System for the Knowledge Based Interpretation of Remote Sensing Data", *Proceedings of the Third International Airborne Remote Sensing Conference and Exhibition, Copenhagen*, Environmental Research Institute of Michigan, Ann Arbor, Vol. II, 1997, pp. 313-20.

CHAPTER 7

PROSPECTS FOR EXTENSIONS OF THE MULTILATERAL OPEN SKIES TREATY

Hartwig Spitzer

In this chapter we will discuss prospects and avenues for extensions of the Open Skies Treaty. We address the inclusion of additional states, applications to additional fields and adoption of additional sensors. At the conclusion of the chapter we discuss the issues and challenges facing the review conference in 2005.

7.1 Inclusion of Additional States Parties

Six months after entry into force, that is, after 1 July 2002 every state, which intends to fulfil the objectives of the Treaty, may apply for membership. It can be expected that additional OSCE participating states may consider joining the Treaty, like Austria, Switzerland and some of the successor states of the former Yugoslavia. Seen from the perspective of crisis prevention and crisis management the inclusion of additional or all Caucasus and Central Asian states would be extremely useful. This objective will require a major diplomatic and political initiative. A first step would be the initiation of the ratification process in Kyrgyzstan and technical support to Georgia, in order to ease its full participation in the Open Skies flight programme. Japan was an observer to the Open Skies negotiations in 1991-92. In 2002 Japan probed informally the possibility of acceding to the Treaty. Reportedly—for the time being—the US would object to the admission of non-OSCE participating states to the Treaty. Decisions on admission require unanimous consent of the states parties.

7.2 Conflict Prevention and Crisis Management

The preamble of the Treaty mentions the possibility to use the Open Skies regime for conflict prevention and crisis management within the framework of the OSCE or of other international institutions. So far—during the trial implementation—Open Skies flights have been carried out in two conflict or post-conflict situations:

a) A Russian flight over US bases and installations in Germany in June 1999 during the NATO air campaign in the former Yugoslavia and the force build-up for the NATO intervention in Kosovo (see section 4.5.);
b) Seven demonstration flights over Bosnia and Herzegovina from 1997 to 2001 in support of post-conflict peace building, verification and damage assessment. The flights were carried out under the auspices of the OSCE in its capacity of monitoring arms control under Article II of the Annex to the Dayton Accord (see sections 4.5 and 8.2).

Similar flights over member states could be performed in the future, in case a crisis emerges in or between member states, as long as the parties involved agree and flight safety is assured. In this context it is important to note that some of the sensor configurations can be flown at altitudes above 5,000 meters outside the range of anti-aircraft artillery and shoulder-launched surface-to-air missiles (e.g., Stinger missiles).

Open Skies flights could in particular become part of present or future *peacekeeping operations*. Observation flights could usefully complement ground monitoring, for example, in Georgia (Ossetia and Abkhazia), in Moldova (in case a solution is found to the Transdniester conflict) or in Azerbaijan and Armenia, in case an international peacekeeping operation is deployed as part of a solution to the Nagorno-Karabakh conflict.

Open Skies flights could become useful tools of *early warning and conflict prevention*. For example, high altitude observation flights along the Russian-Georgian border (the Chechen, the Ingush and the Dagestani part) could usefully complement a ground based monitoring operation by the OSCE. Also, in Central Asia, Open Skies flights could become a highly effective tool of early warning and confidence building along the borders of Central Asian countries with Afghanistan and each other. In case of reappearance of Islamic insurgents in the region, who often move across state borders, observation flights could serve as a tool to dispel misunderstandings, suspicion and accusations based on false perceptions.

Last but not least, highly cooperative joint observation flights (with the addition to the sensor suite of infrared cameras with 50 centimetres resolution) could become a key tool in the fight against *other challenges of the 21st century* like terrorism, organized crime, drug smuggling, trafficking in human beings, illegal transfers of small arms and light weapons, irregular/ illegal migration, etc. These illegal activities often take place in remote regions with poor infrastructure, difficult terrain and high security risks for ground-based observers, like in many parts of Central Asia, the Caucasus and the Balkans. The states of these regions should be enabled to regularly monitor these nefarious activities, agree on a desirable course of action to fight them and request international assistance (by formulating projects based on sound information). Joint flights (perhaps with the participation of international experts) would enable the governments of these regions to provide regular, well-documented information on these activities and base their request for assistance on this information.

The sine qua non precondition for these new types of application would be a cooperative arrangement, under which Western governments would provide technical and operational assistance free of charge (or at low cost) to the countries of Central Asia, the Caucasus and the Balkans. This assistance would enable the less wealthy states of these regions to become effective partners in the fight against the threats that mark the beginning of the 21st century.

The advantages for Western Europe and North America would be significant. Effective action against these new scourges would start not on the Schengen border of the European Union, but already on the border between Afghanistan and Central Asia, the Middle East and the states of the Caucasus; or over Albania, rather than on the Italian coast.

The political arrangements for Open Skies flights in crisis regions outside of the Treaty area are yet to be made. Of course, arrangements can be made by mutual consent of one or several Open Skies states parties and the states affected by a crisis. Alternatively, this could be negotiated under the auspices of the OSCE or the United Nations. However, to date, neither the OSCE nor the United Nations has actively pursued such options. It would be helpful to develop diplomatic and political initiatives in order to exploit the potential of the Treaty and the specialized and dedicated resources of the various states parties for contributing to the management of current or future crises.

7.3 Potential of the Open Skies Regime and Sensor Suite for Environmental Monitoring and Other Non-Military Applications

The preamble of the Treaty envisages "the extension of the Open Skies regime into additional fields, such as the protection of the environment". One obvious field of application is the rapid monitoring of environmental disasters with cross-border impact. This section addresses three questions:

1. To what extent is the present sensor set as specified by the Treaty suited for monitoring of the environment?
2. Which modifications of the sensor set would strengthen the capacity for environmental monitoring?
3. Which institutional provisions and operational procedures have to be established in order to arrive at agreeable and cost-effective solutions?

Initially the interest and expectations in environmental applications of the Open Skies Treaty were quite high. Consequently, the OSCC has held two informal seminars on the possible use of the Open Skies regime for environmental monitoring on 3-4 December 1992 and on 11-12 July 1994. Due to the long delay of entry into force and technical developments in non-military environmental monitoring the initial interest faded away to a large degree. It also has turned out that the responsibility for Treaty implementation and for bearing the costs, so far, has been assigned exclusively to the military establishments of the states parties. Hence, in order to arrive at a viable capacity for environmental monitoring under Open Skies basic questions of institutional interest and responsibility have to be clarified. This issue will be addressed below. Before, though, let us take a closer look at the Open Skies sensor suite and its potential for environmental monitoring.

7.3.1 Potential of Current Sensors for Environmental Monitoring

The current Open Skies sensor suite can be applied for a number of monitoring tasks, which require spatial resolution between 30 centimetres and 3 metres. Applications might exploit either one sensor type only (e.g., photographic cameras for mapping under fair weather conditions), or take advantage of jointly exploiting different sensor types through sensor fusion (e.g., photographic and thermal images for urban heat loss studies). The study of vegetation is currently hampered by the lack of colour and multispectral information. Table 7.1 gives our estimate of the usefulness of current sensors for different monitoring tasks. SAR systems will be particularly useful for situations where 3-metre resolution is sufficient but all-weather capability is necessary.[1]

Table 7.1: Estimated Potential of Current Open Skies Sensors at Treaty Resolution for Different Monitoring Tasks
The estimated potential is indicated by the number of stars.

	Photo Camera+	**Thermal Imager**	**SAR**
Mapping and urban planning	***	**	*
Urban heat losses	*	***	--
Vegetation, crops	*	**	*
Water supplies	*	**	**
Soils	*	**	**
Air Quality	--	--	--
Fires	*	***	**
Floods	**	**	***
Earthquake and hurricane damage assessment	**	**	*
Nuclear reactor accidents	*	***	*

+ With sufficient image overlap for stereo viewing and panchromatic film.

The bottom part of Table 7.1 addresses the monitoring of emergencies. Here thermal images will allow for a very good 24-hour coverage of fires and other heat releases (e.g., from reactor accidents). SAR sensors can spot the extent of flooding at day and night. Although rated lower, photographic images will provide accurate baseline information on the spatial impact of environmental disasters.

7.3.2 Past Environmental Flights of Open Skies Aircraft

So far, the United States, Germany and the Czech Republic have used their Open Skies aircraft successfully in four extensive missions for pre-disaster and post-disaster monitoring.

(a) Oder flood (1997)

In July and August 1997 a major flood of the river Oder affected the Czech Republic, Poland and Germany. The Oder demarcates the border between Poland and Germany.

To assist the regional Polish government and the German state of Brandenburg in estimating the extent of the catastrophe the German Open Skies aircraft was assigned for a training mission to take images of the flooded areas. The aircraft mapped the full river area from the influx of the river Neiße to the Baltic Sea twice within a ten-day period. The black and white photographs were developed over night and were handed over to the governments of Poland and Brandenburg on the next day. Photo 7.1 shows an example of the images taken. It should be noted that environmental satellites like ENVISAT can hardly provide imagery at such short notice due to their long revisit times (typically 2-4 weeks) and data processing times (between days and weeks).

However, even with a capacity to deliver data within 24 hours Open Skies still faces competition in these sorts of missions as demonstrated by the following example. During a major flood in the Czech Republic and in Saxony (Germany) in August 2002 aerial monitoring was performed not by Open Skies aircraft but by Tornado reconnaissance aircraft of the German Air Force.

(b) Hurricane Mitch (1998)

In November 1998 one of the US Open Skies aircraft was sent to Central America, shortly after the devastating impact of hurricane Mitch. The territories of Honduras and Nicaragua and other areas were mapped in five missions at a resolution of 20-30 centimetres. Copies of the images were provided to the governments concerned and to a major US relief organization.[2] The imagery was used for relief and preventive measures.

This underlines the potential of Open Skies assets for disaster monitoring on short notice.

Photo 7.1: Oder flooding near Wiesenau (Germany) as photographed from the former German Open Skies aircraft. Courtesy: Zentrum für Verifikationsaufgaben der Bundeswehr, Geilenkirchen.

(c) Pre-disaster Monitoring in the Caribbean (2000)

Damage assessment through change detection depends equally on the availability and quality of imagery taken prior to the disaster. Since the

Caribbean is hit by several hurricanes each year the US Southern Command has asked for an extensive monitoring flight series by the US Open Skies aircraft over most of the Caribbean islands (with the exception of Cuba and Haiti which did not permit overflights). Images were taken with an overlap of 56% (for stereo viewing) at a resolution of 70 centimetres. Image data were recorded on magnetic tape by a digital module attached to the camera KS-87.This allowed on-line display and eased data duplication. Copies were distributed by the US Southern Command to the states overflown.

(d) Forest damage from Hurricane Lothar (2000)

Shortly after Christmas 1999 large parts of France and Southern Germany were severely devastated by hurricane Lothar. In February 2000 Germany and the United States used a scheduled trial observation flight with the US Open Skies aircraft for assessment of the damaged forest areas. The target areas were selected after coordination with the ministries of forestry of the states of Bavaria and Baden-Württemberg. Similarly forest damage areas in Bavaria were photographed by a Czech-German Open Skies trial flight using the Czech Open Skies aircraft during a scheduled trial observation flight a few weeks later.

In summary, the four missions underlined the advantages of using Open Skies resources for disaster monitoring (large area coverage at adequate resolution, short reaction and image delivery times). In the future, the acceptance of disaster monitoring by foreign Open Skies aircraft will be eased by the fact that Open Skies aircraft have certified sensors with known capabilities. States parties, which have an observation aircraft of their own, should consider preparing the aircraft for quick modifications for such flights beyond the restrictions of the Treaty, for example, by making provisions for providing digitalized photographic image data or the inclusion of additional sensor categories.

7.3.3 Additional Sensors in Support of Environmental Monitoring

The current sensor set was optimized for identification of major weapon systems[3] and of military infrastructure rather than for environmental monitoring. However, the Treaty contains the possibility of including additional sensors at a later stage. According to Article IV "the introduction of additional (sensor) categories and improvements to the capabilities of existing categories of sensors provided for in this Article shall be addressed by the Open Skies Consultative Commission…." In accordance with Article X proposals on the inclusion of additional sensors may be decided upon at any time. The first regular review conference in 2005 seems to be a good opportunity to do so.

For purposes of environmental monitoring the most cost-effective upgrade would be the inclusion of *colour infrared film (CIR)* as a recording medium of photographic cameras. Colour infrared film is sensitive to radiation in the near infrared at wavelengths from 0.7 to 0.9 micrometres. It has been and still is extensively used in civil monitoring of urban areas, vegetation, soils, water supplies, etc. Such film provides also much improved contrast and recognition potential for objects in built-up areas. Although three times more expensive than panchromatic (black and white) film, use of such film will raise the overall costs of an observation flight only by a small fraction. Development of CIR film for a reliable product, however, is a delicate and costly skill, which is mastered only by a few specialized firms and agencies. Not every Open Skies state party will have this capability.

As a next step *multispectral digital imaging sensors* (multispectral line scanners) have to be considered for environmental monitoring.[4] Again, civil multispectral sensors, like the Thematic Mapper on the LANDSAT satellites (featuring seven spectral channels) and their airborne equivalents have been used extensively in wide area multispectral monitoring of urban areas, agricultural areas, nature reserves and geological sites for more than two decades.

The US Defense Nuclear Agency has performed a comparative study, which evaluated the potential benefits of multispectral and hyperspectral sensor additions for Open Skies missions.[5] The study considered multispectral imaging sensors to be the most beneficial addition both for environmental monitoring and for military Open Skies objectives (e.g., camouflage detection). As a low risk approach, the study recommended the Daedalus Thematic Mapper ATM. This sensor has 11 spectral channels at wavelengths from 0.4 to 12.5 micrometres and an instantaneous field of view of 1.25 milliradians in one of two possible operation modes, providing a ground sampled distance of 2.5 metres at a flight altitude of 2,000 metres. Multispectral sensors will enhance considerably the potential for monitoring of urban areas, agricultural land, forests, rivers and special problem areas like waste deposits. Hence, they open the door to detailed studies of land use and the state of the environment. Digital multispectral imagery is also a very useful basis for computer based semi-automatic change detection as discussed in section 6.3. Needless to say analysis of multispectral digital imagery requires some investments and expertise in computing atmospheric corrections and geocoding. In addition, the quality of analysis will improve a lot when airborne data are complemented with ground truth data.

In a few years the role of multispectral line scanners will be largely taken over by *multispectral digital stereo cameras* with resolution in the 0.1 to 1-metre range. Such cameras combine the virtues of panchromatic stereo imaging with multispectral recording, however at the price of a more demanding digital image processing.

A large number of *non-imaging sensors* have been discussed at the informal seminars on the possible use of the Open Skies regime in the field of environmental monitoring which were mentioned above. We want to emphasize here only two types of devices:

a) Lidar (laser reflection measurements) for detection of atmospheric composition and pollution;
b) Air samplers as a basis for the detection of radioactivity in the atmosphere.

7.3.4 Application Scenarios and Institutional Questions

In spite of initial enthusiasm the interest in an extension of the Open Skies regime into environmental monitoring has declined, at least among the governments of major states parties like Germany and the United States. The reason is quite obvious. Many states parties of the Treaty have adequate airborne and spaceborne monitoring devices in the public and commercial sectors for monitoring of the environment.

The respective monitoring aircraft are usually much smaller than current Open Skies aircraft and hence can be operated at lower cost. There is also an element of inter-agency competition. In consequence, several *basic questions* have to be answered first, before environmental application scenarios can be developed:

- What kind of environmental situation in state A could motivate state B to perform a dedicated environmental monitoring flight in state A under the Open Skies regime in spite of the cost?
- Which kind of environmental monitoring tasks would exploit and require the special "virtues" of the Open Skies regime (unlimited territorial access, short response time, priority over any other air traffic)?
- Are dual-use flights, which would cover both military and other target areas in one go, negotiable? Such flights would be most cost-effective.
- Who would be responsible for requesting and analyzing data from environmental Open Skies flights? Who would bear the costs?
- To what extent can data from environmental monitoring flights under Open Skies be made fully open and accessible, for example, to researchers and local users?

Let us discuss several application scenarios in the light of these questions:

Environmental Emergencies

Certain emergency situations and disasters in state A could justify a monitoring flight by state B under Open Skies, if:

- the impact is of border crossing nature, like the radioactive plume of the reactor catastrophe in Chernobyl;
- humanitarian reasons require rapid response from the outside, like a major earthquake or flood damage, which cannot be dealt with by local/national resources.

Here, one can assume sufficient interest on the side of state B. Flight costs would have to be covered by state B from funds for international emergency situations. Alternatively, state B might dedicate one of its obligatory national training flights to the disaster-monitoring mission.

Cross-border Environmental Problems

Certain environmental problems and management tasks are of a cross-border nature (like pollution and flood control of border crossing rivers, salination and wind erosion in arid areas, effects of acid rain, etc.). A particular example is the state of nuclear reactors and waste sites of the Russian Northern fleet, which are of concern to the Scandinavian countries. Such flights under Open Skies will be only attractive if civilian monitoring capacities are lacking, or civilian monitoring agencies of state B do not have full territorial access to state A. In addition such flights might become attractive if they can be arranged in a cost-effective, dual-use way serving both military and civilian purposes.

Here, a mutual interest of two or more states parties affected by the particular environmental problem can be assumed. Hence, it would be natural to share the flight costs or to arrange flights on a reciprocal basis. Within each state cost sharing between military and civilian users has to be clarified also as well as mechanisms for mission request, mission planning, shutter control and data distribution.

Verification of International Environmental Conventions

Several international environmental conventions have been concluded or are in preparation (like the Montreal Ozone Protocol, the Climate Convention, the Convention on Biodiversity, etc.). At present some of these conventions lack agreed verification procedures based on satellite or airborne monitoring. However, airborne multispectral monitoring under Open Skies could make useful contributions in situations where good spatial and spectral resolution matters.

7.3.5 Conclusions on Environmental Monitoring

The Open Skies regime opens interesting avenues for environmental monitoring, in particular through:

- data fusion from different sensors (photographic cameras, thermal imager, SAR);
- inclusion of colour infrared film and eventually also digital multispectral imaging sensors;
- inclusion of non-imaging sensors.

In competition with other data sources (civil airborne and satellite monitoring) application scenarios should concentrate on areas which relate to the main intentions and virtues of the Open Skies Treaty, in particular confidence building and management of (environmental) crises in a cooperative way. This in turn means, applications for the monitoring of

- environmental emergencies and disasters;
- border crossing environmental problems; and
- verification of international environmental conventions

should be considered first and studied in more detail. Past flights have demonstrated that Open Skies aircraft can make valuable and competitive contributions to disaster monitoring. Challenging institutional questions have to be solved in order to make best use of Open Skies in the other two areas.[6]

It should be emphasized, that the Open Skies Treaty allows for mutual voluntary agreement between states parties on observation flights without the restrictions imposed by the Treaty on sensor performance and mission procedures. Thus, states parties have the opportunity to agree on flights for environmental monitoring at performance conditions adapted to the environmental problem. An initial first step in this direction would be flights for environmental monitoring under the full rules of the Treaty. Apart from such flights under an extended Open Skies regime, each state party, which operates an OS aircraft, is free to use its capacity for national monitoring and mapping flights. This route is followed, for instance, quite successfully by Bulgaria and Hungary.

7.4 Additional Sensors and Higher Resolution

As already stated the OSCC can decide on the introduction of additional sensor categories and on improvements of the capabilities of existing sensor categories. This issue might be tabled at the review conference of the states parties in 2005. The outcome will depend primarily on the political will of the parties to develop and adapt the Treaty implementation to current concerns and technical options. We, therefore, will discuss the question of additional sensors and capabilities from the perspective of these two criteria.

7.4.1 Demands from Current Security Concerns

K. Arnhold has argued vividly that in order to survive and flourish in the longer term the Open Skies regime has to be adapted to current security concerns:[7]

- proliferation of weapons of mass destruction;
- crisis prevention and management;
- terrorism and illegal trafficking of humans and goods.

Let us assume for the time being that the states parties will agree on such a reorientation. What kinds of sensor improvements are conceivable and recommendable?

(a) Resolution

The current resolution limit of 30 centimetres of photographic cameras has been set to allow for the identification of major weapons systems, but not for detailed analysis. Given the objective of monitoring illegal trafficking and proliferation a *finer resolution of optical cameras in the order of 10 centimetres would be desirable*. We doubt, however, that all the states parties would agree to this. Still, a significant improvement of the monitoring potential can be obtained by reducing the resolution values of the *other two sensor categories* (thermal imaging and SAR) towards 30 centimetres.

This would respect the concerns of going beyond the identification of major weapons systems, but would largely improve the ability of all-weather, day-and-night monitoring. Such an improvement in resolution of thermal infrared sensors from 0.5 to 0.3 metres could be achieved quite easily by flying at lower altitudes. In contrast, the improvement of SAR resolution from 3 to 0.5 metres would require a major investment in a sophisticated technology, which, however, is commercially available.[8]

(b) Sensors

At the Budapest negotiation round in 1990 the following additional sensors were considered (but ultimately not retained): air samplers, electro-optical (digital) cameras, gravitometers, magneto-meters, multispectral scanners and spectrometers.

Seen from the above security concerns the first priority should be to have operational thermal infrared line scanners in 2006, when the Treaty allows for their use. Beyond that, the highest priority should be given to *multispectral scanners* or *multispectral digital cameras* in order to provide much improved identification of vegetation, camouflage and illegal trafficking as discussed in section 7.3.3. Crisis prevention and management would clearly benefit from the introduction of such multispectral sensors, for example, for the monitoring and identification of freshly laid mine fields, refugee movements and camps, and damage assessment.

Infrared line scanners, *air samplers* and *fluorescent laser detection* of chemicals could support the monitoring of illegal production and storage of *chemical weapons* and the monitoring of *nuclear facilities*. In contrast, the production of *biological weapons* can hardly be identified from the air.

7.4.2 Technology Drive

The trend in commercial remote sensing is moving towards:

- higher resolution;
- replacement of film by digital sensors;
- provision of four colour channels (blue, green, red, near infrared) as a standard.

At the same time GIS, which are built on digital maps and digital image data are becoming the basis of planning and surveying processes as well as of integrated data management. The military and the verification communities will sooner or later have to embark on this leg of the digital revolution.[9] Hence, the question of including digital cameras and of exchanging all image data in digital form is bound to become an issue among the Open Skies states parties.

In the area of SAR the trend runs towards higher resolution, multi-polarization and multi-frequency sensors.[10] At present, non-military SAR sensors are reaching a resolution in the range of 0.5 metres (air) to 1 metre (satellite). An Open Skies SAR at 3-metre resolution is no longer competitive.

7.5 Data Access for Non-Military Organizations

Although the Treaty advocates openness and confidence building, the access to data from Open Skies flights is strictly limited to the level of governments. So far image data *cannot* even be transmitted to *international organizations* concerned with confidence building and verification like the OSCE or the Organization for the Prohibition of Chemical Weapons (OPCW) without the consent of the states parties overflown.

Clearly this should be reconsidered in particular when applications for crisis monitoring and crisis prevention will be on the agenda. For example, the field missions of the OSCE would greatly profit from receiving Open Skies images of their area of concern, which can be used as accurate maps. The same holds for support of on-site inspections under the Chemical Weapons Convention (CWC).[11]

Should pre- and post-disaster monitoring be included in the Open Skies agenda, data access by non-governmental relief organizations would have to be agreed upon.

7.6 Issues and Challenges for the Review Conference of States Parties 2005

According to Article XVI of the Treaty the depository states are obliged to convene the first regular review conference of states parties three years after entry into force, that is, in 2005. The first review conference will be an excellent and fitting opportunity to review and eventually adapt the Treaty implementation. Unlike the CFE Treaty and the Vienna Documents the Open Skies Treaty has not been adapted since its signature in 1992. On the other hand, the Treaty is an extremely flexible legal instrument. The OSCC has a wide range of possibilities to make any necessary changes or modifications to the Treaty implementation, like deciding about new sensors or other fields of application. Most of the foreseeable and desirable adaptations can be decided upon without the need of another ratification process. In addition, the Open Skies Treaty offers as a general rule in many cases the principle of “unless otherwise agreed” (see Article VI, Section I, paras. 9, 10, 11, 20), which means that states parties may deviate from standard Treaty rules and regulations if they agree bi- or multilaterally. This has resulted in a very pragmatic and effective implementation of the Treaty.

Still, the review conference itself offers an incentive to re-evaluate the provisions of the Treaty and its implementation from a political and technical point of view. The conference will be an occasion to adapt the Treaty practice to new challenges and security needs. Needless to say, the outcome of the conference will depend a lot on the conceptual work done in the *preparation process*. Below we discuss as food for thought a number of issues and challenges, which should be properly addressed in the preparatory work. The following points result from the discussions of this chapter and follow up also on some questions, which were touched in the previous chapters.

Quota distribution

The initial allocation of active quota as shown in Table 2.2 was shaped by the situation at the end of the Cold War: most of the Western states were interested in overflying Russia, the Ukraine and other former members of the Warsaw Treaty. NATO member states have agreed not to overfly each other in the framework of regular quota flights. This created an imbalance in the flight distribution, which will be sharpened by the recent NATO extensions.

It is therefore appropriate to rethink the rationale behind the quota distribution. In spite of the high degree of transparency obtained in Europe and North America it is important to appreciate the Open Skies Treaty as an *insurance policy* for rougher times. One has, after all, to be prepared for the unexpected. The instrument of confidence building in security matters through cooperative overflights should therefore be maintained and cultivated on a basis of equity and reciprocity.

Hence, we suggest a *baseline* of a relatively small number of *mandatory quota flights* on an equitable basis. This would include also mutual overflights of NATO member states. Naturally, the geographic size and military potential should be reflected in the number of allocations, too.
As a *second tier* a set of *supplementary flights* is needed, which would be assigned at relatively short notice to support:

a) *Conflict prevention and crisis management*;
b) *Non-proliferation and global arms control*; and
c) *Monitoring of environmental disasters*.

There should be an upper ceiling on the number of such flights, which could but need not be fully exploited.

Support of Conflict Prevention and Crisis Management

In order to make best use of Open Skies flights for support of conflict prevention and crisis management a number of steps and institutional arrangements need to be considered:

a) Accession of as many OSCE participating states as possible, in particular through diplomatic efforts to support the accession of all Central Asian republics as well as all the states in the Western Balkans and the Caucasus;

b) Arrangements with the OSCE on the possibility of the OSCE to request Open Skies support. Provided the state overflown agrees, the requested image material should be made accessible to the OSCE Conflict Prevention Centre and its respective field missions. Such arrangements are logical, since all Open Skies states parties also participate in the OSCE;
c) Apart from that, Open Skies states parties or groups of states should be free to provide their Open Skies aircraft and assets for support of conflict prevention and crisis management by other international organizations like the United Nations, NATO, the European Union or other international organizations with a security mandate;
d) Contributions of Open Skies flights to monitor illegal trafficking of weapons, drugs and people across borders.

Open Skies in support of global arms control and non-proliferation of weapons of mass destruction

As argued above Open Skies flights have the technical potential of supporting the verification of global arms control treaties, which limit or ban weapons of mass destruction, in particular nuclear and chemical weapons. The main contribution in this respect comes from the 50 centimetres resolution of thermal infrared image sensors. Already now the states parties can exploit their active quota to monitor suspect nuclear and chemical production sites or waste storage sites in the Treaty area.

In order to give Open Skies a stronger role in this field it is desirable that arrangements be made with the *International Atomic Energy Agency (IAEA)* and the *Organization for the Prohibition of Chemical Weapons (OPCW)*. The IAEA has begun to use satellite images as a supplementary information source in verifying the Non-Proliferation Treaty (NPT). In contrast, aerial inspections or joint exploitation of satellite imagery is not yet foreseen by the CWC. An appropriate adaptation is desirable.

Open Skies flights can support the verification of the *Global Exchange of Military Information*. This is an additional data exchange under the Vienna Documents. It covers all kinds of weapons systems including naval vessels and naval aircraft of all OSCE participating states *regardless* of their deployment site, worldwide. The exchange is not verified by on-site inspections. Open Skies flights could be used to verify the notified forces in most of the deployment sites, in particular naval forces, which are not subject to inspection under the CFE Treaty.

Monitoring of environmental disasters

States parties should make arrangements for being prepared to launch supplementary flights for the monitoring of environmental and industrial disasters on short notice in coordination with the OSCC. To avoid budgetary complications, such flights should be preferably performed as national training flights.

Additional sensor types

The technological development and potential applications in the above areas suggest the consideration of at least three types of additional sensors and film:

- infrared sensitive film (false colour film), which is essential for the monitoring and evaluation of vegetation;
- digital cameras, which are becoming state of the art in commercial aerial photography;
- SAR at 1-metre (or better) resolution, in order to be competitive with commercial radar satellites.

Trial operation of such devices by single states or a group of states parties can help to promote their future inclusion.

New and jointly operated aircraft

Most of the existing Open Skies aircraft are older than 20 years and have to be replaced within the next decade. In addition, major sensor upgrades are due in 2006 when the full sensor set becomes mandatory for states, which choose to apply the taxi option. This offers the opportunity to consider the introduction of joint aircraft, which are equipped and operated by several states, or a larger group of states. The Pod Group and the Swedish-German aircraft cooperation are two examples along these lines.

In the longer run it would be desirable to make confidence building and conflict prevention through Open Skies flights part of a common foreign and security policy of the European Union. A pool of two or three aircraft operated by a “coalition of the willing” would be a first step into this direction. Such groups of states parties would also coordinate their plans for exploiting their active quota.

Cooperative data analysis

Although the ten years of trial implementation have been quite successful, the exploitation of the image data obtained has been less than optimal. Open Skies images have been analyzed by and large by analysts, without the aid of a modern system of data integration. So far states process and handle their imagery within classified systems and scarcely make data and results available to each other. States still implement arms control as a national prerogative and are reluctant to exercise real cooperation in data analysis. One main future objective should be to achieve more real and substantial cooperation and efficiency in the field of data analysis for arms control verification, conflict prevention and transparency building. Coalitions of the willing should instigate such joint action and set the example.

Analysis centres should be run independently of the respective military (strictly secret) intelligence services in a semi-open fashion.[12] This would enable to share results with international organizations in charge of conflict prevention, peacekeeping and post-conflict management, like the United Nations or the OSCE. Modern data integration methods and the combination of Open Skies imagery with image data from (open) commercial satellites as well as with adequate ground-based data would be the basis for producing first-class results at lower overall cost than the present national operations.

Certification procedures

Finally it will be a major task for the OSCC and its IWG on Sensors and Certification to finalize the certification procedures for infrared and SAR sensors. The complex task of certifying infrared sensors can be eased by adopting a procedure similar to one introduced for optical cameras: states parties provide a so called MRT-curve, which characterizes the resolution properties of their infrared sensors. This curve would then only have to be checked and confirmed at the certification event. In addition, the certification procedure for video cameras has to be re-discussed, because the present procedure based on Decision 14 is valid only until 31 December 2005.

The preparation process for the 2005 review conference can build on a crucial prerequisite: professional Open Skies capabilities, in particular highly skilled specialists. The outstanding cooperation, which the Open

Skies experts of all participating nations have demonstrated frequently during joint certifications and similar events, forms an excellent basis for developing the Open Skies Treaty implementation further.

7.7 Summary

In summary, the Open Skies regime can and should be adapted to current security needs and technological trends. Many of the recommended adaptations can be arranged within the legal framework of the existing Treaty, in particular:

- Inclusion of *additional states parties* in crisis-prone regimes of the application area (e.g., former Yugoslavia, Caucasus states, Central Asian republics);
- Applications for *conflict prevention, crisis management* and support of *non-proliferation* of weapons of mass destruction within the Treaty area of application;
- Monitoring of *environmental disasters* and cross-border environmental problems based on mutual voluntary agreement of the states parties involved (within the Open Skies framework).

Most of the recommended technical adaptations require a Decision of the OSCC but not any further ratification steps, in particular the inclusion of additional sensors and readout media (multispectral, electro-optical, colour infrared film, Laser Fluorescent Spectrometers, digital readout of photographic cameras).

It is also desirable to adapt the resolution limit of thermal infrared line scanners allowed under the Open Skies Treaty to 30 centimetres. The latter change can be implemented without any additional cost simply by adapting the required minimum flight altitude.

Notes

1 The usefulness of different SAR systems for environmental monitoring is further discussed, for example, by Schmullius and Evans. See C. Schmullius and D. L. Evans, "Synthetic Aperture Radar Frequency

and Polarization Requirements for Applications in Ecology, Geology, Hydrology and Oceanography—A Tabular Status after SIR-C/X-SAR", *International Journal of Remote Sensing,* Vol. 18, 1997, pp. 2713-22.

2 B. F. Molnia and C. A. Hallam, "Open Skies Aerial Photography of Selected Areas in Central America Affected by Hurricane Mitch", Internal Report, US Geological Survey, 1999.

3 In the CFE Treaty the respective systems are called Treaty Limited Equipment (TLE).

4 During a workshop of Open Skies experts on 2 April 2003 at Ingolstadt, Germany, Russian experts gave a presentation of a new Russian infrared line scanner for Open Skies use, which would work both within the 9-12 and 0.5 -1.1 micrometer ranges.

5 R. Ryan, P. Del Guidice, L. Smith, M. Soel, N. Fonneland, M. Pagnutti, R. Irwin, and P. Saatzer, "U.S. Open Skies Follow-On Sensors Evaluation Program, Multispectral Hyperspectral (MSHS) Sensor Survey", *Proceedings of the Second International Airborne Remote Sensing Conference and Exhibition*, *San Francisco*, Environmental Research Institute of Michigan, Ann Arbor, Vol. I, 1996, pp. 392-402.

6 For example, loitering is prohibited in regular Open Skies flights but might be desirable for environmental monitoring. Exceptions are possible by bilateral agreement according to Article VII, Section II, para. 4e.

7 K. Arnhold, "Der Vertrag über den offenen Himmel—Ein Konzept zur Aktualisierung des Vertrages", *SWP Studie*, Berlin, June 2002, p. 21.

8 For example, the AER-II SAR currently operated from a C-160 of the German Air Force flight test centre at Ingolstadt could be used as a test-bed. See www.fhg.fgan.de.

9 The US military already has gone quite a way in this direction.

10 Multi-polarization and multi-frequency SAR sensors emphasize different features of a scene similar to the multicolour displays of multispectral sensors.

11 For the time being aerial inspections are not foreseen in the CWC. However, governments can provide "supplementary information" derived from their own sources in support of verification.

12 It is understood that sensitive information related to criminal or terrorist activities would be handled with sufficiently high confidentiality.

CHAPTER 8

REGIONAL APPLICATIONS OF THE OPEN SKIES APPROACH

Márton Krasznai, Hartwig Spitzer and William Wynne

8.1 DETOUR: THE HUNGARIAN-ROMANIAN BILATERAL AGREEMENT ON OPEN SKIES

Well before the signature of the multilateral Treaty on Open Skies on 11 May 1991, Hungary and Romania became the first states ever successfully to negotiate and sign a bilateral Open Skies agreement.

The dramatic changes that had taken place in Europe since the revival of Open Skies in May 1989 made this agreement possible. The collapse of the Warsaw Treaty also brought about the end of the old European security structure based on the existence of the two alliances and the approximate balance between their armed forces. Instability became the most dramatic negative side effect of the profound political changes in Central and Eastern Europe. Earlier arms control agreements lost much of their relevance in the light of the new political realities. Participants in the various arms control fora acted cautiously in this new state of flux. The limitations set in the CFE Treaty aimed at redressing the East-West balance but were not particularly relevant to the new sources of military instability in Central and Eastern Europe, which emerged with the disappearance of the East-West divide.

In this new political and military situation the states of Central and Eastern Europe had a choice: either to renationalize their defence policies with an emphasis on military force, which would further destabilize their region, or to start building a new, cooperative security structure consisting of trans-Atlantic, pan-European, regional, sub-regional and bilateral arrangements. In view of the strong desire of the Central and Eastern European states to align themselves with the West after the end of the Cold War, their preference for building a cooperative security structure was evident. Thus, many of the policies of these states at the time were a reflection of their genuine readiness to share the values and security concepts of the West and to demonstrate their ability to cooperate. The bilateral Hungarian-Romanian Open Skies Agreement was an innovative step in this respect. Furthermore, it proved helpful in promoting the idea of Open Skies on a European scale.

Soon after the second Budapest round of the Open Skies conference, Romania proposed to Hungary to commence negotiations on a bilateral Open Skies agreement. Hungary did not at that time accept the Romanian offer. As designated host of the third round of the Open Skies conference (which was then actually held in Vienna, and, of course, not hosted by Hungary), it made every effort possible to help bring about the continuation of the multilateral negotiations. Hungary was well aware that a multilateral regime would offer several obvious advantages: among others, it could serve as an additional verification regime for existing and future arms control agreements or as a framework for regional crisis-management application of observation flights.

Only in January 1991 did Hungary agree to take up the renewed Romanian proposal. By that time it was clear that an accord on a multilateral Open Skies was impossible unless the Soviet Union was ready to shift its position and stop blocking agreement. The decision to begin bilateral Open Skies negotiations did not mean that Hungary had abandoned the idea of a multilateral regime. In 1989, the Hungarian delegation to the negotiations on confidence- and security-building measures in Vienna introduced the concept of “amplified confidence-building measures” in the relations of neighbouring countries. A bilateral Open Skies regime, functioning in parallel with a multilateral regime, was seen as a good example of the realization of this concept. Furthermore, both countries believed that the creation of a bilateral regime could demonstrate the viability and utility of Open Skies and help convince other participants to continue discussions.

The signing of an Open Skies agreement between Hungary and Romania had special political significance. The two countries had, regrettably, a history of strained relations. For three and a half decades their membership in the Warsaw Treaty had prevented Hungary from properly addressing the problems, which the sizable Hungarian minority living in Romania was facing. After the disbanding of the Warsaw Treaty, however, tension between the two countries threatened to resurface. The willingness to establish a regime which would ensure a high degree of openness and transparency in their military activities and serve as an effective tool of confidence building showed the determination of responsible politicians both in Hungary and in Romania to solve their problems exclusively by negotiations—either bilateral or within the framework of relevant institutions such as the Council of Europe or within the CSCE (now OSCE).

Negotiation of the Agreement

The Romanian delegation arrived in Budapest mid-February 1991. The first round of the negotiations was very intensive and fruitful. The fact that both delegations presented drafts of the bilateral agreements on the basis of the draft Treaty text of the second round of the Open Skies conference facilitated matters. The main body of the agreement was worked out in three days. The second round of the negotiations, held in Bucharest in mid-March, was equally intensive and effective. In two and a half days the delegations agreed on all eight annexes to the Agreement.[1]

The Hungarian and Romanian negotiators agreed from the very beginning that the regime to be created should be simple and yet effective and should match the technical and financial resources of the two countries. The provisions of the Agreement are therefore flexible and take into account the requirement of cost-effectiveness to a great extent.

According to the quota annex, the two countries have a right to carry out four flights a year in each other's airspace. This flight quota is quite substantial if one takes into account the fact that the bilateral regime continues to function even after the multilateral Open Skies agreement enters into force. An observation flight is restricted by the following, whichever applies first: a maximum duration of three hours or a maximum distance of 1,200 kilometres. This was calculated on the average speed (400 kilometres/hour) and range (2,000 kilometres) of the designated observation aircraft. A Hungarian observation aircraft using the nearest point of entry (Timisoara) can carry out an observation flight in Romanian airspace and return to Budapest without refuelling. However, if it uses the more distant point of entry (Bucharest), refuelling is necessary.

Both countries use their existing observation aircraft for the purpose of Open Skies flights: Romania uses the Soviet-made medium-size, two-engine turboprop AN-30 (which is a specialized version of the AN-24 transport plane, modified for aerial photography), while Hungary uses the two-engine turboprop AN-26 transport plane. The observing party may use its own aircraft or an aircraft of the observed party. The right of choice belongs to the observing party. As both countries have only a few aircraft suitable for Open Skies purposes, the observing party must submit a request seven days in advance if it intends to use an aircraft of the observed party.

The sensor annex specifies only the two sensors Hungary and Romania had at the time of signature: aerial cameras and video camera. This annex can, however, be updated if the parties wish to introduce further sensor categories. In view of the possibility of upgrading the sensors, the parties undertook the obligation to use similar sensors of comparable capability and to facilitate access to such sensors for use by the other party. The ground resolution of the sensors is *not limited*. This flexibility allows the pilot of the observation aircraft to fly as low as flight safety requirements permit.[2] Low-level flights might be necessary in cloudy weather, when the only way to take photographs is to fly under the cloud cover.

Request for an overflight is to be submitted 24 hours in advance and shall be accepted promptly, unless *force majeure* prevents the party to be overflown from receiving the observation aircraft. The Agreement guarantees that overflights are as unrestricted as possible. Hazardous airspace must be publicly announced in the aeronautical information publication. If the observed party requests overflight of hazardous airspace, such as airspace over nuclear-power stations, chemical plants or exercise grounds where a firing exercise is taking place, the observed party may specify the minimum safe altitude, may propose an alternate flight route as near to the hazardous airspace as safety requirements permit, or may propose a change in the timing of the overflight in the hazardous airspace.

The observed party has the right to inspect the aircraft and its sensors. According to the Agreement, this pre-flight inspection may last no longer than eight daylight hours and shall terminate no later than three hours prior to the actual commencement of the observation flight. This timeframe had been agreed with the intention of ensuring that the observation aircraft would have to spend no more than two days on the territory of the observed party. If the aircraft arrives in the observed country in the morning, the inspection is finished by nightfall, the observation flight then takes place the next morning, and the processing of observation materials (e.g., film) can be completed in the afternoon of the second day.

Information sharing is ensured by the use of double cameras that record two identical images of each scene. The two rolls of film are developed by a joint team of the two parties at the end of the observation flight in an established ground facility of the observed party. One negative is taken by the observing party while the other remains with the party that has been overflown. If a double camera is not available, the negative is copied and the copy is taken by the party which carried out the observation flight. The same applies to video cameras.

The Agreement establishes a Hungarian-Romanian Open Skies Consultative Commission. The Commission's task is to solve any dispute that may arise in the course of the implementation of the Agreement. The Commission is also responsible for updating the annexes on sensors, on the flight quotas, and on entry and exit points. In the hypothetical case that a party discovers, as a result of an overflight, disturbing or unusual military activity on the territory of the other party, the issue may also be raised in the Commission.

The Demonstration Flight

Hungary and Romania carried out a demonstration flight on 29 June 1991 not much after the signature of the bilateral Agreement. Representatives of all countries participating in the multilateral Open Skies discussions were invited to take part as observers in the trial flight. The purpose of the flight was threefold: to demonstrate to other participants of the Open Skies negotiations the viability and utility of Open Skies, to take advantage of the confidence building potential of bilateral overflights even before the Agreement entered into force,[3] and to test in practice the solutions to various technical problems which were worked out in the course of the negotiations.

Before the Agreement was signed, France had offered technical assistance to both countries. France provided Hungary and Romania with double cameras and automated film-developing machines. A French team of technicians was sent to Budapest and Bucharest to install the cameras and the apparatus and to train local personnel in their use.

The Romanian AN-30 aircraft arrived at Tököl military airport outside Budapest on 28 June. Hungarian officials accompanied by Romanian escorts inspected the aircraft to make certain there were no hidden sensors on board of the aircraft. The inspection team divided itself into three sub-teams: one sub-team inspected the fuselage, the second group the avionics, the third group the sensor, a French-made OMERA-33 aerial camera.[4] The team was able to check the aircraft thoroughly in less than three hours because of the fact that the Hungarian air force had used this type of aircraft for decades. After completion of the inspection the aircraft took off for a short flight to calibrate and check the sensor. When the inspection and the test flight were over, the Romanian crew filed a flight plan and the Hungarian officials approved it. Before the aircraft took off the next morning, Hungarian officials briefed the Romanian crew on expected weather conditions and flight safety and navigation regulations.

The Romanian AN-30 aircraft took off at 8:00 a.m. on 29 June. The observers followed the observation aircraft on board of an AN-24 transport plane flown by the Hungarian air force. Following the flight plan, the observation aircraft flew over various militarily significant objects: a civilian airport, a military college with heavy armament openly displayed for this occasion, an abandoned Soviet military airport and an exercise ground. After a short technical landing on Romanian soil, the demonstration flight was continued over Romania. There the observation plane flew over a military airfield, a training ground, an ammunition depot and a railroad junction.

Weather over Hungary was fair, with a cloud base at 2,000 to 3,000 metres. The plane therefore flew at an altitude of 1,500 metres. Photographs taken from this altitude had a ground resolution of 10 to 15 centimetres. The weather over Romania was poor: it was raining and the cloud base at some places was at 400 metres. The aircraft therefore had to fly as low as 200 to 250 metres. The crew of the observation aircraft decided to take the risk of low-level flight because of the desire on the part of both countries to have a successful demonstration. Photographs taken at this altitude had a ground resolution of 2 to 3 centimetres. Navigation proved to be a much more serious problem than either side had expected. The obsolete navigation equipment of the aircraft, the absence of detailed maps of the sites to be overflown and the lack of an electronic pointing device for the camera were responsible for the problems. The observation aircraft had to fly over some sites twice or even three or four times to take a good photograph. These repeated passes would have been impossible during a "real" observation flight, as the Agreement prohibits loitering over the same site.

After completion of the observation flight, the aircraft landed at Otopeni Airport in Bucharest, the then civilian international airport of the Romanian capital. A joint team of Hungarian and Romanian technicians developed the films (for reasons of easy development, only black and white film was used). They were able to produce a few prints as well. The quality of some of the pictures was not satisfactory because of the adverse weather conditions and a slight malfunctioning of the focusing mechanism of the camera. Observers were briefed on the results of the demonstration flight in Budapest.

The most important conclusion to be drawn from the more than 30 observation flights that have been carried out between the entry into force of the Agreement and the end of 1998 is that *two countries with modest technical and financial resources can create and operate a relatively effective Open Skies regime*. Both the Hungarian and the Romanian air forces have to perform regular training flights, and some of these flights are used for Open Skies purposes. In this way the costs of observation flights are kept to a minimum. Hungary spends about EUR 5,000 per flight for aircraft operation costs (mostly fuel) and the per diem of two camera technicians. The film was surplus material from France (close to expiration date) and came for free.

Simple and not very expensive sensors—such as aerial cameras—can be used very effectively under various meteorological conditions, provided that the terms of the agreement are flexible enough (the so-called success rate, that is, the ratio of good quality imagery has been about 80-85% in the last six years). The mutual consent of setting no resolution limit makes the agreement technically much simpler (and operationally less cumbersome) than the multilateral Treaty. The agreement works well without a complicated certification procedure (H_{min}-determination) and leaves more flexibility in film developing. At the same time, participation in a multilateral Open Skies regime offers several (mainly political) advantages compared to a bilateral regime.

The observation flights carried out so far have fully demonstrated the excellent confidence building potential of Open Skies. The preparation and carrying out of an observation flight requires a high degree of cooperation and real teamwork on the part of the personnel involved. This in itself is a confidence-building exercise. Short-notice overflights are tangible proof, not only for the militaries of Hungary and Romania but also for the average person, of the considerable degree of confidence between the two countries. The confidence strengthened by these flights—no doubt—contributed to the solution of bilateral problems and the more recent dramatic improvement of bilateral relations.

The signing of the bilateral Agreement and the carrying out of the demonstration flight facilitated efforts to bring about the continuation of the multilateral Open Skies discussions. Technical experience gained during the demonstration flight was used extensively by the Hungarian delegation in preparation for the third round of the Open Skies conference. The Hungarian-Romanian bilateral regime, functioning in parallel with the multilateral Open Skies regime, could serve as an example for a sub-regional or regional Open Skies structure—for example, within the framework of a regional confidence- and security-building regime to be negotiated under Article V Annex 1-B of the Dayton Agreement.

Last but not least, this cheap and effective bilateral Open Skies regime can serve as an example for countries on other continents. Regions of tension—such as the Middle East and the Korean peninsula—also could take advantage of this new and highly effective confidence-building tool, which in case of an arms limitation accord can also be used for verifying its observance.

8.2 Regional Application: The Bosnia Experiment and the Bosnia Experience

From proposal to reality

The possibility of a regional Open Skies regime—parallel with the multilateral one or embedded within it—had been discussed informally from the very beginning of the Open Skies conference. However, this option was not taken up "officially" during the Ottawa and the Budapest discussion rounds due to an agenda overburdened with more important political and technical issues. The proposal to include some language on regional application into the Treaty was first made by the French and

Hungarian delegations during the Vienna round of the conference. The proposal was not welcomed by all delegations with enthusiasm. Some expressed fear that the mere idea of a regional Open Skies regime represented a dangerous deviation from the main thrust of the negotiations: the creation of an East-West confidence- and security-building tool which would further increase transparency between NATO members and (former) member countries of the Warsaw Treaty. Some other delegations questioned the feasibility of Open Skies flights in a crisis area. They argued that a slow, unarmed observation aircraft could easily become victim to a provocation by any of the conflicting parties.

After long negotiations in the working group that dealt with legal issues (chaired by Ambassador M. de Brichambaud of France) a compromise was found: delegations agreed to include a sentence into the Preamble of the Treaty which took notice of the possibility of using Open Skies observation flights for crisis management purposes.

This sentence found practical application in Bosnia and Herzegovina well before the Treaty entered into force. Paragraph II of Annex 1-B of the Dayton Agreement of November 1995 foresaw the conclusion of a Confidence- and Security-Building Agreement by the two entities (the Bosnian-Croat Federation and the Republika Srpska). This document (the Agreement on Confidence- and Security-Building in Bosnia and Herzegovina) was concluded on 26 January 1996 in Vienna. The record-breaking speed and efficiency of the negotiations, chaired by Ambassador István Gyarmati of Hungary, surprised even the most optimistic observers. Implementation started a few days later and from May on was supervised by one of the authors of this chapter—in his capacity of Personal Representative of the Chairman in Office of the OSCE. The Agreement—modeled on the pan-European Vienna Document of 1994—was implemented much more successfully than other parts of the Dayton Accord. The willingness of the parties to implement a rather intrusive CSBM regime could be explained by war fatigue and a relative equilibrium of forces, which did not make the option of renewed hostilities too tempting to any, but a few of the military leaders.

As implementation proceeded with increasing efficiency and the parties acquired considerable experience in arms control implementation, the possibility and desirability of new, additional measures was mentioned more and more frequently in informal contacts. Since the Agreement on

Confidence- and Security-Building Measures in Bosnia and Herzegovina contained a full set of "classic" measures, a regional Open Skies regime, as the logical continuation of the process of military stabilization, was proposed by the Personal Representative. By the end of 1996 the parties had signaled their readiness to examine the feasibility of a regional Open Skies regime in and around Bosnia and Herzegovina.[5]

On 12 and 13 February 1997 a seminar on Regional Confidence-Building and Open Skies was organized in Sarajevo by the Personal Representative. Keynote speakers from Bulgaria, Canada, France, Germany, Greece, Hungary, the Russian Federation, Turkey, the United Kingdom and the United States made presentations on both subjects. The speakers briefed the audience on the Open Skies Treaty national programmes of trial flights and also on possible other (non-military) applications of unarmed observation flights. All the local participants—civilian and military experts—expressed interest in Open Skies and requested the Permanent Representative to continue with the programme.

All the foreign and local participants agreed that an Open Skies regime for Bosnia and Herzegovina, which could also be extended to the neighbouring countries or the whole sub-region of the former Yugoslavia, would have several advantages:

- An aerial observation regime would be the cheapest and most efficient way to improve transparency and openness in a country (or countries) with an extremely rugged terrain;
- Short notice observation flights would be a convincing and cost-effective way to deter any preparation for a surprise attack of a large-scale offensive;
- Comparative analysis of imagery produced by regular Open Skies flights over a longer period of time, covering most of the military objects (military bases, airfields, storage facilities, training grounds, etc.) would enable the parties to follow closely the development of military infrastructure of the other sides;
- Open Skies flights are more visible than any other CSBM, and therefore present a much higher public relation value. Between countries where deep-rooted suspicion of one another is the rule rather than the exception, the beneficial effect of extensive media coverage of arms control and CSBM activities can hardly be overestimated;

- Implementation of a regional Open Skies agreement would require the assistance of "third states", that is, countries with an operational Open Skies observation aircraft and enough expertise to act as lead nations. The involvement of other European and North American states would create a certain "trip-wire effect": discovery of any unusual or threatening military activity would be reported also by a neutral, third party. This would increase the likelihood of a timely and appropriate reaction by the international community;
- Finally, a regional Open Skies agreement could only be the result of free and voluntary negotiations between the interested parties. These negotiations would represent a significant step forward compared to the Dayton Agreement, which was negotiated and concluded under considerable external pressure.

The Hungarian-Romanian Demonstration Flight

The next step towards introducing Open Skies into Bosnia and Herzegovina and the Balkans was a Hungarian-Romanian demonstration flight between 17 and 19 June 1997. In spring 1997 Romania welcomed the Hungarian initiative of a joint flight. This action undertaken a few weeks before the Madrid NATO Summit was to demonstrate the determination and readiness of the two countries to cooperate in spreading stability in the Balkans. The two countries were well prepared for such a demonstration flight: Hungary and Romania had performed dozens of observation flights over each other's territory within the framework of their bilateral Open Skies regime. Their accumulated experience was truly exceptional at the time of the demonstration.

A number of observers were invited from the member states of the Contact Group and countries of the region. Participation of observers from other Balkan states (including the Federal Republic of Yugoslavia, Croatia and Slovenia) was to familiarize them with the idea of a regional Open Skies regime.

Preparation of the demonstration flight was a politically complicated exercise. Permission to use the airspace of Bosnia and Herzegovina had to be given by four actors: the Stabilisation Force in Bosnia and Herzegovina (SFOR), the state of Bosnia and Herzegovina, the (Bosnian-Croat) Federation and the Republika Srpska. It was a complicated diplomatic exercise to convince state authorities (particularly the Foreign Ministry of Bosnia and Herzegovina) to previously consult Republika Srpska authorities on the matter. According to the Dayton Agreement, the three-member Presidency of the state of Bosnia and Herzegovina was to decide on matters pertaining to sovereignty. Since the Presidency had not been convened by that time, it was the Foreign Ministry that acted on behalf of the state. Any action by the Foreign Ministry not cleared beforehand by the entities of Bosnia and Herzegovina entailed the danger of obstruction by one or both of the entities. An independent permission by the two entities, controlling the two armed forces, the army of the Republika Srpska and the army of the Federation, was also necessary to ensure safety of the aircraft. Finally, permission by SFOR was required, since Bosnian airspace was effectively controlled by NATO at that time (including air traffic control).

As a result of intensive preparations (mostly by the Office for Regional Stabilisation, a section of the OSCE Mission in Sarajevo, tasked with assisting the implementation of CSBM and arms control agreements in Bosnia and Herzegovina), both entities and all three constituent nations of Bosnia and Herzegovina cooperated with Hungary, Romania and the OSCE in carrying out the demonstration flight. They had volunteered to play an active role in the preparations and in carrying out the demonstration flight. Hungarian and Romanian experts and the observers stayed in three different locations (hosted by the Army of the Republika Srpska, the HVO (Croatian component of the Army of the Federation) and the Army of Bosnia and Herzegovina (the Bosnian component of the Army of the Federation). Transportation, technical equipment and other services were provided also by all three parties. The cooperative nature of the exercise represented a new stage in the process of confidence building.

The Hungarian AN-26 with a joint Hungarian-Romanian crew landed in Sarajevo on 17 June 1997. The aircraft was equipped with a French-made Omera-33 double camera. This camera produces two identical sets of films, which makes data sharing an easy exercise. The chief of the Hungarian Open Skies Team briefed the representatives of the parties (some 30 civilian and military experts) and the observers on the multilateral Open Skies Treaty, the Hungarian-Romanian bilateral Agreement and technical characteristics of the aircraft and sensors. Briefings on the flight plan and safety regulations were made by other members of the team.

On 17 and 18 June the AN-26 carried out two flights with identical flight plans. Since the small, two engine turboprop transport aircraft modified for the purposes of Open Skies could carry only 25 observers, two flights were required to enable all the experts and observers to participate in the demonstration. The flights lasted some three hours and the distance covered was about 1,000 kilometres. The flight plan included nine military objects—six on the territory of the Federation and three on the territory of the Republika Srpska.

There was considerable media coverage of the event. Central Television (Sarajevo) as well as TV stations of the Republika Srpska broadcast a short report about the demonstration flight—in addition to coverage by local radio stations and newspapers.

The black and white aerial photographs were developed within 24 hours by Hungarian and Romanian technicians in Sarajevo. Negatives of the two films remained with the local authorities. The imagery was displayed and analyzed by a joint team of Hungarian, Romanian and local experts. Quality and resolution of the imagery was rather poor due to changing weather and a very high flight altitude (5,000-6,000 metres) required by SFOR air traffic control.[6] SFOR in Sarajevo and air traffic control in Vicenza, Italy were very helpful throughout the flight. The restrictions on flight altitude were dictated by safety considerations (a few days earlier an anti-aircraft battery of one of the parties had locked onto a NATO military aircraft, so stricter regulations were introduced on minimum altitude).

Parties assessed the demonstration flight very positively. The representative of the Republika Srpska stated that an Open Skies regime was needed for the region. The representative of the HVO added that the demonstration flight convinced them of the usefulness of such a regime. The Bosnian representative also supported the idea of a regional regime and promised further cooperation. He added that potential civilian uses of Open Skies flights (e.g., for environmental monitoring or technical assistance to reconstruction efforts) were of great interest.

The German Demonstration Flight

The next demonstration flight took place on 27 August 1997 with the German Open Skies aircraft (this aircraft was lost a few weeks later in a tragic accident near the Western shores of Africa).

Preparation of this second demonstration flight was hardly easier than that of the first—both politically and technically. The original idea foresaw a flight path covering both Bosnia and Herzegovina and the western part of Croatia. This gradual broadening of participation was proposed in order to explore the possibility of a regional Open Skies regime. A following joint flight by the United States and the Russian Federation in turn would have covered the Federal Republic of Yugoslavia and Bosnia and Herzegovina. Croatia in the end did not allow the German aircraft to produce imagery over its territory. Despite this refusal the German Open Skies aircraft took off and landed in Split, Croatia, because the setup of the Sarajevo airport was unsuitable.

The German aircraft flew at an altitude of around 6,000 metres with a speed of around 660 kilometres/hour. Its 2,300 kilometres-long flight path covered 122 military and civilian objects (proposed by the parties) on the territory of both entities.

Representatives of the three parties and observers from the Contact Group, Office of the High Representative, OSCE and journalists from both entities were present on board. Observers were able to move freely on board during the flight and observe the navigators and sensor operators. The presence of TV crews on board helped in making this demonstration flight a media event. A relatively good coverage by the Central TV Station in Sarajevo and TV Banja Luka in the Republika Srpska helped significantly to spread knowledge among the population on the military stabilization process in Bosnia and Herzegovina. Earlier attempts to attract media coverage for "regular" CSBMs had been less successful.

Photographs of the targets were taken by three framing and three video cameras (a vertical framing camera LMK-2015 with 152 millimetres lens, two oblique cameras placed at an angle of 33 degrees, one vertical and two oblique video cameras VOS-60, also at an angle of 33 degrees). The films were developed at the German laboratory in Cologne, monitored by representatives of all three parties. Despite unfavourable weather conditions during the last hour of the flight (growing cloud cover), the German crew managed to photograph some 70% of the targets successfully.

Germany had planned another observation flight over Bosnia and Herzegovina in October 1997. Unfortunately, due to the crash of the German Open Skies aircraft that observation flight could not take place.

The American-Russian Demonstration Flight

Since the carrying out of demonstration flights also carried a political message, it was important to involve as many of the Contact Group countries as possible. The willingness of the United States (providing military assistance to the Federation within the framework of the Train and Equip programme) and the Russian Federation (a strong supporter of the former Republic of Yugoslavia and the Republika Sprska throughout the war) to undertake a joint flight had a special significance. These two powers working together to facilitate the military stabilization of Bosnia and Herzegovina had an unmistakable effect on the parties.

The demonstration flight took place between 3 and 7 November 1997—somewhat later than originally planned. Preparations were done mainly by the Office for Regional Stabilisation—in a very short time, since information on the planned flight had been conveyed to the Office only on 2 October.

The flight plan was put together in the German Verification Centre—using the same object list that had been provided for the previous (German) flight. Two flight profiles were developed, each covering 28 different—military and civilian—objects. The two demonstration flights were carried out with a Russian Air Force AN-30B Open Skies aircraft with eight Russian and four American experts on board as mission team. The organizers provided ten guest seats during each flight for the local parties and the guest observers. This time the local media showed little interest in the event.

One set of film was developed in Hungary while the other set was taken to Moscow for processing and copying. Due to very unfavourable weather conditions the quality of the imagery was generally very poor.

By the conclusion of the third demonstration flight over 122 separate military and civilian objects had been photographed and copies of the entire imagery obtained were exchanged among the three entities, as well as with the governments of the lead nations. More significantly, the flights themselves over the year had transformed from being an extraordinary event to merely a "routine" exercise, which in the context of Bosnia and Herzegovina is a major success.

There is no doubt that the three demonstration exercises conducted in 1997 proved valuable in the confidence-building arena but it became obvious that the process needed to be developed further, certainly by engaging the parties of Bosnia and Herzegovina in a more professional way and possibly by widening the group of participating states. Clearly, further Open Skies activities would be dependent upon the cooperation, goodwill and financial commitment of assisting states since the local parties have neither the money, the equipment, nor the experience to maintain the initiative unaided.

Further Flights

During the following years (1998-2001) four more flights were carried out.[7] As a result of these missions military personnel from the Bosnian Federation and from Republika Srpska were trained for aerial observation.

Conclusion of an Aerial Inspection Regime

Subsequent to the initial demonstration flights of 1997 the conclusion of a regional Open Skies regime in Bosnia and Herzegovina was discussed as a confidence- and security-building measure. One problem resulted from the fact that none of the entities operates fixed wing aircraft suitable for observation flights. Hence the continued use of existing foreign Open Skies aircraft was considered. In the end a more modest solution was favoured: the use of helicopters owned by the entities.

In April 2000 the Joint Consultative Commission of the three parties in Bosnia and Herzegovina agreed to establish a regime of aerial inspections. This project is taking place within the context of the Agreement on Confidence- and Security-Building Measures in Bosnia and Herzegovina (Annex 1-B of the Dayton Peace Accord), under risk reduction. Inspections will be carried out by helicopters equipped with video cameras. Each observed entity will provide a helicopter for flights within its boundaries. Helicopters are not allowed to cross the borders of the entities. The agreement was finally signed after Denmark provided technical assistance (video cameras). By August 2000 two aerial inspections had been performed. Observers on board included representatives of the three entities as well as from OSCE and NATO.

Assessment and Future Prospects

Technically the conclusion of the aerial inspection regime can be seen as a minimum solution. The quality and area coverage of video images taken from helicopters is likely to be much lower than that of imagery taken from fixed-wing aircraft fitted with cameras. It remains to be seen whether the three entities will implement the accord appropriately. On the other hand, the application of Bosnia and Herzegovina for membership in the multilateral Open Skies Treaty is—ultimately—a positive result of the extended foreign investment in demonstration flights.

8.3 Regional Open Skies Agreement in the Balkans: A Missed Opportunity

Article V of Annex 1-B of the Dayton Accord of 1995 foresaw regional negotiations on confidence-building and stabilization measures in the Balkans. The negotiations comprised all successor states of the Former Republic of Yugoslavia (Bosnia and Herzegovina, Croatia, the Republic of Macedonia, the Federal Republic of Yugoslavia, Slovenia) as well as Albania, Austria, Greece, Hungary, Italy, The Netherlands, Romania, Spain, Turkey and the members of the Contact Group (France, Germany, Russia, the United Kingdom and the US). The negotiations lasted from 8 March 1999 to 18 July 2001.

Several attempts were made to include Open Skies elements in the draft agreement. The last proposal for "aerial observation over the territory of other participating States" was tabled by the French chairmanship in spring of 2001 (Ambassador Jacolin). These flights were meant to be conducted in addition to any rights or duties under the multilateral Open Skies Treaty. Technical details of the flights including sensors and the resolution as well as sharing of data would have to be agreed between the observed and the observing states in an observation mission agreement. Flights would be conducted by multinational observation teams from Article V participating states. The draft also suggested that all participating states which were not signatories of the multilateral Open Skies Treaty would apply for accession after its entry into the force. In the end—upon insistence by the US—any reference to aerial observation was dropped. The participating states just reaffirmed the significance of the Open Skies Treaty. Apparently the United States rather preferred to see the new states joining the multilateral Open Skies Treaty.[8] This materialized to some extent, since by February 2003 three of the seven potential applicants (Bosnia and Herzegovina, Croatia and Slovenia) had applied for accession to the multilateral Open Skies Treaty.

Thus, the idea of a regional Open Skies Regime in the Balkans under Article V turned to naught. The concept could have been attractive as a means of strengthening regional cooperation, confidence building and identity building. The merit of the French proposal had been its flexibility in fixing the details of flights; the weakness was the lack of binding commitments. In the end the pull towards the established European security systems and treaties like NATO and the adapted CFE Treaty respectively, as well as the wish to join the European Union were stronger than the interest in regional approaches. It remains to be seen to what extent participation in the multilateral Open Skies Treaty can make up for the missed opportunity. The Concluding Document of the Article V negotiations allows for some confidence-building and security cooperation measures on a voluntary basis.[9] It is thus a rather weak agreement of much less weight than the Vienna Documents, the adapted CFE Treaty or even the agreements reached on arms control and risk reduction in Bosnia and Herzegovina itself under Article II of Annex 1-B of the Dayton Accord.

8.4 Open Skies Outside of Europe: Precedents and Prospects

Understandably, much of the foregoing has been confined to discussing Open Skies in the geographic context of Europe and the historical political and military schisms that once—and in several cases, still—divided it. Nor can one ignore the comparatively long experience European nations have acquired from the negotiation and implementation of numerous CSBM agreements dating back to the mid-1970s. When coupled with the relatively large amount of resources European nations have been able to devote to arms control, it is not unfair to ask whether CSBMs such as Open Skies have any potential relevance outside the isolated case of Europe. The answer, in a word, is most assuredly.

In order to understand this relevance, it is necessary to review the key concepts underlying the Treaty on Open Skies. Only in this way it is possible to elaborate on how something like an Open Skies regime could make a significant contribution to enhancing regional security outside Europe. It will also help later explain why proposals to create aerial observation regimes in regions such as Latin America, South East Asia, and elsewhere have found receptive audiences.

Before doing so, a caution is in order. It cannot be overly emphasized that a regional aerial observation regime need not replicate either the expense or the level of complexity of the European Open Skies Treaty. Unique national and regional considerations such as geography and history will dictate similarly unique bilateral and multilateral approaches to the political and technological considerations associated with an aerial observation regime. That is to say, an aerial observation regime negotiated among neighbouring states in other regions of the world will undoubtedly utilize different treaty provisions, as well as different categories of aircraft and sensors that are better suited to those states' unique operational environments. It is a measure of the Open Skies concept's inherent flexibility that it can be so easily adapted to meet these other requirements.

Open Skies: One Piece in a Broader Mosaic

The preceding sections have addressed many of the very technical issues associated with implementation of the Open Skies Treaty. However, the question to which we must now turn is *why* other non-European regions of the world find some adaptation of the Open Skies Treaty to be appropriate to their security concerns. In order to answer this question, it is necessary to first place Open Skies in the broader context of "arms control", and thereby to explain *what* Open Skies does. In this way, it will be easier to understand *how* Open Skies in one form or another could make a significant contribution to enhancing national and regional security.

Arms control represents an agreement between two or more nations to enter into a dialogue concerning the types of military activities each perceives as potentially threatening. It reflects an interim step in the transition from confrontation to cooperation by codifying the steps each will take to allay the fears of the other. Arms control creates, if not trust, at least a legal basis for acquiring some degree of confidence between nations. By increasing transparency, arms control measures contribute to building national confidence and reducing incentives to attack, thereby allowing countries to direct scarce resources to safer, more productive activities.

Arms control agreements often share two common elements. The first is an exchange of information on the weapons, forces, or military activities that are viewed as potentially threatening. This information serves to define the long-term military balance. The second element is the opportunity for nations to, by some means, reassure themselves, that is, to verify, that the information they were provided is accurate.

Each arms control agreement is unique in the opportunities that it provides to confirm or verify information that has been exchanged by touching, seeing, photographing, measuring, remotely monitoring, *overflying*, or otherwise recording information. These variations can be attributed to several considerations, the most important of which is the military significance of what is being controlled. For example, Open Skies' "loose" criteria of military significance are far less demanding than the START Treaty provisions governing nuclear warheads. These variations are also designed to prohibit access to sensitive areas and to protect legitimate national security concerns, thus ensuring that information unrelated to a particular arms control agreement cannot be gathered.

By defining the size, composition, and deployment of neighbouring militaries, arms control agreements allow national security planners to tailor the size, composition and disposition of their own military structure in order to field only such forces as are necessary for self-defence. It also allows them to reassure themselves that ambiguous military activities, such as redeployments, exercises and the like, are not misinterpreted as a prelude to surprise attack. By reducing the fear of aggression, arms control thus leads to greater stability.

Why An Aerial Observation Regime?

At the political level, beginning with the initiation of the Helsinki process in the mid-1970s, US officials have met with representatives from throughout the international community concerning the potential application of military confidence- and security-building measures to regions of the world still characterized by tension and distrust. These CSBMs span a wide range of activities, from the simple exchange of information, to measures requiring extremely intrusive on-site inspection. Why, then, is there specific international interest in the Open Skies Treaty?

Open Skies lies along the middle of this continuum of measures in that it permits nations to confirm information they have acquired, but in a way that does not require intrusive physical access. Because an aerial observation flight does not arouse the same degree of political sensitivity as having foreign military personnel conduct an on-site inspection, it is generally thought to provide a more "neutral" means through which to pursue monitoring as well as closer military-to-military contacts.

Closely related to the above point is the very nature of the contact between the militaries taking part in this exercise. For example, ground-based arms control inspections involve two clearly defined teams, the inspected state party (us) and the inspecting team (them); they most often take place under Treaty provisions permitting *challenge* inspections; and result in a report jointly signed attesting to whether or not a nation is in compliance with its treaty commitments. Not surprisingly, an on-site inspection can assume an adversarial character.

In contrast, participants in an aerial observation mission, in addition to generally being of the same military profession (i.e., pilots, navigators, sensor operators), share a common interest in ensuring the safe operation of the aircraft and that the flight conforms with regulations governing international air traffic. This "commonality of purpose" tends to foster a much more cooperative relationship throughout the mission between the observed and observing states parties.

It is probably one of the unintended consequences of such individual interactions that adversaries are not only forced to meet face-to-face, but to actually cooperate. These opportunities allow each to learn something about the other, to explore the perceptions and motivations of their adversaries, and to learn what they share in common and what they do not. At the national level, the term "military-to-military contacts" is the official phrase used to encourage this behaviour.

Beyond the personal dynamics of an Open Skies mission another fundamental difference distinguishes this from other treaty regimes. Key among the central concepts underlying the Open Skies Treaty is the right of states parties to *jointly collect information* over the entire territory of other states parties without any restrictions for reasons of national security. In other words, the judgement of compliance or non-compliance is not at issue. Additionally, the Treaty allows these observation aircraft to be equipped with a variety of sensors, such as panoramic cameras, infrared line scanning devices and SAR. In concert, these sensors allow imagery to be gathered during day and night, under any weather conditions.

By allowing one nation to overfly and image areas where it suspects suspicious military activity to be taking place, Open Skies affords reassurance against the fear of pre-emptive attack by a neighbour. Of equal importance, aerial observation flights can be used to demonstrate the absence of any activity that could be perceived as threatening.

The Open Skies Treaty is not a diplomatic European euphemism for spying. As fundamental to the success of the Open Skies Treaty as territorial access is, it is also the one provision most likely to raise the discomfort of foreign audiences. This is particularly true in areas outside Europe where there is not a comparatively long history of amicable military-to-military contacts and where widespread reliance on national technical means is still the rule. It is not difficult to understand why. Outside of Europe, having one's national defence establishment routinely overflown and imaged by potential adversaries is a novel experience for most nations.

On the positive side, the right to conduct airborne observation missions over other countries provides most of these nations with their first independent opportunity to confirm the location and activities of their neighbour’s military forces. Furthermore, unlike more sensitive means of gathering information, it importantly provides a source of information that can be shared with foreign governments and the public owing to the multinational composition of the observation team.

Central to then President Bush's proposal was that Open Skies sensors only be capable of distinguishing major items of military equipment. For example, negotiated limitations on sensor resolutions allow for the ability to distinguish a tank from a truck, but not the ability to distinguish one type of tank from another or its state of operational readiness.

Accordingly, a number of safeguards are built into the Treaty that significantly minimize the possibility that Open Skies overflight missions can be used to collect information in violation of the Treaty. For example, the Treaty requires an intensive examination of the aircraft and sensors as part of its certification as an Open Skies observation aircraft. Furthermore, the observed nation has the right to conduct an extensive pre-flight inspection of the aircraft upon its arrival in the country to satisfy itself that no modifications have been made to the aircraft or sensors since its certification. Finally, representatives of the observed nation fly onboard the aircraft during the observation mission to ensure that the agreed flight route is not deviated from and that the sensors are used only in compliance with what has been agreed to by the observed and observing countries. Protections like these are fundamental in allaying suspicions in regions outside Europe that aerial observation flights are merely legalized aerial reconnaissance missions, particularly in those regions where the memories of conflict remain fresh.

For nations to benefit equally from the Open Skies Treaty, they obviously must be capable of equally implementing the Treaty. This is one reason why the Open Skies Treaty requires that all aircraft and sensors must be commercially available. This requirement ensures also that no nation can take technological or financial advantage to the detriment of its Treaty partners. Further assurances are provided by Treaty provisions allowing flights to be conducted with aircraft belonging to the observing nation, the observed nation, or leased from another signatory nation.

From the perspective of the European arms control community, it is sometimes easy to forget that such attention to ensuring the rights and responsibilities of all states stems from a long-term, widely shared objective, in this case the preservation of peace in Europe. In other regions where this "collective sensitivity" is not so well developed, bilateral and multilateral military-to-military relations on the basis of equality provides a novel alternative to costly arms races and armed conflicts, particularly for those nations too long accustomed to poverty, illiteracy and instability.

This is not to suggest that only benign intentions animate Open Skies Treaty signatories. Otherwise, the level of complexity and expense of the Open Skies Treaty would not have been necessary. It is, however, meant to suggest that the nations of North America and Europe have come to accept arms control as being in their individual and collective self-interest. This is seen, too, in the common vocabulary of arms control words they have developed over 30-plus years to describe that common experience. With the increasing "internationalization" of arms control represented by agreements such as the NPT, CTBT, MTCR and CWC,[10] it may be that this lesson of the Cold War is being more widely accepted, although recent events in the Balkans, Southeast Asia, and elsewhere provide scant basis for optimism in the near-term.

Although perhaps obvious, one more observation is in order. Outside of Europe, few nations possess active nuclear, biological or chemical weapons programmes. All, however, possess conventional military forces and equipment—albeit in differing quantities and qualities—and share the same suspicions that have divided nations since time immemorial.

From a non-European perspective, there are a number of advantages inherent in an aerial observation regime that are not to be found in other potential arms control measures. This is particularly true in those regions where there is not a long, well-established history of trust and cooperation, and where military-to-military contacts remain largely in the tentative stages. Three advantages are of particular note.

Traditionally, arms control treaties have restricted or limited military forces and activities. For example, the CFE Treaty establishes precise limitations on five categories of military equipment in each of the geographic zones defined by that treaty. Moreover, under the verification provisions of the CFE Treaty, any facility with a door two meters or greater in width is subject to intrusive on-site inspection. The Open Skies Treaty imposes no such constraints. Signatories are free to modernize their forces, and to station and deploy them wherever they choose, subject only to the possibility of being overflown and photographed.

Second, an aerial observation regime allows participating countries to overfly and to photograph extremely large and in some cases rugged areas rapidly and inexpensively. One need only briefly visualize the rain forests of Latin America or the mountains of Central and Southeast Asia to grasp the political and military complications posed by geography.

Third, beyond making a significant contribution to increased national security, aircraft modified to conduct aerial observation missions may be used for a wide variety of other purposes. These additional purposes help to ensure the most cost-effective use of these aircraft. Among the more traditional applications are: conducting environmental assessments; documenting the consequences of natural disasters such as flooding and forest fires; evaluating land usage, like tracing vegetation and deforestation; mapping in order to establish territorial boundaries; and providing terrain characteristics in support of infrastructure construction projects such as roads, bridges, dams and distribution centres.

Other non-traditional uses could include recording the movements of migratory peoples, such as those fleeing man-made and natural disasters, and terrain exploration. Preliminary analysis of using airborne platforms to identify and map minefields is encouraging.[11]

These are not "rocket science" cutting edge programmes, and are in fact being conducted daily throughout the world. In all likelihood, requisitely equipped aircraft that could be rapidly and economically modified to perform aerial observation missions are already in national or commercial service, thus significantly reducing the costs associated with a regional observation regime.

Must a Regional Aerial Observation Regime Look Like "Open Skies"?

If, in truth, nations outside Europe find these concepts and aircraft uses so compelling, then why have no other regional observation regimes been concluded? The answer, in large part, is that until recently the world of arms control and CSBMs was defined by NATO and the Warsaw Treaty. With the dissolution of the Warsaw Treaty and the emergence of a still ambiguous new international security environment, Open Skies represents for many their first introduction to the concept that arms control and CSBMs can actually contribute to maintaining and enhancing their national security. Regrettably, while Open Skies may be brilliant in the simplicity of the concepts that underpin it, most—including many of its signatories—regard it as technologically intimidating for all but the richest nations.

In this, there is a presumption that the very success of the Open Skies Treaty is inseparably linked to the aircraft and sensors that are in use by its US and European parties. This is not only unfortunate, but also completely wrong. It is a mistake of the first order to assume that a regional aerial observation regime must replicate the cost and complexity of the European Open Skies Treaty. Each region of the world, whether in Asia, Latin America, the Middle East, or elsewhere, presents distinctive political and operational requirements.

For example, the sensors permitted under the Open Skies Treaty are more than adequate to detect significant military concentrations or activities that would be of concern to the nations of Central Europe. They are completely inadequate to allow for the detection and identification of mortars, a more immediate concern to the components of the former Yugoslavia. Similarly, Open Skies sensors are of little utility in penetrating the tropical canopy that covers much of South America or, more specifically, in areas along the contested border between Ecuador and Peru.

It thus becomes readily apparent that nations must first agree amongst themselves what types of forces or activities constitute a potential threat to regional security and stability. For some, that may be heavily armed forces stationed along border areas; for others, it may be more lightly armed forces operating in remote or mountainous regions. In either case, clarity of purpose regarding the objects to be imaged and in what detail is essential to selecting the appropriate sensor(s). Open Skies can serve as a precedent for this decision only to the extent the signatories are willing to share the extensive operational experience they have acquired preparing for its implementation.

For example, in hindsight one of the lessons the United States learned is that the selection of an observation aircraft is closely related to the question of sensor operating parameters. The selection of the KA-91 optical camera forced the US to select an aircraft capable of flying up to 10,668 metres. Unfortunately, the selection of an OC-135 prohibited sensor packages that operate at very low altitudes, which, of course, is the only region where optical cameras have much utility given the prevailing cloud cover across most of Europe throughout the year.

By the same token, many point to the size and sophistication of the aircraft currently configured to perform Open Skies missions and erroneously assume that the cost implications of an aerial observation regime are prohibitive. Frequently lost in such considerations is that the selection of an airframe must be based on operational requirements, and that a wide variety of air platforms are readily available to perform such missions. The United States is a case in point.

Under the terms of the Open Skies Treaty, the United States has the right to conduct an un-refuelled 6,500 kilometres overflight of the Russian Federation. At the operational level, exercise of this right means the US aircraft must transit the Atlantic Ocean and refuel in Western Europe before transiting to the Russian designated point-of-entry. Both requirements dictated that the US select an airframe capable of flying extremely long distances, in this case an OC-135, a predecessor of the civilian Boeing 707. Other Open Skies countries such as the United Kingdom and Ukraine must meet far less demanding requirements.

For these countries, propeller aircraft such as the Russian AN-30 or American C-130 are more widely available, operationally simpler to use (e.g., they can fly low and slow) and can far more easily operate from austere locations. Indeed, austerity is another major determinant of what aircraft and sensors are selected. For example, austere locations argue against selection of extremely sophisticated sensor packages because of size, weight and support requirements. Furthermore, austere airfields infrequently are of the requisite length, width and strength to support large jet aircraft; nor are sophisticated electronic maintenance facilities generally available.

To take our example one step further, one of the options—which was eventually retained—in support of an aerial observation regime in Bosnia and Herzegovina would rely on a hand-held digital camera operated from a helicopter. Excluding the operating costs of fuel, etc., digital cameras are available in the US for about $600. Processing of the image data can be accomplished on laptop computers, which are probably more widely available than typewriters.

Returning to the precedent established by the Open Skies Treaty, at a minimum an observation aircraft should be capable of carrying up to three individuals in addition to the normal crew compliment. One representative each from the observing and observed nations to ensure that questions do not later arise concerning whether the imagery has been tampered with, and that the observing nation has not gathered information in violation of their agreement. In the case where the observing nation provides its own observation aircraft, experience preparing to implement the Open Skies Treaty has demonstrated the desirability of including a second individual from the observed nation in order to facilitate coordination with the local air traffic control authorities. At the operational level, observation aircraft need only be capable of safely transiting the area of interest on the way to the next refuelling field.

Regional Aerial Observation Regimes

Clearly, most nations already possess the technical capability to implement some form of an aerial observation regime once the political decision is made to do so. Have any states given indications of doing so? The answer to date is mixed, but encouraging.

Latin America is a case in point. Since the late 1980s, the US, working through the Organization of American States (OAS), has sought to establish the relevance of CSBMs to the inter-American security system. Advances in the establishment of CSBMs in the region have improved both military-to-military and civil-military relations and thereby have served to decrease tensions in the region. Since the OAS regional conference on CSBMs in Santiago, Chile, US policy has aimed at fostering regional arms restraint and control in Latin America through institutionalizing CSBMs, and expanding as well as deepening security dialogue and transparency throughout the hemisphere.

For example, the majority of Latin American states comply with annual United Nations and OAS reporting for the Registers of Conventional Arms and Military Expenditures; Argentina and Chile are producing the region's first Defence White Papers; Argentina and Chile hosted the first OAS-sponsored conference on identifying and codifying regional CSBMs; the OAS adopted the Santiago Declaration on CSBMs as a formal reporting requirement; in April 1997 the Brazilian and Argentine Presidents signed a Military Cooperation Agreement to prevent arms races; in May 1997 the Rio Group of South American countries agreed to establish a working group to study the issue of arms races and to exchange information on the acquisition of sophisticated weapons; and the US sponsored a resolution for advance notification of major arms acquisitions at the June 1997 OAS General Assembly and again at the March 1998 Summit of the Americas.

In support of these efforts, US representatives have sought to educate civilian and military officials from throughout the inter-American region on the concepts underlying the Open Skies Treaty, which have potential application to this region. These efforts have included:

1) Beginning in May 1998, the Treaty on Open Skies was included as a regularly scheduled agenda topic during bilateral Department of Defense staff talks with Ministry of Defence representatives from throughout Latin America. In March of this same year, the United States Open Skies aircraft was displayed at the International Air and Space Show (FIDAE '98), in Santiago, Chile. Beyond its simple participation in this unique Latin American event, the presence of the US Open Skies aircraft was hoped to underscore the importance the United States attaches to this potential regional CSBM measure in anticipation of the Second Summit of the Americas, which was also held in Santiago the following month.

2) In August 1997 the United States and the Russian Federation jointly sponsored an Open Skies programme for representatives of the OAS and their Washington, DC embassies, including an exhibition of the US

and Russian Open Skies aircraft. This followed a similar programme in April of 1997, when the American and Ukrainian Open Skies aircraft were placed on exhibition for representatives of the Inter-American Defence Board and the OAS. Beyond the broad national makeup of the invitees, this later event was notable in two respects. First, among the key presenters of information on the potential relevance of an aerial observation regime to Latin America were the Head of the Ukrainian Armed Forces Verification Center and the Hungarian Ambassador to the OSCE. Of perhaps more historic importance, certainly to the United States, the participation of the Ukrainian observation aircraft marked the first time ever that an aircraft—especially one from a former Warsaw Treaty country—had been allowed unrestricted access to American airspace and to image the areas it chose.

3) These events followed highly successful conversations held during the first US- Chile Defense Consultative Committee session in July of 1996, which included a briefing on the Open Skies Treaty and a tour of the US Open Skies aircraft for the Chief of the National Defence Staff and other delegation members. Also in 1996, Peru and Ecuador sent delegations to the United States for an orientation workshop on the contribution of regional CSBMs to Latin American security and to learn more about the Open Skies Treaty.

Perhaps no greater practical demonstration exists of the high regard in which the US holds the Open Skies Treaty than its willingness to conduct a programme on regional CSBMs, to include the Treaty on Open Skies, at the invitation of appropriate government officials throughout Latin America and the Pacific region. As part of this programme, the United States has made clear that it is prepared to also place its Open Skies aircraft on exhibition for representatives of the government and the public at large.

The purpose of this programme is to allow the United States to share the extensive experience it has gained during the Open Skies Treaty's negotiation, and from the wide range of activities the US has participated in during preparation for its implementation. These activities include discussions concerning the creation of aerial observation regimes in the Middle East, the former Yugoslavia, and in South East Asia. The theme of this American policy is that the concepts underlying the Open Skies Treaty could make a significant contribution to enhancing regional confidence and security building, and that an unarmed aerial observation regime is relevant to any region of the world on either a bilateral or multilateral basis.

Turning to **East Asia**, twice, once in 1996 and again in 1997, US Open Skies Delegations travelled onboard the US Open Skies aircraft to Tokyo, where extensive briefings were conducted for representatives of the Japanese government on the regional security contribution of a measure similar to Open Skies. Also in Eastern Asia, the US Open Skies aircraft was placed on exhibition in the southern Chinese city of Zhuhai in November of 1998. Elsewhere in the region, something akin to Open Skies has been proposed as one possible means of monitoring a disengagement zone or buffer area between North and South Korea. In early 1999, an aerial observation CSBM formed the centerpiece of the US presentation during the annual arms control conference sponsored by the United States Air Force. Over 23 nations from throughout Southeast Asia attended this unique regional programme.

Southern Asia: On a regular and now routine basis, the United States has provided briefings and documentary information concerning the Open Skies Treaty to representatives from both India and Pakistan, particularly as it may relate to potential joint activities in and/or over the highly disputed Kashmir region. These efforts have been supported by the Cooperative Monitoring Center at Sandia National Laboratories, Albuquerque, New Mexico. The Center assists experts from all over the world to acquire the technology-based tools they need to assess cooperative security measures. While India and Pakistan have negotiated some information exchange and confidence-building measures, in particular on nuclear issues, cooperative aerial observations are still missing. It was at the Cooperative Monitoring Center where two retired air marshals from India and Pakistan drafted the outline of an aerial monitoring regime for the border region between India and Pakistan.[12] The proposal foresees the implementation of elements of the Hungarian-Romanian and the multilateral Open Skies Treaty. A resolution limit of 30 centimetres is envisioned, as well as initial training and assistance from a third party, a party to the Open Skies Treaty. In the same vein, the US is planning to charter an aircraft that will be used to conduct a demonstration flight between India and Pakistan in the summer of 2004.

Middle East: Some beneficial, although limited use of aerial inspections has been made in the Middle East by the United Nations peacekeeping operations in Lebanon, along the Iran-Iraq border, and by peacekeepers in the Sinai implementing disengagement and peace between Israel and Egypt. Third party aerial inspections have also been carried out by the United States to ease tensions over sensitive border areas in the region, but the operation of these arrangements have not been widely acknowledged.[13] M. Krepon and P. Constable have suggested a conceptual framework for the expanded use of aerial inspections for four related tasks: (1) enhancing border security; (2) observing areas where levels of military personnel and equipment have been limited by agreement; (3) monitoring exclusion or demilitarized zones; and (4) monitoring facilities of special interest.

Conclusions

In the words of former US Defense Secretary Perry: "Our arms control initiatives are an essential prevention measure that can yield disproportionately significant results, often eliminating the need for a more substantial response later." In other words, arms control is a form of defence by other means. Key among those measures has been the Treaty on Open Skies.

Open Skies is not primarily about multispectral sensors, infrared imagers, photographic resolutions, or large sophisticated aircraft. Open Skies is about developing trust, cooperation, and good will between and among neighbouring nations. Or, failing that, helping to diffuse the tensions and distrust that otherwise could lead to an arms race or armed conflict. At its most elementary level, the Open Skies Treaty does this by establishing the precedents that observation missions will be conducted by representatives of *both* the observing and observed nations, and that no restrictions may be placed on the flight other than those related to the safety of the crew and aircraft.

As a means of facilitating military transparency, Open Skies is unique in the wide range of technologies and methodologies from which nations may draw. The concept is flexible enough to be adapted to regional conditions and concerns. What is needed is the mutual politics to establish a regional agreement at one or several of the hotspots outside of Europe where highly armed forces face each other and tensions are high. Clarity of purpose regarding the type of objects to be imaged and in what detail is absolutely essential. So too is the need to be aware of the operational implications of those decisions.

Postscript

Since the coming into office of the Republican administration in January 2001 concern has been expressed in some quarters that the commitment of the United States to the Open Skies Treaty and its adaptation to meeting other regional concerns has diminished. In fact, the recent American “silence” concerning the Open Skies Treaty is as much testimony to the Treaty's now routine acceptance by the American arms control community as a vital component of the US's efforts to promote ever greater transparency and trust among its Treaty partners. Nor has the United States commitment to its possible adaptation to meeting other regional challenges diminished. For example, the United States continues to work with countries such as India and Pakistan in examining how an aerial observation regime might be tailored to meet their unique security concerns. These efforts are perhaps best illustrated by the recent joint publication written by two former Indian and Pakistani Air Marshals describing how an aerial observation regime might be put in place in that region through a series of incremental steps. Elsewhere, the US continues to work with countries from across Latin America, such as Peru and Argentina, in examining how an aerial observation measure might contribute to reducing concerns unique to South America. In Bosnia and Herzegovina, US Open Skies representatives continue to routinely take part in aerial observation missions designed to preserve the peace in that region through the promotion of measures that enhance cooperation and trust.

Indeed, as this is being written, the Defense Department's National Defense University is sponsoring a programme for visiting scholars and government representatives from across Northeast and Southeast Asia dedicated to a discussion of cooperative measures to reduce cross-border security concerns in those regions. Foremost among those measures is the adaptation of the Open Skies Treaty to meet their distinct challenges, which range from interdicting proliferation networks (roads, airfields and waterways) to resolving jurisdictional issues through joint mapping efforts, to responding to environmental and humanitarian challenges, in addition to the more traditional mission of promoting greater transparency and trust.

In spite of concerns expressed above, the United States remains fully committed to the realization of the benefits offered by the Open Skies Treaty, whatever distinct or unique regional form that agreement might take.

Notes

1 The complete text of the Agreement was issued as a United Nations document, A/46/188-S/22638, Annex, and was published in *Disarmament*, Vol. XIV, No. 4, 1991. It is reproduced in Appendix H.

2 The ground resolution of an aerial camera or a video camera depends on its focal length and the altitude of the aircraft. If there is an upper limit for the ground resolution, it might force the aircraft not to fly lower than a certain minimum altitude.

3 There was extensive media coverage of the event in both countries.

4 This type of double camera has a focal length of 200 millimetres.

5 Observers from the regions were first introduced to Open Skies practice during two joint Hungarian-US demonstration flights in Hungary (28-31 October 1996).

6 The Hungarian-Romanian Open Skies Agreement does not contain any limitation on flight altitude or resolution; therefore, it is possible to fly as low as required by cloud cover and the technical characteristics of the camera. The "ideal" imaging altitude for the Omera-33 camera on board the Hungarian aircraft is 1,500-3,000 meters.

7 A joint Russian-German flight was conducted on 13-17 July 1998, using a Russian AN-30 aircraft. A flight arranged by France on 21-23 September 1999 using a French Hercules C-130 H equipped with a sensor pod. Two flights provided by the Czech Republic using its AN-30 aircraft and co-organized by Denmark on 9-13 October 2000 and 25 May-1 June 2001. The former flight was accompanied by a demonstration of aerial inspections via helicopter, organized by Denmark. Film processing took place in Prague with participation of all parties (13-18 October 2000). See Table 4.3.

8 The US was also concerned about the protection of its troops in Bosnia and Herzegovina and Kosovo under such observation flights.

9 See *Concluding Document of the Negotiations Under Article V of Annex 1-B of the General Framework Agreement for Peace in Bosnia and Herzegovina*, www.osce.org/representatives/arms/article5/article5.pdf and *Statement by Ambassador Henry Jacolin, Special Representative of the OSCE for Article V (Regional Stability)*, at the Joint PC/FSC Meeting, http://www.osce.org/representatives/arms/documents/files/statement_19jul2001.pdf.

10 The Nuclear Non-Proliferation Treaty, the Comprehensive Test Ban Treaty, the Missile Technology Control Regime and the Chemical Weapons Convention.

[11] Ben Maathuis, "Remote Sensing Based Detection of Landmine Suspect Areas and Minefields", dissertation, University of Hamburg, 2001, available from ITC, P.O. Box 6, NL 7500 AA Enschede, The Netherlands.

[12] Air Marshal M. A. Chaudhry PAF (Ret.) and Air Marshal K. C. Cariappa IAF (Ret.), "How Cooperative Aerial Monitoring Can Contribute to Reducing Tensions Between India and Pakistan", Report, SAND98-0505/22, Dec 2001, http://www.cmc.sandia.gov/Links/about/about-mainframe.htm.

[13] M. Krepon and P. D. Constable, *Confidence Building, Peace Making and Aerial Inspections in the Middle East*, Occasional Paper No. 6, Washington, DC: The Henry L. Stimson Center, 1992.

CHAPTER 9

THE IMPROVEMENT OF SATELLITE CAPABILITIES AND ITS IMPLICATIONS FOR THE OPEN SKIES REGIME

Hartwig Spitzer

In this chapter we will address the technological competition to Open Skies brought by the advance of high-resolution commercial imaging satellites and unmanned aerial vehicles (UAVs).

9.1 THE ADVENT OF COMMERCIAL 1-METRE SATELLITES

The digital revolution of information technology is conquering the world in several ways. One of them is the unprecedented availability of commercial satellite imagery at ground pixel resolution values of 1 meter or better.[1,2] Such resolution performance had been achieved by US and Soviet military reconnaissance satellites already in the early 1970s. It took another 20 years and the collapse of the Soviet Union, before such imagery was made accessible on the open market for research, business and "other interests". "Other interests" include the secret services and militaries of countries around the world, which can acquire such imagery.

Commercial distribution of high-resolution images was authorized in 1987 through the Soviet trade association Soyuskarta, which offered imagery with spatial resolution of approximately 5 meters. In 1992 two Russian firms began to sell selected images with resolution values as low as 2 metres.[3] The availability and reliability of delivery was limited. It triggered, however, a development and push towards the commercialization of such imagery elsewhere, in particular in the US. Several industrial consortia were formed, which could draw on know-how and manpower transferred from military space technology.

In 1992 the US Congress passed the Land Remote Sensing Policy Act, which was signed into law in October of that year. The law streamlined the procedure for considering license applications for commercial satellites, and eliminated many of the legal obstacles existing theretofore. In March 1994, in a further attempt to improve US commercial competitiveness vis-à-vis Russia and France, President Bill Clinton issued a Presidential Decision Directive (Nr. 23), which loosened the restrictions on the sale of high-resolution imagery to foreign entities.[4] The US government, however, maintains the option of temporarily blocking the collection and dissemination of commercial satellite imagery. It is expected that such collection and dissemination limitations will be exercised only in rare instances.[5,6]

The US Department of Commerce granted the first licence to operate a high-resolution satellite to World View Inc. (now Digital Globe). A total of 14 commercial satellite systems were licensed between January 1993 and March 1999.[7] Not every system was completed, however. The development was and still is marked by technical delays and failed launches. Eventually, on 24 September 1999, the first fully commercial 1-metre satellite, IKONOS 2, was launched successfully by Space Imaging Corporation, USA. On 18 October 2001 Digital Globe Inc., launched the Quickbird satellite, which delivers panchromatic images even at 61 centimetres resolution. A third US consortium, Orbital Sciences Inc., succeeded in launching their ORBVIEW-3 1-metre satellite in June 2003. All of these satellites have a stereo capability (for terrain recognition) and four spectral channels (for colour displays and vegetation analysis in the near infrared, see section 7.3.3). The Israeli owned company Image Sat International launched a commercial satellite, EROS A, in December 2001, which can provide images at 1.8 metres resolution (1 metre after re-sampling). Finally, India launched an experimental defence 1-metre satellite, TES, which will provide the technology base for a similar commercial satellite (Cartosat-2).

Table 9.1 gives an overview of the commercial 1m satellite systems in space.[8] Several more are to follow in the coming years, both with optical and SAR sensors as shown in Tables 9.2 and 9.3. As a result a substantial market for 1-metre satellite images with an estimated volume of $500 million per year was created.[9] Even at such market volume it will be difficult for all four consortia to recover their substantial investment costs (e.g., $700 million for Space Imaging) and operation expenditures. Main customers are industrial developers and the US National Imagery and Mapping Agency (NIMA, now National Geospatial-Intelligence Agency, NGA). NIMA awarded two five-year contracts of up to $500 million to both Space Imaging Corporation and Digital Globe Inc.[10] A similar contract was promised to Orbital Sciences.[11] In addition, several European and Asian countries have developed or are developing military high-resolution satellites, which might later on also supply images to commercial markets (see Table 9.4). Given the success and quality of the new high-resolution commercial satellite imagery it is thus appropriate to ask to what extent such imagery can substitute for imagery from Open Skies flights.

Table 9.1: Performance Parameters of Commercial 1-Metre Optical Satellites

System/Corporation	Mode	Resolution (nadir) GSD (m)	Spectral Bandwidth (μm)	Swath at nadir (km)	Stereo option	Revisit Cycle (days)	Repeat Cycle (days)	Launch date
IKONOS-2 Space Imaging, USA www.spaceimag- ing.com	Pan MS	1 4	0.45-0.90 0.45-0.52 0.52-0.60 0.63-0.69 0.76-0.90	11.3 11.3	in & cross- track	14 (max)	1-3 (max)	24 Sept. 1999
EROS-A Image Sat International Antilles/Israel www.imagesatintl.com	Pan Pan	(a) 1.8 (b) 1	0.5-0.9 0.5-0.9	13.5 9.5	in & cross- track	7 7	2-3 2-3	5 Dec. 2000
QUICKBIRD-2 Digital Globe, USA www.digitalglobe.com	Pan MS	0.61 2.44	0.45-0.90 0.45-0.52 0.52-0.60 0.63-0.69 0.76-0.90	16.5	in & cross- track		1-3	18 Oct. 2001
ORBVIEW 3 Orbital Sciences, USA www.orbimage.com	Pan MS	1 4	0.45-0.90 0.45-0.52 0.52-0.60 0.63-0.68 0.78-0.90	8 8	in & cross- track			26 June 2003

Pan = panchromatic, MS = multispectral, GSD = ground sampled distance.
Repeat cycle refers to the frequency of imaging opportunities of a particular site if sensor tilt is exploited. Nadir refers to a direction perpendicular to the Earth's surface.

Table 9.2: Future Commercial High-Resolution Optical Satellites

Country	Company, System	Resolution at nadir (m)		Swath at nadir (km)	Launch date	Remark
		panchrom.	multispectral			
USA	Space Imaging IKONOS 3/BLOCK 2	0.5	2		2007?	
USA	Digital Globe World View	0.5	2 (8 channels)		2006	Dual use
Israel	ImageSatInternational EROS B1 EROS B2	 0.82 0.82	 - 3.2 (4 channels)		 Second half 2004 2005?	
India	Indian Space Corporation Cartosat 2	1	2.5	9.6	2005?	
France	SPOT/Pleiades HR	0.7	2.8 (4 channels?)	21	2008 (Nr 1) 2009 (Nr 2)	Open access?
South Korea/ Malaysia	MACSAT, a project of the company SatRec, Korea and a Malaysian government agency	2.5	5 (4 channels)	20	2004	Dual use? Near equatorial orbit

Sources: Y. A. Dequanzada and A. M. Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World*, Washington, DC: Carnegie Endowment for International Peace, 2000; G. Steinberg, *Dual Use Aspects of Commercial High-Resolution Imaging Satellites*, Mideast Security and Policy Studies, Bar-Ilan University, Israel, No. 37, Feb. 1998, www.biu.ac.il/SOC/besa/books/37pub.html; J. C. Baker, K. M. O'Connell and R. A. Williamson (eds), *Commercial Observation Satellites*, Santa Monica and Bethesda: RAND and ASPRS, p. 643; G. Petrie, "Current Developments & Future Trends in High Resolution Imaging & Mapping from Space", ISPRS Workshop—High Resolution Mapping from Space, 6 October 2003, Hannover, Germany.

Table 9.3: High-Resolution Commercial and Dual Use Radar Satellites

Country	System	Wave-length (cm)	Resolution (m)	Swath (km)	Launch date	Remark
Canada	RADARSAT-2 www.rsi.ca	5.6 (C Band)	3-100	20-500	2005	
Germany	Terra SAR-X (DLR/Astrium)	3.3 (X Band)	(a) 1 (b) 2.5-3	(a) 5x10 (b) 15 (stripmode)	Oct. 2005	
Italy/France	Cosmo-Skymed SAR X, 4 satellites	3.3 (X Band)	(a) 1 (b) few m	(a) 10x10 (b) stripmode	2005?	Dual use
Japan	IGS-1B IGS-2B		3 ?		23 March 2003 lost Nov. 2003	Mass 1.2t, dual use?
USA	RADAR-1 (Research Development Laboratories Space Corporation)*		1-5	4	?	Revisit time: 1 day

*RDL is the only US company which has received a license to launch a 1-metre resolution commercial radar satellite. RDL was placed under stringent operating constraints and it was understood that the US government could insist on limiting the resolution to 5 metres. According to the Federal Aviation Administration (endnote 12) the licence was subsequently cancelled. Germany is also building five military radar satellites with resolution below 1 metre (scheduled to be launched between 2005 and 2007).

Source: G. Petrie, "Current Developments & Future Trends in High Resolution Imaging & Mapping from Space", ISPRS Workshop—High Resolution Mapping from Space, 6 October 2003, Hannover, Germany.

Table 9.4: High-Resolution Military Optical Satellites in Europe and Asia[12]
Little is known about Chinese high-resolution satellites. The Helios-2 satellites will have a medium-resolution sensor for full night vision, probably in the mid-infrared (3.5-5 micrometres).

Country	System	Resolution at nadir (Pan) [m]	Resolution at nadir (MS) [m]	Launch date	Remarks
France, Italy, Spain	Helios-1A Helios-1B	1 1	?	July 1995 Dec. 1999	Share of France 79% Mass of satellite 2.5 tons
France, Belgium, Spain	Helios-2A Helios-2B	0.5 0.5	(a) near infrared (b) mid-infrared	2004	Share of France 95% Mass of satellite 4.2 tons
Israel	Ofeq 3	2		1997	Mass of satellite 225 kg, lasted till 2000
Israel	Ofeq 5	1		May 2003	Much heavier than Ofeq 3
Israel	Ofeq 6, 7	below 1?		2004, 2008	
India	Technology Experimenal Satellite (TES)	1		22 Oct. 2002	Sensor from Israel (El Op Industries)
Japan	IGS-1A IGS-2A	1		28 March 2003 lost Nov. 2003	Supposed to be for dual use
South Korea	Kompsat-2	1	4 (4 channels)	Nov. 2004	Dual use (?) Based on foreign technology
Taiwan	ROCSAT-2	2	8	Feb. 2004 (?)	Imager built by Alcatel Space (France)
United Kingdom	TopSat	1	2.5	2004	Enhanced microsatellite Dual use

Source: G. Petrie, "Current Developments & Future Trends in High Resolution Imaging & Mapping from Space", ISPRS Workshop—High Resolution Mapping from Space, 6 October 2003, Hannover, Germany.

9.2 Comparing Apples and Oranges

In comparing high-resolution commercial satellite and Open Skies imagery, first of all, one has to recall that both the Open Skies Treaty and commercial satellite business have been designed with widely different purposes in mind. Commercial companies sell pictures to almost any customer irrespective of the end use of the images, be it research, media, industrial development or data collection by foreign secret services. The imagery may but does not necessarily increase transparency and openness. The element of cooperation between the militaries of states in the data taking process is non-existent. In contrast the Open Skies Treaty intends to enhance transparency in military-security matters through joint overflights, which embody the element of openness and cooperation. These qualities and political achievements can *never* be replaced by the acquisition of satellite images! The fact that a country agrees to be subjected to aerial observation measures like Open Skies is in itself a visible sign of its readiness for cooperation and openness.

On the other hand, if openness and cooperation between states have developed sufficiently it may be fair to ask whether any remaining need for image information could be met in a more cost-effective way by acquiring commercial satellite images. It is only for the sake of this argument that we try to compare the performance of Open Skies and commercial satellite sensors and their images products.

The comparison is carried out according to five performance criteria:

- resolution;
- scheduling flexibility and access time;
- area coverage;
- hindrance by clouds;
- costs.

Resolution

Table 9.5 shows the pixel resolution (ground sampled distance) of Open Skies sensors and commercial satellites. For completeness, we include also the reported resolution of US reconnaissance satellites of type KH11 (optical) and Lacrosse (radar).[13] Although commercial photo-satellites reach resolution values of 0.6-1 metre in nadir mode the actual resolution can be worse by factors 2 to 3 if the camera is tilted (for quick access). Hence, Open Skies images are sharper by factors of at least 2 to 3 than commercial satellite images.[14] Even more important, the 0.5 metres resolution of thermal infrared images under Open Skies is unrivalled by *any* commercial or even military reconnaissance satellite![15] In contrast, the 3-metre resolution of Open Skies SAR sensors will be reached and surpassed by commercial satellites soon. *Hence, the strength of Open Skies is the combination of good optical resolution combined with a unique thermal infrared resolution*.

Table 9.5: Resolution (Ground Sampled Distance) of Imaging Sensors on Open Skies Aircraft, Commercial and Reconnaissance Satellites

Sensor	**Optical**	**Mid-infrared at 3.5-5 μm (?)**	**Thermal infrared**	**SAR**
Open Skies	0.3 m	-	0.5 m	3 m
Commercial satellites	0.6-1.0 m	-	(90 m)	1 m (2005)
US reconnaissance satellites	0.1-0.5 m	0.6-0.9 m	-	0.6-0.9 m

Scheduling flexibility and access time

Commercial satellite operators offer priority data taking within a typical timeframe of 7 to 14 days after order placement. Open Skies flights can be scheduled and carried out within less than seven days (see section 2.3.4). This would allow for reasonably quick responses in times of political tension, assuming that quota were still available. Under normal circumstances, however, Open Skies flights are planned in accordance with the annual quota allocation and the quarterly sequencing. But in principle the imaging access time of both systems is comparable. Yet, Open Skies is vastly superior in allowing an overflight of many separate sites exactly at nadir for optimum resolution.

Area coverage

Open Skies optical cameras cover ground swaths between about 2 and 28 kilometres (see Table 4.1), whereas the swath of optical 1-metre satellite sensors is between 8 and 16 kilometres. Here, the capabilities are roughly comparable.

Hindrance by clouds

Open Skies aircraft can underfly cloud ceilings at altitudes around 1,000 metres when using optical cameras. When using thermal infrared line scanners flight altitudes may even be slightly lower. Most importantly, infrared line scanners can be operated irrespective of available daylight, that is, 24-hours-a-day. In addition, thermal infrared radiation penetrates haze, thus making Open Skies sensors all in all superior to satellites on cloudy or hazy weather.

Costs

An Open Skies flight can image some 30 geographically separate sites of interest within five flight hours at a total cost of about Euro 1,400 per site.[16] Imaging of 30 geographically separate sites by commercial satellites would require ordering 30 scenes of the mandatory minimum size (typically 10x10 kilometres) at a cost of Euro 20-40 per square kilometre and a total cost of € 2,000-4,000 per site (standard geometric correction, no priority tasking). Thus, Open Skies flights provide images of higher resolution at approximately half of the cost. In addition, stereo coverage comes virtually for free from the optical Open Skies cameras whereas stereo imagery from commercial satellites is charged additionally.

In summary, Open Skies imaging is at present comparable or clearly superior to the acquisition of commercial satellite imagery in all of the five discussed technical categories. On the other hand, for objectives like producing precision maps imagery from 1-metre satellites is the best choice.

9.3 Unmanned Aerial Vehicles

UAVs are lightweight remotely controlled or autonomously navigated aircraft, which can operate both in hazardous airspace and at very high altitudes, without endangering a pilot. The performance and reliability of UAVs has increased in the 1990s considerably. As a result, the US military was able to use UAVs successfully for tactical reconnaissance in the recent Kosovo, Afghanistan and Iraq wars. It is said that the US-made Predator can operate at 12 kilometres altitude with an endurance of 20 hours and a payload of 317 kilograms, whereas the Global Hawk flies at 20 kilometres altitude with endurance up to 42 hours (range 25,000 kilometres) and a payload of 481 kilograms.[17] Both systems can carry electro-optical, infrared (probably in the wavelength band of 3.5-5 micrometres) and SAR sensors with ground resolution in the range of 0.3-1 metre, similar to the resolution of US reconnaissance satellites.

We have argued above that such systems are being operated in modes (highly secret) and for purposes (strategic and battlefield reconnaissance) which are completely different from those of Open Skies and thus cannot substitute for Open Skies assets. Recently, however, UAVs have been tested in a civilian experiment for the monitoring of wildfires. Such use of UAVs might eventually compete with the use of Open Skies aircraft for disaster monitoring. We therefore shortly elaborate on the potential and limitations of UAVs in this context.

The above-mentioned experiment was performed by a collaboration of NASA Ames Research Center with California State University and three industrial firms.[18] An ALTUS II UAV built by General Atomics-Aeronautical Systems, Inc., USA, was flown over test fires in a desert test field. By using a 4-channel optical and infrared line scanner it was demonstrated that georectified image and temperature data of wildfires could be obtained and transmitted via a satellite data link and distributed via the Internet in nearly real-time. As a next step an ALTAIR UAV (built also by General Atomics) will be tested. This UAV flies at altitudes up to 16.7 kilometres with endurance of up to 32 hours and a payload of up to 340 kilograms. At present, the operational use of most UAV types is prohibited in regular airspace by rules of the US Federal Aviation Administration (FAA) and by international agreements.[19] The US UAVs industry is working closely with the FAA to develop the regulatory framework to allow UAVs unrestricted access in national airspace. These issues are expected to be resolved in the near future allowing expanded use of UAVs for commercial and disaster support activities.

In conclusion, although UAVs—similarly to satellites—exclude a basic quality of Open Skies, the cooperative data taking by joint teams, they can become a substitute means for Open Skies flights in the area of disaster monitoring in the long run. It remains to be seen to what extent the use of UAVs in peacetime will be agreed upon internationally.

Notes

1 Y. A. Dequanzada and A. M. Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World*, Washington, DC: Carnegie Endowment for International Peace, 2000; G. Steinberg, *Dual Use*

Aspects of Commercial High-Resolution Imaging Satellites, Mideast Security and Policy Studies, Bar-Ilan University, Israel, No. 37, Feb. 1998, www.biu.ac.il/SOC/besa/books/37pub.html.

2 J. C. Baker, K. M. O'Connell and R. A. Williamson (eds), *Commercial Observation Satellites*, Santa Monica and Bethesda: RAND and ASPRS, p. 643.

3 G. J. Tahu, "Russian Remote Sensing Programs and Policies", in ibid., p. 166.

4 Y. A. Dequanzada and A. M. Florini, op. cit., pp. 18-19.

5 B. Preston, "Space Remote Sensing Regulatory Landscape", in J. C. Baker, K. M. O'Connell and R. A. Williamson (eds), op. cit., pp.501-31.

6 As an example, during the Afghanistan war of 2001 the US government—instead of imposing shutter control—bought all the imagery taken by Space Imaging over Afghanistan as a sole priority customer. In contrast, no attempt to restrict the availability of imagery was made during the 2003 Iraq war. John Pike, Global Security, Inc., Washington, DC, private communication.

7 Y. A. Dehquanzada and A. M. Florini, op. cit., p. 20.

8 Additionally, in June 2000 the Russian firm Sovinform Sputnik announced that it was ready to distribute 1-metre resolution images from Russian imagery archives.

9 John Pike, private communication, March 2003.

10 The new 1-metre satellite images form an excellent base for producing high-resolution maps at scales of 1:10,000 or 1:25,000, depending on the effort invested in applying geometric corrections. Prof. Heipke, University of Hannover, Germany, private communication, 2003.

11 These contracts reflect a further shift in the US government's image acquisition policy. The National Reconnaissance Office has been faced with a data supply crisis, since two of their three high-resolution KH11/12 satellites have been in orbit since 1995/96 and need to be replaced eventually. The operationalization of the subsequent generation (Future Imagery Architecture, FIA) is much delayed. US President George W. Bush has ordered in April 2003 federal agencies to rely to the maximum practical extent on images from commercial satellites. The new policy recognizes the improved quality and range of commercial imagery. As a result of these developments, a contract in excess of $500 million was awarded on 30 September 2003 to Digital Globe to build a next generation of high-resolution commercial satellites with NIMA/NGA as an anchor customer with privileged data

access. It is expected that Digital Globe and Space Imaging will operate satellites of 0.5 metres resolution or better. Both Digital Globe and Space Imaging were already been granted authorization to develop a satellite capable of generating 0.5 metres imaging. Digital Globe and Space Imaging have also applied for licenses to operate satellites at 0.25 metres resolution.

12 G. Petrie, "Current Developments & Future Trends in High Resolution Imaging & Mapping from Space", ISPRS Workshop—High Resolution Mapping from Space, 6 October 2003, Hannover, Germany. For links to the websites of remote sensing satellite operators see http://www.weblinks.spakka.net/db/393. See also Federal Aviation Administration and Commercial Space Transportation Advisory Committee, *2002 Commercial Space Transportation Forecasts*, May 2002, http://www.futron.com/pdf/FAA%202002%20NGSO%20 Forecast.pdf. For information on Pleiades see http://www.space.se/node2823.asp.

13 C. Couvault, "Secret NRO Recons Eye Iraqi Threats", *Aviation Week & Space Technology*, Vol. 16, 2002, p. 23.

14 This is illustrated by a comparison of Photo 4.1 (satellite image at 1-metre resolution) and Photo 6.1 (Open Skies image at 30 centimetres resolution).

15 The KH11 satellites carry infrared sensors. These operate probably—as guessed by the author—in the spectral band 3.5-5 micrometers, not 8-13 micrometers, as can be deduced from the quoted resolution values and the diameter of the mirrors on board (about 2.5 metres).

16 This cost estimate is based on a case study in which Germany leases an AN-30 aircraft for a five-hour data taking flight as part of a five-day mission in an European country:
(a) Aircraft and sensors leased at a cost of Euro 4,000 per flight hour (price includes aircraft maintenance, depreciation, kerosene and salaries of eight foreign flight and sensor operators). Total: € 20,000;
(b) Per diem of Euro 120 per day for eight foreign and ten German personnel (four days). Arrival and departure day count as one day. Total: € 8,640;
(c) Salary of ten German personnel for five days. Total: € 7,000;
(d) Cost for a group ticket on a commercial airline for ten German personnel to and from point of entry. Total: about € 4,200;
(e) Cost of film and film development. Total: € 1,800.
Grand total: € 41,640, i.e., € 1,370 per site. Missions which require trans-Atlantic transfer of Open-Skies aircraft will be more expensive.

17 *Military Technology*, Vol. 11, 2002, p. 55. See also A. R. Pustam, "Strategic UAVs", *Military Technology*, Vol. 12, 2003, pp. 60-70, which quotes somewhat different performance values.

18 V. G. Ambrosia et al., "Demonstrating UAV—Acquired Real-Time Thermal Data Over Fires", *Photogrammetric Engineering & Remote Sensing*, April 2003, pp. 391-402.

19 Because of its reliability, the Global Hawk was the first UAV to be granted blanket clearance by the FAA to fly in US airspace. See S. J. Zaloga, "UAVs Increase in Importance", *Aviation Week and Space Technology*, January 2004, p. 105.

CHAPTER 10

OUTLOOK: NOTHING TO HIDE? PERSPECTIVES FOR THE OPEN SKIES TREATY

Pál Dunay

This concluding chapter briefly examines the political prospects for the Open Skies Treaty. To recall, the Open Skies Treaty came into existence as the Cold War was drawing to a close for the purpose of filling the double task of European arms control verification and confidence building. The future of the Open Skies Treaty is thereby contingent on its ability to continue to fruitfully assume these two functions, as well as perhaps new ones, in the face of two significant changes that have emerged since the Treaty was signed: the reorganization of European security relations since the end of the Cold War along largely non-conflictual lines, which has severely diminished the scope for arms control and confidence building in Europe, and the emergence of competing technical monitoring means in the form of commercial high-resolution satellites and UAVs that threaten to make Open Skies techniques obsolete.

Undoubtedly, the end of the Cold War and the reorganization of security relations in Europe have largely diminished the scope for new, and to some extent even existing, arms control measures on the continent. As a result, the importance of the Open Skies Treaty for the *verification of structural arms control* has practically vanished and there is no reason to expect this trend to be reversed.[1] Although this observation appears to hold grim implications for the future of Open Skies, in practice the situation is somewhat different. As it happens, Western and Eastern European states still want to inspect Belarus, Ukraine and especially the Russian Federation, as in the days when there still was a Soviet Union. The current and foreseeable practice of verification is thus in stark contrast to the general perception of a decline in the utility of Open Skies due to the sharp amelioration of European security relations. Moreover, it is also interesting to note that formerly neutral countries such as Finland and Sweden have acceded to the Open Skies Treaty and that many more from the Balkans and all Baltic states have applied for accession. Quite curiously, many of these states, which traditionally paid less attention to conventional arms control, are still extremely keen to obtain as many flight quota allocated as possible, and in fact insist on it on the diplomatic scene.

In terms of its other original purpose, *military confidence building*, despite the vast improvement in European security relations since the end of the Cold War, the Open Skies Treaty continues to retain a certain amount of relevance. First, the Open Skies Treaty is still considered as a useful implement in the management of relations between Western states and Russia, in particular in the light of NATO expansion, by both sides. As well, the fact that the Open Skies Treaty makes territories accessible for overflights both in North America and in North Asia, neither of which was theretofore accessible to such measures, makes it a valuable contributor to enhancing confidence between Russia and the West. Second, the Open Skies Treaty is widely seen and accepted as a key element of a pan-European cooperative security structure, something that is regarded by virtually all states in the region as extremely valuable of itself and which thus lends the Treaty a large amount of political legitimacy. The recent application of eight additional states for accession to the Treaty underscores this point. Finally, although security relations in Europe have improved tremendously over the past decade, new difficulties have emerged in particular areas such as the former Yugoslavia, in the Caucasus and in Central Asia. Here, the introduction of Open Skies procedures could make a useful contribution in stabilizing relations between weary neighbours that have either only recently been involved in open conflict or amongst whom the spectre of war remains ever-present.

In addition to these two original purposes, arms control verification and confidence building, the Open Skies Treaty could very well also take on a number of additional functions in the future. As we have already seen, the Open Skies Treaty is an extremely flexible and versatile tool that lends itself well to the performance of valuable tasks not initially envisaged by its founders but that are currently regarded as worthy. As such, Open Skies measures could be deployed in support of international crisis prevention and crisis management efforts within the framework of the OSCE or the United Nations, it could be used as a model for the development of similar arrangements in other regions of the world that would want to profit from verification and confidence building and it could serve as an instrument for environmental monitoring, particularly in terms of coping with natural catastrophes, a role in which it has already proved itself. The inclusion of some of these additional functions into the Open Skies regime will necessitate an adjustment in the provisions of the Treaty, particularly with respect to the type of sensors allowed and the modalities of their use, as we have discussed in Chapter 7. However, the Open Skies Treaty being by its design a very adaptable instrument, such adjustment could be implemented without undue difficulties either through the OSCC or through the accord of those parties directly concerned. The upcoming review conference of 2005 provides a good opportunity to begin heading in this direction.

Although the Open Skies Treaty still has a valuable role to play in the new conditions of thaw of European security relations, both in terms of arms control verification and confidence building, and increasingly in terms of new tasks related to crisis management and environmental monitoring, the advent of new technical means in the shape of easily accessible high-resolution commercial imaging satellites and UAVs has been held by some to imply the obsolescence of Open Skies. The argument made in support of this claim is that high-resolution commercial imaging satellites and UAVs can perform the same aerial monitoring functions as Open Skies, at a lower cost. As we have shown above (see Chapter 9), however, this in fact is not at all the case. When compared to high-resolution commercial imaging satellites and UAVs, Open Skies retains decisive advantages or is at least comparable in all decisive performance areas of resolution, scheduling flexibility and access time, area coverage, hindrance by clouds and costs, and is unmatched in its ability to foster cooperation and confidence by virtue of the joint cooperative data taking that it implies, something that the use of neither commercial high-resolution satellites nor of UAVs could possibly accomplish. Moreover, an overhaul of the allowable sensor set and operating procedures would further strengthen the advantages of Open Skies over its technological competitors. Again, the review conference scheduled for 2005 presents an excellent opportunity to address these issues.

While the circumstance under which the Open Skies Treaty was devised have radically changed since its signature, coping with change is nothing new for the idea of Open Skies. The notion of Open Skies was born at the height of the Cold War and has adapted itself successfully ever since to suit the prevailing conditions. This characteristic of flexibility is in fact embedded in every provision of the Open Skies Treaty, which remain open to modification without the need for laborious and cumbersome procedures of national ratification. The current trend of good neighbourly security relations in most of Europe has diminished the role of arms control and confidence building in the region, but has not eliminated it altogether. The Open Skies Treaty, with the cooperative aerial monitoring that it implies, continues to occupy an important place in the new cooperative approach to security relations that has sprung up in Europe and its contribution toward these is likely to remain appreciated by the states parties for the foreseeable future. Moreover, the extension of the Treaty to address other issues of rising interest such as conflict prevention, conflict management and environmental monitoring can only strengthen its appeal, especially in the light of its persisting advantages over other competing technical means. Ever since its inception, the idea of Open Skies has been carried by two related concerns: the project of cooperative security relations within Europe and the need to adapt to circumstances in order to bring this project into being and to sustain it. As of now, these two imperatives look set to continue into the indefinite future.

Note

1 For example, the Adapted CFE Treaty no longer mentions aerial inspections among its associated measures.

APPENDIX A

ADDRESSES OF OPEN SKIES UNITS

The table lists the units in charge of implementing the multilateral Open Skies Treaty. The units are in most cases affiliated with the Verification Centre of the Ministry of Defence (status April 2003).

Country	Name of Organisation	Fax	Address
Belarus	National Verification Centre	+375 172 261 538	57 Kuibyshev Str. Minsk 22 00 30
Belgium	Verification Unit	+32 2 7016671	Ministry of Defence General Staff JSO D/WV Queen Elisabeth Barracks Everestraat B-1140 Brussels
Bulgaria	Arms Control Agency (ACA), Open Skies Dept.	+359 2 992 22 71	Totleben Bld. 34 1606 Sofia
Canada	J3 Arms Control Verification Directorate National Defence-Headquarters Attn: J3 ACV 4	+1 613 9922348	MGen George R. Pearkes Building 102 Colonel By Drive Ottawa, ON K1A OK2
Croatia	Croatian Verification Centre	+38513784194	Ilica 242 10000 Zagreb
Czech Republic	Arms Control Agency	+420 2 20202161	160 00 Praha 6-Dejvice Tychonova 1
Denmark	Tactical Air Command	+45 99624955	Koluraa DK-7470 Karup
Estonia	Arms Control Verification Section	+37 26661343	N.A.
Finland	C/Arms Control Branch Defence Staff	+3589181822259	P.O. Box 919 00131 Helsinki
France	Unité Française de Vérification	+33 344 286292	BA-110 F-60314 Creil Cedex

Georgia	Verification Center	+995 32 990404	8 Gergeti Line 380008 Tbilisi
Germany	Zentrum für Verifikations-aufgaben der Bundeswehr Open Skies Division	+49 2451 992210 +49 2451 992230	Selfkant-Kaserne Postfach 1391 52503 Geilenkirchen
Greece	Arms Control Section	+30 10 646 5037	156 Messogion Athens
Great Britain	Joint Arms Control Implementation Group (JACIG)	+44 1462 851515 x6317 +44 1462 813825	RAF Henlow Bedfordshire SG16 6DN
Hungary	Arms Control Agency POC Open Skies HDF JOC	+361 4741274	Balaton u. 7-11 1885 Budapest
Iceland	Defence Dept. Ministry of Foreign Affairs	+35 4115 680	N.A.
Italy	Verification Center (CIVA)	+39 06 46915922	Aeroporto Roma 00040 Ciampino
Kyrgysztan	Kyrgyz Verification Section	+996 312228648	26 Logvirenko St. 720001 Bishkek
Latvia	Latvian Air Force	+3717207258	Int. Airport Riga LV-1053 Riga
Lithuania	Head of Supp. Div. Lithuanian Air Force	+3707223650	Gedmino 25 3000 Kaunas
Luxembourg	Groupe d'Inspections Vérifications et Observations Armée Luxembourgeoise	+352 496306	38-44 rue Goethe B.P. 1873 1018 Luxembourg
Netherlands	Defence Staff, Coordinator Verification Organization Arms Control Agency, Army Staff Arms Control Agency, Air Staff	+31 70 3187558 +31 70 3169258 +31 70 3397286	P.O. Box 20701 2500 ES The Hague P.O. Box 90824 2509 LV The Hague

Norway	Arms Control Branch Coordinator Open Skies	+47 23098319	HQ Defence Command Oslo Mil/Huseby 0016 Oslo
Poland	Verification Unit Department of Military Foreign Affairs	+48 22 6826030	Ulica Krolewska 100-909 Warsaw 60
Portugal	Portuguese Verification Unit Open Skies Section	+351 2 13013471	National Verification Unit Portugal - UNA VE/EMGFA- Av. Ilha da Madeira 1449-004 Lisbon
Romania	Verification Section Regional Cooperation & OS Office	+40 1 3122648	13-15 Izvor Street, 70462 Bucharest
Russia	National Nuclear Risk Reduction Center (NRCC) OS Section	+7 095 2004261	Znamenka Str. 19103160 Moscow, K-160
Slovakia	Slovak Verification Centre OS Department	+421 244250694	Ministerstvo obrany SR, 132/23 Slovenské Verifikacné Centrum Kutuzovova 8 83247 Bratislava
Sweden	Chief, Open Skies Swedish Air Force Command	+4618281579	P.O. Box 660 71528 Uppsala
Spain	Spanish Verification Unit (JUVE)	+34 91 4651942 +3491 5616322	Camino Ingenieros 6 28047 Madrid
Turkey	Genelkurmay GN.P.P.BSK.LIGI SUGI.D.SKUD.S. Disarmament Division	+90 312 4250813 +90 312 4183047	Genelkurmay 06100 Bakanliklar Ankara

Ukraine	Verification Directorate of the GS of Ukrainian Armed Forces	+380 44 2955429 +380 44 2440813 +380 44 2440828 +380 43 2212608	Vozdukhoflotsky Str. 6, Kiev 252049
USA	Open Skies, DTRA European Operation DTRA	+1 703 810 4893 +49 69 693482	Washington, DC 20166 45045 Aviation Drive P.O. Box 5000 Rhein Main Air Base 60549 Frankfurt a. M., Flugplatz

APPENDIX B

OPEN SKIES AIRCRAFT

Photo B.1: One of the two US Open Skies aircraft, a Boeing OC-135B (San Francisco, 1996). Photo: H. Spitzer.

The US Open Skies Aircraft

The United States uses two OC-135B observation aircraft to implement the Open Skies Treaty. The Open Skies aircraft was reconfigured from a WC-135B weather research and atmospheric sampling plane (see Photo B.1). The OC-135B aircraft is assigned to Air Combat Command's 24th Reconnaissance Squadron at Offutt Air Force Base, Nebraska. In modifying the WC-135B, the United States installed the full complement of optical sensors permitted by the Treaty, including four cameras in the aircraft fuselage and a variety of other equipment designed to support the OC-135B's observation mission. One vertical and two oblique KS-87 framing cameras are used for low altitude photography (1,500 metres above ground). Each camera has a field of view of 73 degrees. The axes of the oblique cameras are tilted by 38 degrees from the vertical direction. One KA-91 panoramic camera provides a wide sweep of 93 degrees for high altitude photography between 5,000 and 11,000 metres above ground. Other modifications included installing an auxiliary power unit, work stations for the observation flight representative (inspector) team chief and the flight monitor (escort and interpreter) team chief, crew luggage compartment, sensor operator console, flight-following console, upgraded avionics and compartments to store and maintain film.

The aircraft has seating for 38 people, including the flight crew, aircraft maintenance crew, foreign country representatives and crew members from the Defense Threat Reduction Agency (DTRA). While the US Air Force will provide the flight crew for the OC-135B, DTRA is responsible for providing observation inspectors and escorts, linguists and other operations support personnel for Open Skies overflight and escort missions.

Specifications:[1]

- Power Plant Mfr: Four Pratt & Whitney TF33-P-5 Turbofans with thrust reversers;
- Thrust: 16,050 pounds (7,222 kg) each engine;
- Speed: 460 knots (850 kmph);
- Unrefueled range: 3,900 miles (6,500 km);
- Dimensions: Wing Span 131 feet (39.9 m); Length 135 feet (41.1 m); Height 42 feet (12.8 m);
- Max Takeoff Weight: 300,500 lbs (136,281 kg).

Photo B.2: The former German Open Skies aircraft, a Tupolev 154 M, during its test certification in June 1997 (airfield Köln-Wahn). The aircraft crashed two months later on 13 September 1997, leaving 33 dead. Photo: R. Wiemker.

The former German Open Skies Aircraft

Germany retrofitted a Tupolev 154 M for Open Skies use (see Photo B.2). This aircraft had been originally purchased by the German Democratic Republic (GDR) to serve as the official aircraft of then GDR-president Honecker. The aircraft was fully equipped with vertical and oblique framing cameras and three color RGB video cameras.[2]

In a tragic accident on 13 September 1997 the Tupolev collided with a US "Starlifter" C-141, 100 kilometres west off the Namibian coast. Both aircraft crashed at 5:10 p.m. from 12,000 metres altitude, leaving all 24 crew and passengers on board the Tupolev and the 9 on board the Starlifter dead. The German Tupolev was flying southward from Niamey en route to Cape Town. The flight was not related to Open Skies matters but carried German officers on the invitation of the South African Naval Forces. The US Starlifter was bound northwest flying en route from Windhoek to Ascension. Neither aircraft was equipped with anti-collision warning systems (TCAS), and the Starlifter did not feature a transponder. The German Ministry of Defence decided not to retrofit another Tupolev 154 M for Open Skies use, which left Germany without an Open Skies aircraft.

Photo B.3: The Hungarian Open Skies aircraft, an Antonov 26 at Tököl airfield, October 1996. Photo: R. Wiemker.

The Hungarian Open Skies Aircraft

Hungary uses a two-engine turboprop transport plane AN-26, made in the former Soviet Union (see Photo B.3). The cruising speed is 390 kilometres/hour. One camera window was cut in the fuselage. After using a French-made Omera-33 aerial camera for some years, Hungary recently acquired a modern Leica Wild RC 30 framing camera.

Photo B.4: The UK Open Skies aircraft, an Andover twin turboprop (United Kingdom).

The British Open Skies Aircraft

The United Kingdom's Open Skies aircraft (see Photo B.4), a former Royal Air Force Andover, was operated by the Aircraft and Armament Evaluation Establishment at Boscombe Down. It was decommissioned in April 2003. The aircraft has two turboprop engines. The cruising speed is about 360 kilometres/hour at altitudes of about 2,500 metres. Cruising at much higher altitudes is prevented by lack of a pressurized cabin. The aircraft was equipped with one KA-95 B panoramic camera (made by Recon/Optical Inc., USA), which scans a field of view of up to 164 degrees with a rotating prism. The sensor operation altitude of the camera is above 2,500 metres. However, the camera was equipped with a forward motion compensation mount and a special degrading filter for Treaty-compatible operation at altitudes as low as 850 metres. The extremely wide field of view provides for a ground swath of 12.2 kilometres at such low altitudes. However, the Treaty resolution of 30 centimetres is obtained only in a narrow swath around the vertical axis.

The scanning system is capable of six different scan angles:

40 V	scanning 20°	either side of vertical;
90 V	scanning 45°	either side of vertical;
90 L/R	scanning 85°	from the vertical left or right 5° past nadir;
140 V	scanning 70°	either side of vertical;
165 V	scanning 82.5°	either side of vertical.

The United Kingdom will have to lease foreign aircraft for future active quota flights. It has expressed interest in leasing the Swedish aircraft.

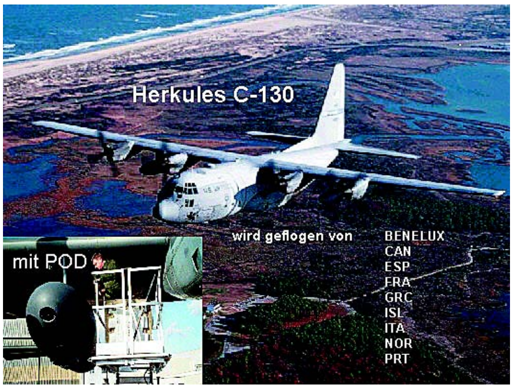


Photo B.5: Image of a Lockheed C-130 Hercules (operated by the Pod Group). Source: German Verification Center, Geilenkirchen. The insert shows the sensor pod mounted under a wing.

The Open Skies aircraft of the Pod Group

The group consisting of Belgium, Canada, France, Greece, Italy, Luxembourg, the Netherlands, Norway, Portugal and Spain uses C-130 Hercules aircraft (see Photo B.5) equipped with a "SAMSON" sensor pod to conduct observation flights. The aircraft—a standard transporter—has four turboprop engines. The cruising speed is 430 kilometres/hour (maximum). The pod is a converted C-130 fuel tank that has been modified to carry the permitted sensors. The costs of purchasing and maintaining this pod are shared, based on each nation's flight quota and actual use. The pod was produced using existing photographic cameras. It is a unique piece. The mounting time is about 6 hours. The cycle time for one mission and maintenance at the Brussels base is about 10-14 days. The camera set includes one KS-116 A panoramic camera, one vertical and two oblique KS-87 B framing cameras and two SEKAI RSC-100 video cameras (forward looking and vertical). The field of view of the photo cameras is:

KS-116 A	along track: 20°; across-track selectable: (1) 70° left to 70° right; (2) 45° left to 45° right; (3) 0° to 90° right; (4) 0° to 90° left;
KS-87 B	along and across track 74° x 74°; angle of deviation of oblique sensor axis from vertical direction: 32°.

Photo B.6: The An-30 aircraft of Ukraine. Photo: A. Rothkirch, University Hamburg.

The Antonov 30 aircraft operated by Bulgaria, the Czech Republic, Romania, the Russian Federation and Ukraine

An-30 is a high-wing aircraft, powered by two AI-24 VT turboprop engines with 2,072 kilowatts output each and one RU-19A-300 additional turbojet unit with 8 kilonewton trust (see Photo B.6). The additional unit supplies the necessary power for starting up the main engines and it is used for taking-off, climbing and, should the main power pack fail, for flying.

The An-30 flies at an operation speed of 430 kilometres/hour at an altitude of 6,000 meters. The fuel consumption is approximately from 850 up to 1000 kilograms/hour at that altitude with an un-refuelled range of 2,600 kilometres. The range for image taking flights at low altitudes (1,000 metres) is about 1,500 kilometres. The An-30 aircraft distinguishes itself by:

- high operational reliability;
- easy maintenance;
- the ability to take-off from and land on non-asphalted runways.

One characteristic feature is the multi-window nose, which houses the navigators cabin. It is situated under the elevated cockpit. The fuselage has five camera hatches, which are closed by built-in blinds when not operating. Russia and the Ukraine have equipped their aircraft with existing cameras and navigation systems. Bulgaria, Romania and the Czech Republic have installed new framing cameras of type Zeiss LMK 1000/9 (Czech Rep.) and Leica Wild RC30 (Bulgaria, Romania), as well as modern navigation systems. Bulgaria operates also a panoramic camera Vinten 900 B with along track field of view of 41degrees and across track field of view of 140 degrees. Details of all cameras which are currently in use on board of Open Skies aircraft are given in Table C.1 (Appendix C).

The Tu 154-M aircraft of Russia

Russia is using a Tupolev 154-M aircraft for Open Skies. This aircraft has an operational range between 2,500 and 5,000 kilometres depending on flight altitude. It is thus much better suited for transatlantic flights than the An-30. Flight tests and data gatherings took place in 2003. Certification took place for spring 2004.

Photo B.7: The CASA CN-235-M transporter. *Source*: German Verification Center, Geilenkirchen.

The Open Skies Aircraft of Turkey

Turkey has retrofitted one CASA CN-235M aircraft for Open Skies use (see Photo B.7). The CN-235M is a light medium-range military transporter with two turboprop engines. It was jointly developed by Spain and Indonesia. The aircraft can take-off from short non-asphalted runways independent of ground service. It cruises at an altitude of 6,800 metres with a speed of 460 kilometres/hour. Physical characteristics of the aircraft include:

- Length of freight bay: 9.65 metres;
- Width of freight bay: 2.36 metres;
- Height of freight bay: 1.84 metres;
- Max weight of load: 6 tons.

Turkey is equipping its aircraft with existing US-made vertical and oblique framing cameras (KS-87), with a panoramic camera (KS-116) and an infrared line scanner (AA/AAD-5). There will be one vertical and two oblique video cameras, as well. The panoramic camera has six options for the field of view: 40 degrees, 60 degrees, 90 degrees, 120 degrees, 140 degrees, 160 degrees. Certification took place in April 2004.

Photo B.8: The SAAB 340 aircraft of Sweden in its former capacity as aircraft of the Royal Family. *Source*: German Verification Center, Geilenkirchen.

The Swedish Open Skies Aircraft

Sweden has dedicated a Saab 340 two-engine turboprop aircraft for Open Skies use (see Photo B.8). The aircraft will be equipped with a ZEISS RMK framing camera and probably also an infrared line scanner AA/AAD-5, both of which have been provided by Germany. Close cooperation between Sweden and Germany in using the aircraft has been agreed upon in a Memorandum of Understanding, which was signed on 14 May 2003. Certification took place in April 2004.

Notes

1 See www.dtra.mil/news/fact/nw_oc135b.html (January 2003).

2 B. Uhl, "High Resolution Digital Colour EO Camera System VOS", *Proceedings of the Third International Airborne Remote Sensing Conference and Exhibition, Copenhagen*, Environmental Research Institute of Michigan, Ann Arbor, Vol. II, 1997, pp. 21-28.

APPENDIX C

SENSOR PROPERTIES

The focus of the trial implementation of the Open Skies Treaty from 1992 to 2001 and of the certification events in 2002 has been on testing and operating **optical cameras.** The cameras themselves take little space as shown in Photo C.1, the control electronics are more bulky, as shown in Photo C.2. Different combinations of cameras, film and filters were used and the resulting Treaty-compatible sensor operation altitude $\boldsymbol{H}_{min}$ was determined. The finer the grain and resolution of film and camera the higher the flight altitude $\boldsymbol{H}_{min}$ at which the Treaty-compatible minimum resolution of 30 centimetres is obtained. Table C.1 shows from left to right the state party, sensor (camera) type, camera field of view (FOV), film type and width, filter type, focal length of camera objective, $\boldsymbol{H}_{min}$ and ground swath covered while operating at $\boldsymbol{H}_{min}$. This list contains all configurations, which passed certification by August 2002.

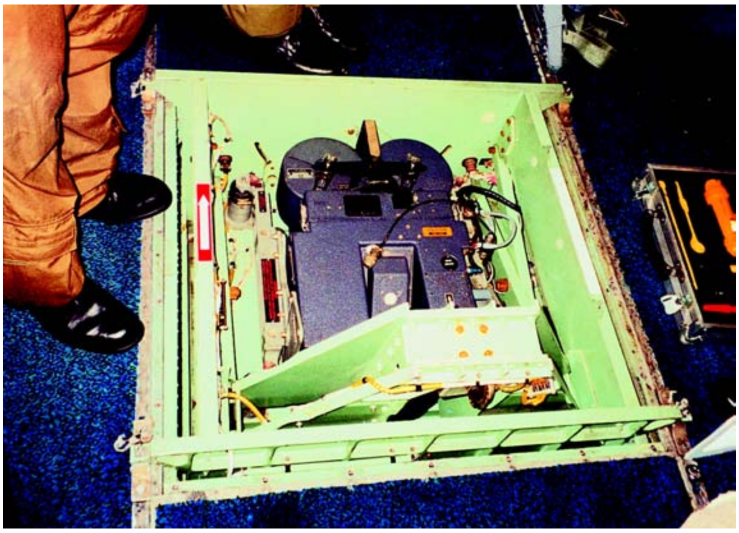


Photo C.1: Panoramic camera mounted on board the United Kingdom Open Skies aircraft. Photo: A. Rothkirch, University Hamburg.

Table C.1: Sensor Specifications of Open Skies Aircraft

	State	Sensor	FOV degree	Film	Width mm	Filter (factor)	Objective mm	H_{min} m	Swath km
1	BUL	Leica Wild RC 30	74	PAN 200	240	Dark Yellow (2)	152.9	3,149	4.7
2		Leica Wild RC 30	74	KODAK 3404	240	Dark Yellow (2)	152.9	2,724	4.1
3		Vinten 900B	140	KODAK 3404	70	Minus BLUE (2)	76.2	1,174	6.5
4	RUS	AFA 41-7.5	99	TYP 42 L	190	Zhs-18 (Y_2.62)	75	1,210	2.8
5		AFA 41-10 (2121)	84	TYP 42 L	190	Zhs-18 (Y_2.7)	100	1,711	3.1
6		AFA 41-10 (2123)	84	TYP 42 L	190	Zhs-18 (Y_2.7)	100	1,711	3.1
7		AFA 41-10 (2221)	84	TYP 38	190	Zhs-18 (Y_2.7)	100	3,103	5.6
8		AFA 41-10 (2233)	84	TYP 38	190	Zhs-18 (Y_2.7)	100	3,103	5.6
9	ROM	Leica Wild RC 30	74	KODAK 2403	240	Yellow (2)	152.9	2,000	3.0
10		Leica Wild RC 30	74	PAN 200	240	Yellow (2)	152.9	2,800	4.2
11	HUN	Leica Wild RC 30	74	KODAK 2403	240	Yellow (2)	152.9	1,972	3.0
12		Leica Wild RC 30	74	KODAK Plus-X 2402	240	Yellow (2)	152.9	2,993	4.5
13	CZ	LMK 1000/9	104	FOMA AIR 200	240	Yellow	89	1,803	4.6
14		LMK 1000/9	104	FOMA AIR 200	240	Orange	89	1,803	4.6
15		LMK 1000/9	104	PAN 200	240	Yellow	89	2,047	5.2
16	USA	KA-91 C	93	KODAK 3412	127	Yellow (2)	427.2	10,814	22.8
17		KA-91 C	93	KODAK 3404	127	Yellow (2)	427.2	6,169	14.0
18		KA-91 C	93	KODAK 3404	127	Red (4)	427.2	6,624	14.0
19		KA-91 C	93	SO-050 KODAK TRI X	127	Yellow (4)	427.2	4,834	10.2
20		KS-87 E (left)	145	SO-050 KODAK TRI X	127	Yellow (4)	152.4	2,099	13.3
21		KS-87 E (left)	145	SO-050 KODAK TRI X	127	Red (8)	152.4	2,224	14.1
22		KS-87 E (left)	145	KODAK 3404	127	Yellow (2)	152.4	3,004	19.1
23		KS-87 E (left)	145	KODAK 3404	127	Red (4)	152.4	2,801	17.8
24		KS-87 E (vert.)	73.7	KODAK 3404	127	Yellow (2)	76.2	1,506	2.3
25		KS-87 E (vert.)	73.7	KODAK 3404	127	Red (4)	76.2	1,440	2.2
26		KS-87 E (vert.)	73.7	KODAK 3412	127	Yellow (2)	76.2	2,172	3.3

27		KS-87 E (vert.)	73.7	KODAK 3412	127	Red (4)	76.2	1,954	3.0
28		KS-87 E (right)	145	SO-050 KODAK TRI X	127	Yellow (4)	152.4	2,099	13.3
29		KS-87 E (right)	145	SO-050 KODAK TRI X	127	Red (8)	152.4	2,224	14.1
30		KS-87 E (right)	145	KODAK 3404	127	Yellow (2)	152.4	3,004	19.1
31		KS-87 E (right)	145	KODAK 3404	127	Red (4)	152.4	2,801	17.8
32	UKR	AFA 41-7.5 (V)	99	TYP 42 L	190	ZhS-18 (Y_1.5)	75	1,073	2.5
33		AFA 41-20 (V)	48.5	TYP 42	190	ZhS-18 (Y_2.0)	200	2,308	2.1
34	POD	KS 116	140	KODAK 3404	127	Yellow (1.8)	305	5,290	29.1
35		KS 116	140	KODAK 3404	127	Yellow (1.8) Red.F.	305	766	4.3
36		KS 116	140	Agfa PAN 200	127	Yellow (1.8)	305	4,987	27.4
37		KS 116	140	Agfa PAN 200	127	Yellow (1.8) Red.F.	305	824	4.5
38		KS 116	140	SO-050 KODAK TRI X	127	Yellow (1.8)	305	3,999	22.0
39		KS-87 B (left)	150	KODAK 3404	127	Yellow (1.8)	76.2	1,622	12.1
40		KS-87 B (vert.)	74	KODAK 3404	127	Yellow (1.8)	76.2	1,684	2.5
41		KS-87 B (right)	150	KODAK 3404	127	Yellow (1.8)	76.2	1,996	14.9
42		KS-87 B (left)	150	Agfa PAN 200	127	Yellow (1.8)	76.2	1,758	13.1
43		KS-87 B (vert.)	74	Agfa PAN 200	127	Yellow (1.8)	76.2	1,965	3.0
44		KS-87 B (right)	150	Agfa PAN 200	127	Yellow (1.8)	76.2	1,903	14.2
45		KS-87 B (left)	150	SO-050 KODAK TRI X	127	Yellow (1.8)	76.2	1,308	9.8
46		KS-87 B (vert.)	74	SO-050 KODAK TRI X	127	Yellow (1.8)	76.2	1,354	2.0
47		KS-87 B (right)	150	SO-050 KODAK TRI X	127	Yellow (1.8)	76.2	1,545	11.5
48	UK	KA-95 B	164	KODAK SO-50	127	Yellow IDF Red.F.	305	750	10.7

Table C.1 shows from left to right the states parties, sensor (camera) type, camera field of view, film type and width, filter type, focal length of camera objective, $\boldsymbol{H}_{min}$ and ground swath covered while operating at $\boldsymbol{H}_{min}$. Red.F. denotes the use of a reduction filter. This list contains all configurations that had passed certification in 2002. The configurations of the Czech Republic and Romania are tentative, and have still to be certified.

As mentioned before, the United Kingdom has used a special degrading filter in order to operate its high-resolution panoramic camera at altitudes as low as 850 metres. Similarly the framing camera on the Swedish aircraft and the panoramic camera of the Pod Group can be operated with different kinds of degrading filters in order to allow for a wide range of flight altitudes between 800 and about 5,000 metres.

Photo C.2: Camera control electronics on board the Ukrainian Open Skies aircraft. Photo: A. Rothkirch, University Hamburg.

Thermal infrared line scanners: The United States tested in 1995-97 a thermal infrared line scanner of type AA/AAD-5, which was formerly used for reconnaissance missions.[1,2,3] Germany has set aside similar sensors of type AA/AAD-5 for Open Skies use. Germany has performed several demonstration flights of that sensor mounted in a Transall C-160 transporter. One of the sensors will probably be installed as a German-Swedish cooperation project on the Swedish Open Skies aircraft. The sensor readout has been reconverted from digital to wet film readout. Some of the relevant parameters are shown in Table C.2.

Turkey is also preparing for the installation of an AA/AAD-5 infrared line scanner on its Open Skies aircraft. Russia is planning to mount an infrared line scanner with an angular resolution of 0.3 milliradians, field of view of 120 degrees and digital readout.

Table C.2: Sensor Parameters of the German AA/AAD-5 Thermal Infrared Line Scanner

Spectral sensitivity	8-13 micrometers
Ground swath	1.15 x h (h = flight altitude)
Angular resolution (instantaneous field of view)	(a) 0.25 mrad (b) 0.50 mrad
Scan angle (Field of view)	(a) ± 30 ° (b) ± 60 °
Ground swath at flight altitude h = 1 km	(a) 1,150 m (b) 3,460 m
$\boldsymbol{H}_{min}$	1,500-2,000 m (to be verified)
Temperature resolution	0.2 °C
Film type	Kodak RA R2494
Film width	5 inch
Film length/cassette	350 ft
Film coverage/cassette at h = 3,500 m	3,500 km

Radar sensors: The US has modified an existing US AN/APD-12 analog radar system for Open Skies use (SAROS). The SAROS system has digital recording of radar, motion and annotation data. SAROS is an X-band SAR operating at 9.6 gigahertz. The ground coverage is a constant 18.5 kilometres swath, located to the side of the aircraft ground track at a range dependent on the mode of operation selected. SAROS performance and image quality specifications, an illustration of the baseline mission geometry, and a table listing SAROS modes of operation is shown below in Figure C.1 and Table C.3.[4,5] SAROS has been further modified since 1996, however system tests have been halted for the time being. Russia, in cooperation with Germany, has developed a SAR-system ROSSAR for Open Skies use. Russia is also considering another existing system. Russia already installed one of the SAR systems on its TU-154 aircraft for testing.

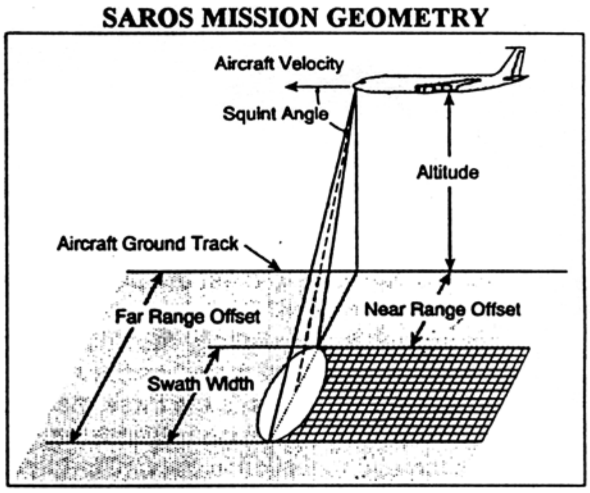


Figure C.1: SAROS specifications and mission geometry

Table C.3: SAROS Operating Modes

SAROS SPECIFICATIONS

Parameter	Value
Radar Center Frequency	9.6 GHz ± 10 MHz
Aircraft Velocity	85 - 278 m/s
Squint Angle	90°
Azimuth Resolution	3.3 ± 0.3 m
Slant Range Resolution	3.3 ± 0.3 m
Image Dynamic Range	≥ 50 dB
Peak Sidelobe Ratio	≤ -25 dB
Integrated Sidelobe Ratio	≤ -10 dB
Ambiguity Level	≤ -20 dB
Geometric Distortion	< 1 IPR or 2%

Notes

1 L. Lesyna, A. Grillo, G. Gilchrist, M. Pagnutti, P. Saatzer, K. Simco and R. Yurman, "Characterization of Infrared Line Scanners for the Treaty on Open Skies", *Proceedings of the Third International Airborne Remote Sensing Conference and Exhibition*, *Copenhagen, Denmark*, Environmental Institute of Michigan, Ann Arbor, Vol. II, 1997, p. 2.

2 V. Kumar, P. Saatzer, W. Goede, Maj. Rhett Ferguson and Ken Fortner, "Film vs. Magnetic Tape Recording IRLS AN/AAD-5 for Open Skies Imaging", *Proceedings of the Second International Airborne Remote Sensing Conference and Exhibition*, *San Francisco, California*, Environmental Institute of Michigan, Ann Arbor, Vol. III, 1996, pp. 200-9.

3 R. S. Bird and C. S. Kaufmann, "Digital Conversion of Infrared Camera for 'Open Skies' Application", *Proceedings of the Third International Airborne Remote Sensing Conference and Exhibition*, *Copenhagen, Denmark*, Environmental Institute of Michigan, Ann Arbor, Vol. II, 1997, pp. 3-11.

4 For further details on the SAROS system see K.R. Fortner and P. L. Hezeltine, "The Open Skies Synthetic Aperture Radar (SAROS)", *Proceedings of the Second International Airborne Remote Sensing Conference and Exhibition*, *San Francisco, California*, Environmental Research Institute of Michigan, Ann Arbor, Vol. III, 1996, pp. 359-65.

5 P. L. Hezeltine, K. R. Fortner and J. B. Floyd, "Portable SAR Data Processor for System Resolution Determination", ibid., pp. 368-76.

APPENDIX D

OPEN SKIES TEST MISSIONS AND QUOTA FLIGHTS (AS OF DECEMBER 2002)

Date	Mission	Observing State	Observed States	Additional Observers	Observation Aircraft
02.04.92	Test flight	Benelux	Poland		C-130
07.04-08.04.92	Test flight	Poland	Benelux		C-130
02.09-07.09.92	Trial observation flight	UK	Russia, Belarus		Andover
Oct./Nov. 92	SAR Test flights	CND, DK, RUS	Hungary		3 aircraft
April 93	Training	USA	Canada		CV-580
16.06-19.06.93	Test flight	Russia	UK	Belarus	AN-30
15.06-17.06.93	Test flight	Hungary	Romania		AN-26
10.07-12.07.93	Test flight	USA	Hungary		CV-580
26.07-30.07.93	Test flight	Germany	Russia		AN-30
23.08-26.08.93	Test flight	Russia	Germany		AN-30
05.12-10.12.93	Test flight	Germany	USA		CV-580
07.02-11.02.94	Test flight	USA	Germany		OC-135
28.02-04.03.94	Test flight WEU-Group	realized by UK	B, D, F, UK, NL		Andover
08.03-10.03.94	Test flight	Russia	France		TU-154 M
14.03-17.03.94	Test flight	UK	Ukraine		Andover
27.03-31.03.94	Test flight WEU-Group	realized by F	D, UK, NL		Andover
10.04-16.04.94	Test flight	Romania	Hungary		AN-30
18.04-22.04.94	Test flight	USA	Greece		OC-135
25.04-29.04.94	Test flight	Ukraine	UK		
23.05-24.05.94	Test flight	UK	Ukraine		
24.08-31.08.94	Test flight	Ukraine	USA		OC-135
05.09-09.09.94	Test flight	Slovakia	Ukraine		
26.09-30.09.94	Test flight	Slovakia	Ukraine		AN-30
10.10-15.10.94	Test flight	Ukraine	Slovakia		AN-30
24.10-28.10.94	Test flight	Ukraine	Germany		AN-30
14.11-18.11.94	Test flight	Germany	Ukraine		AN-30
05.12-09.12.94	Test flight	USA	Canada		
16.01-20.01.95	Exercise Flycatcher	UK	Norway		Andover
28.02-03.03.95	Exercise Sparrow Hawk	USA	UK		OC-135 B

20.03-24.03.95	WEU-Test flight	Romania	D, Benelux		AN-30
24.04-28.04.95	Test flight	Germany	Spain		TU-154 M
08.05-12.05.95	Test flight	Germany	Portugal		TU-154 M
29.05-02.06.95	Test flight	Ukraine	Germany		TU-154 M
06.06-07.06.95	Exercise Sparrow Hawk	UK	Slovakia		Andover
19.06.95	Test flight	France	Czech Rep.		AN-30
26.06-02.07.95	Test flight	Germany	Canada		TU-154 M
26.06-30.06.95	WEU-Test flight	UK	I, UK, E		Andover
17.07-21.07.95	Test flight	USA	Germany		OC-135 B
07.08-11.08.95	Test flight	Germany	Ukraine		TU-154 M
11.09-15.09.95	Test flight	Russia	Germany		AN-30
24.09-28.09.95	Test flight	Germany	Poland		TU-154 M
09.10-17.10.95	Test flight	Germany	Russia		TU-154 M
23.10-27.10.95	Test flight	UK	Ukraine		Andover
23.10-27.10.95	Test flight	Czech Rep.	France		AN-30
23.10-27.10.95	Test flight	Poland	Germany		TU-154 M
27.10-03.11.95	Test flight	Italy	Romania		AN-30
06.11-11.11.95	Test flight	Germany	Romania		AN-30
12.02-16.02.96	Test flight	Germany	Italy		TU-154 M
10.03-21.03.96	Test flight	UK	Georgia		
March 96	Test flight	UK	Czech Rep.		
19.03.96	Exercise Adv. Express				TU-154 M
April 96	Test flight	USA	Canada		
09.04-24.04.96	Reference data gathering	Germany	Spain		TU-154 M
06.05-10.05.96	Test flight	Hungary	Germany		AN-26 T
13.05-17.05.96	Test flight	UK	Slovakia		
20.05-24.05.96	Test flight	Germany	Turkey		TU-154 M
10.06-14.06.96	Test flight	Italy	Czech Rep.		
01.07-05.07.96	Test flight	UK	Hungary		
08.07-12.07.96	Test flight	USA	Czech Rep.		
15.07-19.07.96	Test flight	Bulgaria	Germany		AN-30
12.08-16.08.96	Test flight	Hungary	UK		
26.08-30.08.96	Test flight	Germany	Bulgaria		TU-154 M
02.09-06.09.96	Test flight	Poland	UK		
02.09-06.09.96	Test flight	Germany	Hungary		TU-154 M
23.09-27.09.96	Test flight	Czech Rep.	Germany		AN-30
30.09-04.10.96	Test flight	UK	Romania		
07.10-11.10.96	Test flight	Romania	UK		AN-30
14.10-18.10.96	Test flight	Romania	Germany		AN-30
14.10-18.10.96	Test flight	USA	Ukraine		
21.10-25.10.96	Test flight	Germany	Czech Rep.		TU-154 M
21.10-25.10.96	Test flight	UK	Poland		

28.10-01.11.96	Test flight	USA	Hungary		
11.11-22.11.96	Reference data gathering	Germany	Spain		TU-154 M
03.02-08.02.97	Test flight	Poland	USA		OC-135 B
10.02-15.02.97	Test flight	Germany	Greece		TU-154 M
09.03-14.03.97	Test flight	Slovakia	USA		OC-135 B
10.03-21.03.97	Test flight	UK	Georgia		Andover
17.03-21.03.97	Test flight	Hungary	Romania		AN-26
07.04-11.04.97	Test flight	Germany	Slovakia		TU-154 M
16.04-24.04.97	Test flight	Ukraine	USA		AN-30
21.04-25.04.97	Test flight	Germany	Czech Rep.		TU-154 M
25.04-05.05.97	Test flight	Georgia	UK		Andover
May 97	Test flight	Hungary	USA		OC-135 B
12.05-17.05.97	Test flight	USA	Poland		OC-135 B
02.06-06.06.97	Test flight	Ukraine	Poland		AN-30
16.06-23.06.97	Test certification	multilateral	Germany		TU-154 M
23.06-27.06.97	Test flight	Poland	Ukraine		AN-30
30.06-04.07.97	Test flight	Czech Rep.	Germany		AN-30
30.06-04.07.97	Test flight	Russia	UK		AN-30
14.07-18.07.97	Test flight	Russia	Germany		AN-30
14.07-19.07.97	Test flight	USA	UK		OC-135 B
21.07-25.07.97	Test flight	Hungary	Germany		AN-26 T
22.07-24.07.97	Desaster monitoring (Oder)	Germany	Germany/ Poland		TU-154 M
28.07-01.08.97	Desaster monitoring (Oder)	Germany	Germany/ Poland		TU-154 M
28.07-01.08.97	Test flight	Russia	USA		AN-30
04.08-09.08.97	Test flight	Russia	Canada		AN-30
18.08-23.08.97	Test flight	USA	Russia		OC-135 B
25.08-30.08.97	Test flight	Bulgaria	UK		AN-30
01.09-05.09.97	Test flight	Germany	Hungary		TU-154 M
01.09-05.09.97	Test flight	Turkey	Russia		AN-30
08.09-12.09.97	Test flight	Germany	Russia		TU-154 M
08.09-12.09.97	Test flight	Ukraine	France		AN-30
14.09-20.09.97	Test flight	Italy	Russia		AN-30
22.09-26.09.97	Test flight	Russia	France		AN-30
22.09-26.09.97	Test flight	Turkey	USA		OC-135 B
29.09-03.10.97	Test flight	Norway	Russia		C-130-Pod
06.10-10.10.97	Test flight	Germany	Romania		AN-30
06.10-10.10.97	Test flight	Bulgaria	Germany		AN-30
20.10-24.10.97	Test flight	France	Russia		C-130
03.11-07.11.97	Test flight	Germany	Bulgaria		AN-30
03.11-07.11.97	Test flight	France	Ukraine		AN-30
10.11-14.11.97	Test flight	Russia	Italy		AN-30
Not known	Test flight	France	Romania		AN-30
Not known	Test flight	Ukraine	Romania		AN-30

Not known	Test flight	Russia	Turkey		AN-30
12.01-16.01.98	Test flight	USA	Turkey		OC-135 B
02.02-06.02.98	Test flight	Czech Rep.	USA		OC-135 B
02.03-06.03.98	Test flight	Czech Rep.	UK		AN-30
16.03-20.03.98	Test flight	UK	Czech Rep.		AN-30
06.04-10.04.98	Test flight	Russia	Bulgaria		AN-30
06.04-10.04.98	Test flight	Hungary	France		AN-26
06.04-10.04.98	Test flight	Romania	Germany		AN-30
Not known	Test flight	Ukraine	Italy		AN-30
13.04-17.04.98	Test flight	Bulgaria	Romania		AN-30
20.04-24.04.98	Test flight	USA	Czech Rep.		AN-30
20.04-24.04.98	Test flight	Hungary	Germany		AN-26
20.04-24.04.98	Test flight	UK	Russia		
25.04-30.04.98	Test flight	Italy	Ukraine		AN-30
27.04-08.05.98	Reference data gathering	Germany	Bulgaria		AN-30
04.05-08.05.98	Test flight	Germany	Hungary		AN-26
11.05-15.05.98	Test flight	Turkey	Romania		
11.05-15.05.98	Test flight	Russia	Germany		AN-30
18.05-22.05.98	Test flight	Czech Rep.	Turkey		AN-30
18.05-22.05.98	Test flight	Romania	UK		AN-30
18.05-22.05.98	Test flight	Bulgaria	Russia		RUS AN-30
25.05-28.05.98	Test flight	USA, UK	Georgia		OC-135 B
01.06-05.06.98	Test flight	France	Russia		AN-30
01.06-05.06.98	Test flight	USA	Bulgaria		OC-135 B
08.06-12.06.98	Test flight	UK	Romania		AN-30
08.06-12.06.98	Test flight	Russia	Norway		AN-30
08.06-12.06.98	Test flight	Germany	Czech Rep.		AN-30
15.06-19.06.98	Test flight	Germany	Russia		AN-30
16.06-19.06.98	Test flight	Turkey	Bulgaria		AN-30
22.06-26.06.98	Test flight	Bulgaria	Turkey		AN-30
22.06-26.06.98	Test flight	USA	Ukraine		OC-135 B
23.06-26.06.98	Test flight	Hungary	Romania		AN-26
29.06-03.07.98	Test flight	Turkey	Czech Rep.		AN-30
06.07-10.07.98	Test flight	Romania	Hungary		AN-30
06.07-10.07.98	Test flight	Russia	Germany		AN-30
13.07-19.07.98	Test flight	Slovakia	UK		CZE AN-30
20.07-24.07.98	Test flight	Romania	Turkey		AN-30
26.07-01.08.98	Test flight	Bulgaria	USA		AN-30
27.07-31.07.98	Test flight	Germany	Ukraine		AN-30
03.07-07.08.98	Test flight	Romania	Bulgaria		AN-30
07.08-14.08.98	Test flight	Turkey	Ukraine		AN-30
10.08-14.08.98	Test flight	Germany	Russia		AN-30
10.08-14.08.98	Test flight	Canada	USA		C-130 H
24.08-28.08.98	Test flight	Germany	Romania		AN-30

24.08-28.08.98	Test flight	Czech Rep.	Germany		AN-30
24.08-28.08.98	Test flight	Russia	UK		AN-30
24.08-28.08.98	Test flight	Turkey	Hungary		AN-26
31.08-04.09.98	Test flight	Poland	Germany		UKR AN-30
31.08-04.09.98	Test flight	Russia	France		AN-30
21.09-25.09.98	Test flight	Ukraine	UK		AN-30
21.09-25.09.98	Test flight	Bulgaria	Germany		AN-30
05.10-09.10.98	Test/ Training flight	USA	Germany		OC-135 B
12.10-16.10.98	Test flight	Germany	Poland		OC-135 B
12.10-16.10.98	Test/ Training flight	UK	Slovakia		Andover
26.10-30.10.98	Test flight	Romania	Germany		AN-30
25.01-29.01.99	Test flight	France	Germany		C-130 H
08.02-12.02.99	Test flight	Ukraine	USA		OC-135 B
20.02-26.02.99	Test flight	France	USA		C-130 H
22.02-26.02.99	Test flight	Romania	Hungary		AN-30
01.03-05.03.99	Test flight	USA	Romania	Germany	OC-135 B
22.03-26.03.99	Test flight	Germany	Czech Rep.	France, Turkey	US OC-135 B
30.03-02.04.99	Test flight	Hungary	Romania		AN-26
12.04-16.04.99	Test flight	Italy	Hungary		C-130 H
17.04-23.04.99	Test flight	Czech Rep.	USA		OC-135 B
25.04-30.04.99	Test flight	UK	Georgia		Andover
26.04-30.04.99	Test flight	Russia	Norway		AN-30
03.05-07.05.99	Test flight	Czech Rep.	Germany		AN-30
03.05-07.05.99	Test flight	Italy	USA	Germany	OC-135 B
17.05-21.05.99	Test flight	Poland	Russia	Germany	AN-30
17.05-21.05.99	Test flight	Bulgaria	France		AN-30
07.06-11.06.99	Test flight	Russia	Germany		AN-30
02.06-10.06.99	Test flight/ Data gathering	Bulgaria	UK		AN-30
07.06-11.06.99	Test flight	USA	Czech Rep.		OC-135 B
21.06-25.06.99	Test flight	UK	Turkey	Finland	Andover
21.06-25.06.99	Test flight	Russia	Poland	Belarus	AN-30
21.06-02.07.99	Test flight/ Data gathering	Germany	Bulgaria	Denmark	AN-30
28.06-02.07.99	Test flight	Hungary	Italy		AN-26
05.07-09.07.99	Test flight	Russia	UK		AN-30
06.07-10.07.99	Test flight	Ukraine	Germany		AN-30
12.07-16.07.99	Test flight	Italy	Hungary		AN-26
19.07-30.07.99	Test flight/ Data gathering	Bulgaria	Germany		AN-30
19.07-22.07.99	Test flight	USA	UK		OC-135 B
23.07-27.07.99	Test flight	USA	Italy		OC-135 B

26.07-30.07.99	Test flight	Canada	Russia		C-130 H
26.07-30.07.99	Test flight	Germany	Hungary		AN-26
02.08-06.08.99	Test flight	Ukraine	Canada		C-130 H
02.08-06.08.99	Test flight	Turkey	UK		Andover
08.08-13.08.99	Test flight	Canada	Ukraine		C-130 H
09.08-13.08.99	Test flight	Germany	Russia		AN-30
16.08-20.08.99	Test flight	Poland	UK		AN-30
16.08-20.08.99	Test flight	Russia	Turkey		AN-30
23.08-27.08.99	Test flight	USA	Italy		OC-135 B/ C-130 H
23.08-27.08.99	Test flight	Norway	Russia		AN-30
30.08-03.09.99	Test flight	USA	Bulgaria	Germany	OC-135 B
30.08-03.09.99	Test flight	Turkey	Ukraine		AN-30 B
31.08-03.09.99	Test flight	Hungary	Romania		AN-26
06.09-10.09.99	Test flight	Germany	Ukraine		AN-30
06.09-10.09.99	Test flight	Czech Rep.	Russia		RUS AN-30
13.09-17.09.99	WEU test flight	USA	Germany, France, Spain		OC-135 B
13.09-17.09.99	Test flight	Turkey	Russia		AN-30
20.09-24.09.99	Test flight	UK	Bulgaria		Andover
27.09-01.10.99	Test flight	Hungary	Germany		AN-26
27.09-01.10.99	Test flight	Ukraine	UK		AN-30
04.10-08.10.99	Test flight	Romania	Germany		AN-30
04.10-08.10.99	Test flight	Russia	Czech Rep.		AN-30
11.10-15.10.99	Test flight	UK	Russia		Andover
12.10-15.10.99	Test flight	Hungary	Romania		AN-26
18.10-22.10.99	Test flight	Turkey	Bulgaria		CASA CN-235
25.10-29.10.99	Test flight/ Data gathering	Germany	Romania		AN-30
25.10-29.10.99	Test flight	Hungary	Denmark	Germany	AN-26
01.11-05.11.99	Test flight	Greece	USA		OC-135 B
08.11-12.11.99	Test flight	Czech Rep.	Slovakia		AN-30
08.11-12.11.99	Test flight	UK	Ukraine		Andover
08.11-12.11.99	Test flight	Bulgaria	Italy		AN-30
13.11-18.11.99	Test flight	Slovakia	Czech Rep.		AN-30
15.11-19.11.99	Test flight	USA	Greece		C-130 H
29.11-03.12.99	Test flight	Italy	Bulgaria		C-130 H
06.12-10.12.99	Test flight	Germany	Germany	Slovenia	BR-Atlantic
13.12-17.12.99	Test flight	France	Bulgaria		C-130 H
17.01-21.01.00	Test flight	USA	France	Germany	OC-135 B
07.02-11.02.00	Test flight/ Desaster monitoring	USA	Germany		OC-135 B
28.02-03.03.00	Test flight	Italy	Czech Rep.	Germany	C-130 H
Feb./ March 00	Test flight	Romania	Hungary		AN-26
07.03-10.03.00	Test flight	Hungary	Romania		AN-26

12.03-18.03.00	Data gathering	Benelux	Benelux	Germany	C-130 H
13.03-17.03.00	Test flight	Ukraine	UK		AN-30
20.02-24.03.00	Test flight	Czech Rep.	Germany		AN-30
27.03-31.03.00	Test flight	Germany	Romania		AN-30
27.03-31.03.00	Test flight	Georgia	UK		Andover
27.03-31.03.00	Test flight	France	Poland	NL, Austria	C-130 H
02.04-07.04.00	Test flight	Greece	Russia		AN-30
03.04-07.04.00	Test flight	Italy	Ukraine		AN-30
10.04-14.04.00	Test flight	Germany	Russia/ Belarus		AN-30 B
10.04-14.04.00	Test flight	UK	Ukraine		Andover
25.04-28.04.00	Test flight	France	Czech Rep.		
08.05-12.05.00	Test flight	Romania	UK		AN-30
08.05-12.05.00	Test flight	Benelux	Hungary		C-130 H
15.05-19.05.00	Test flight	Czech Rep.	France	Slovakia	AN-30
15.05-19.05.00	Test flight	Germany	Ukraine		AN-30
15.05-19.05.00	Test flight	Bulgaria	Greece		AN-30
15.05-19.05.00	Test flight	Turkey	Russia		AN-30 B
22.05-25.05.00	Test flight	USA	Romania	Germany	OC-135 B
22.05-26.05.00	Test flight	Russia	WEU	Bulgaria, USA	TU-154 M
22.05-26.05.00	Test flight	Ukraine	Norway		AN-30
26.05-29.05.00	Test flight	USA	Hungary	Germany	OC-135 B
29.05-02.06.00	Test flight	Italy	Romania		C-130 H
05.06-09.06.00	Test flight	Poland	France		AN-30
05.06-09.06.00	Test flight	Germany	Czech Rep.		AN-30
05.06-09.06.00	Test flight	Denmark	Hungary		AN-26
05.06-09.06.00	Test flight	UK	Russia		AN-30 B
13.06-17.06.00	Test flight	Russia	Poland	Bulgaria	AN-30 B
17.06-24.06.00	Test flight	Slovakia	UK	Czech Rep.	Andover CMK 1
25.06-30.06.00	Test flight	Hungary	Benelux		AN-26
21.07-31.07.00	Test flight	Russia	USA	Germany	TU-154 M
25.07-29.07.00	Test flight	Bulgaria	Germany		AN-30
31.07-04.08.00	Certification exercise	Bg, Cz, Hun, Rom, Ukr	Germany	25 states	five aircraft
07.08-11.08.00	Test flight	UK	Romania		Andover
13.08-19.08.00	Test flight	Germany	Russia	USA	TU-154 M
04.09-08.09.00	Test flight	Germany	Hungary	Slovenia	AN-26
04.09-08.09.00	Test flight	USA	Ukraine		OC-135 B
18.09-22.09.00	Test flight	Germany	Ukraine		AN-30 B
18.09-22.09.00	Test flight	Czech Rep.	Russia	Germany	AN-30
25.09-29.09.00	Test flight	Russia	Germany		AN-30 B
25.09-30.09.00	Test flight	USA	Russia	Germany	TU-154 M
01.10-06.10.00	Test flight	Greece	Hungary		AN-26
02.10-06.10.00	Test flight	Ukraine	Germany	USA	AN-30 B
02.10-06.10.00	Test flight	Czech Rep.	Italy		AN-30
09.10-13.10.00	Test flight	UK	Poland		Andover
09.10-13.10.00	Test flight	USA	Benelux	Germany	OC-135 B

16.10-20.10.00	Test flight	Russia	Greece		AN-30
23.10-27.10.00	Test flight	Hungary	Greece		AN-26
30.10-10.11.00	Test flight	Germany	Bulgaria		AN-30
04.11-11.11.00	Test flight	Hungary	USA	Germany	OC-135 B
12.11-17.11.00	Test flight	Spain	France		C-130 H
27.11-01.12.00	Test flight	Benelux	USA	Germany	OC-135 B
22.01-26.01.01	Test flight	Germany	USA	Bulgaria	OC-135 B
04.02-10.02.01	Test flight	Ukraine	USA	Germany	OC-135 B
11.02-15.02.01	Test flight	Spain	Hungary		C-130 H
26.02-02.03.01	Test flight	USA	Poland	Germany	OC-135 B
26.02-02.03.01	Test flight	USA	Ukraine		OC-135 B
05.03-09.03.01	Test flight	Romania	Greece		AN-30
12.03-16.03.01	Test flight	Italy	Poland		C-130 H
19.03-23.03.01	Test flight	Ukraine	Germany		AN-30 B
20.03-23.03.01	Test flight	Hungary	Romania		AN-26
26.03-30.03.01	Test flight	Russia	Germany	USA	AN-30
02.04-06.04.01	Test flight	Russia	Norway	Germany, Latvia	AN-30
02.04-06.04.01	Test flight	Romania	France		AN-30
21.04-27.04.01	Test flight	Poland	USA		OC-135 B
23.04-28.04.01	Test flight	Germany	Russia/Belarus	Poland	AN-30 B
23.04-27.04.01	Test flight	Ukraine	UK		AN-30 B
29.04-04.05.01	Test flight	USA	Canada		OC-135 B
14.05-18.05.01	Test flight	Bulgaria	Spain	Italy	AN-30
12.05-19.05.01	Test flight	Romania	USA		
14.05-18.05.01	Test flight	France	Ukraine		
17.05-30.05.01	Test flight	Russia	WEU (Germany, Benelux, UK)		AN-30
28.05-01.06.01	Test flight	Turkey	Italy		
28.05-01.06.01	Test flight	Hungary	Spain		AN-26
05.06-12.06.01	Test flight	Germany	Hungary		AN-26
07.06-11.06.01	Test flight	Russia	Denmark	Germany, Norway, Sweden	AN-30 B
10.06-16.06.01	Test flight	Greece	Romania	Norway	
11.06-15.06.01	Test flight	USA	Norway		OC-135 B
11.06-22.06.01	Test flight	Germany	Bulgaria	Germany	AN-30
11.06-15.06.01	Test flight	Ukraine	France		AN-30 B
18.06-22.06.01	Test flight	Germany	Russia	Czech Rep.	AN-30
25.06-29.06.01	Test flight	UK	Romania		ANDOVER CMK 1
02.07-06.07.01	Test flight	Germany	Ukraine		AN-30 B
10.07-13.07.01	Test flight	Hungary	Romania		AN-26
16.07-20.07.01	Test flight	Bulgaria	UK		AN-30
22.07-26.07.01	Test flight	Italy	Turkey		C-130 H

30.07-13.08.01	Test certifica-tion	CND, HUN, RUS, UKR, UK	Germany	31 states	five aircraft
13.08-17.08.01	Test flight	USA	Ukraine	Germany	OC-135 B
13.08-17.08.01	Test flight	Russia	Germany	USA	AN-30
20.08-24.08.01	Test flight	UK	Russia		AN-30 B
03.09-07.09.01	Test flight	Germany	Hungary		AN-26
03.09-07.09.01	Test flight	Italy	Russia		AN 30
03.09-07.09.01	Test flight	UK	Bulgaria		Andover CMK 1
10.09-14.09.01	Test flight	Germany	Russia	Belgium	AN-30
17.09-21.09.01	Test flight	Romania	Italy		AN-30
17.09-21.09.01	Test flight	Norway	Russia	Latvia	AN 30 B
17.09-21.09.01	Test flight	UK	Ukraine		Andover CMK 1
24.09-28.09.01	Test flight	Denmark	Russia		AN-30 B
24.09-28.09.01	Test flight	Germany	Ukraine	Kyrgyzstan	AN-30 B
01.10-05.10.01	Test flight	Spain	Bulgaria		C-130 H
02.10-05.10.01	Test flight	Hungary	Romania		AN-26
08.10-12.10.01	Test flight	UK	Georgia		Andover CMK 1
08.10-12.10.01	Test flight	France	Russia	Belgium	AN-30 B
15.10-19.10.01	Test flight	USA	Bulgaria	Germany	AN-30
15.10-19.10.01	Test flight	Germany	Czech Rep.	USA	AN-30
16.10-19.10.01	Test flight	Romania	Hungary		AN-30
22.10-26.10.01	Test flight	Russia	Italy/France	Belarus	AN-30 B
29.10-02.11.01	Test flight	Germany	Romania		AN-30
12.11-16.11.01	Test flight	Benelux	Czech Rep.		C-130 H
12.11-16.11.01	Test flight	Romania	UK		AN-30
27.11-30.11.01	Test flight	USA	Slovakia/ Czech Rep.		AN-30
19.02-22.02.02	Test flight	Hungary	Romania	Germany	AN-26
04.03-08.03.02	Test flight	Germany	Hungary	USA	AN-26
05.03-08.03.02	Test flight	Romania	Hungary		AN-30
11.03-15.03.02	Test flight	Ukraine	Germany	USA, Ukraine	AN-30 B
18.03-22.03.02	Test flight	Russia	Germany	Belarus	AN-30 B
19.03-22.03.02	Test flight	Romania	Hungary		AN-30
29.04-03.05.02	Test flight	UK	Bulgaria		Andover CMK 1
30.04-04.05.02	Test flight	Canada	Portugal		C-130 H
13.05-17.05.02	Test flight	Russia	Sweden		AN-30
27.05-31.05.02	Test flight	Czech Rep.	Benelux		AN-30
27.05-31.05.02	Test flight	Germany	Russia	Ukraine, Sweden, Germany	AN-30
03.06-07.06.02	Test flight	Sweden	Russia	Germany	AN-30

17.06-21.06.02	Data gathering	Romania	Germany	Sweden, Finland, Denmark, Lithania, Spain, Latvia, Estonia	AN-30
02.07-05.07.02	Test flight	Bulgaria	UK		AN-30
15.07-19.07.02	Test flight	Germany	Ukraine	Denmark	AN-30 B
20.07-26.07.02	Test flight	Slovakia	USA		OC-135 B
05.08-09.08.02	Test flight	USA	Romania		OC-135 B
05.08-09.08.02	Quota flight	Russia	UK		AN-30 B
05.08-09.08.02	Quota flight	Ukraine	Hungary		AN-30 B
12.08-16.08.02	Quota flight	Germany	Russia	Norway	AN-30 B
12.08-16.08.02	Quota flight	Russia	Benelux/ Germany		AN-30 B
19.08-23.08.02	Quota flight	Ukraine	Romania		AN-30 B
26.08-30.08.02	Quota flight	Belarus/Russia	Norway		AN-30 B
01.09-06.09.02	Test flight	Finland	Norway		C-130 H
02.09-06.09.02	Quota flight	Turkey	Russia		AN-30 B
02.09-06.09.02	Quota flight	Ukraine	Turkey		AN-30 B
09.09-13.09.02	Quota flight	Russia	UK		AN-30 B
09.09-13.09.02	Quota flight	Poland	Ukraine		AN-30 B
09.09-13.09.02	Test flight	Germany	Bulgaria		AN-30
16.09-20.09.02	Test flight	USA	Italy	Germany	OC-135 B
16.09-20.09.02	Quota flight	Norway	Russia	Germany	AN-30 B
16.09-20.09.02	Quota flight	Hungary	Ukraine		AN-26
16.09-20.09.02	Quota flight	Greece	Bulgaria		C-130 H
23.09-27.09.02	Quota flight	Russia	Germany	Belarus	AN-30 B
23.09-27.09.02	Test flight	Denmark	Bulgaria	Finland, Norway, Sweden	
23.09-27.09.02	Test flight	Italy	USA	Germany	OC-135 B
30.09-04.10.02	Quota flight	France	Russia		AN-30 B
30.09-04.10.02	Quota flight	Ukraine	Poland		AN-30 B
07.10-11.10.02	Quota flight	UK	Russia		Andover CMK 1
07.10-11.10.02	Quota flight	Russia	Italy		AN-30 B
14.10-18.10.02	Test flight	Germany	Ukraine		AN-30 B
14.10-18.10.02	Quota flight	Italy	Russia		
15.10-18.10.02	Quota flight	Hungary	Romania		AN-26
21.10-25.10.02	Quota flight	Russia	France		AN-30 B
21.10-25.10.02	Quota flight	Ukraine	Slovakia		AN-30 B
28.10-01.11.02	Quota flight	UK	Ukraine		Andover CMK 1
28.10-01.11.02	Test flight	Norway	Estonia, Latvia, Lithua-nia		C-130 H
04.11-08.11.02	Quota flight	Russia	Turkey		AN-30 B

11.11-15.11.02	Test flight	Benelux	Bulgaria		C-130 H
11.11-15.11.02	Test flight	USA/Romania	Greece	Germany	OC-135 B AN-30
18.11-22.11.02	Quota flight	Russia	Greece		AN-30 B
25.11-29.11.02	Quota flight	Spain	Slovakia	France	C-130 H
26.11-29.11.02	Test flight	Romania	Hungary		
02.12-06.12.02	Test flight	Romania	Germany	Bulgaria, Finland, Sweden	AN-30
07.12-13.12.02	Quota flight	USA	Russia		OC-135 B
09.12-13.12.02	Quota flight	Russia	Turkey		AN-30 B

APPENDIX E

VERIFYING THE GROUND RESOLUTION LIMIT (PHOTO & VIDEO)

E.1 WHAT IS "RESOLUTION"?

"Resolution" is one of the central terms of the Treaty. Its definition, measurement, and observance are responsible for the vast amount of technical provisions of the Treaty, and constitute a notable obstacle in its implementation.[1] Therefore, we want to probe a little further into the question what "resolution" means, and clarify under which conditions the resolution of an image can be enhanced (i.e., sharpened).

Considering digital data, we have to distinguish between the ground sampled distance (GSD), which is also called pixel size or pixel footprint, on the one hand, and the resolution (ground resolved distance, GRD) on the other hand. The pixels are considered as samples taken from the true continuous image at regular intervals, the ground sampled distance.

Let us consider a group of black bars of equal width on a white background, in other words, black bars which are separated by white bars of the same width (Figure E.1). We want to be able to resolve single bars within this pattern. How fine a pixel size (GSD) is necessary? Obviously, the absolute resolution limit is reached when the separation (*SEP*) is $SEP = 1/2\ GSD$ (Figure E.1), i.e., when each pixel covers equal areas of black and white.

The modulation transfer function (MTF) describes how the contrast of a sinusoidal wave pattern is diminished by the sensor with increasing spatial frequency, i.e., with decreasing separation. Here, the spatial frequency is the inverse of the separation.[2] The MTF of an ideal pixel-sampling sensor is known to be the "sinc-function" ($\sin\omega t/\omega t$). In Figure E.4 we see that the MTF (dashed line) vanishes for a frequency of 1/pixel, i.e., one wavelength of 1 pixel contains a white and a black bar, and thus the bar width and the Open Skies definition of separation is $SEP = 1/2$ pixel. With $SEP = 0.5\ GSD$ being the theoretical resolution limit, the practical resolution limit is commonly[3] taken to be at $SEP = 0.7\ GSD$ (see Figure E.1b). There, the MTF has already dropped to 37 per cent of the original contrast (Figure E.4, top).

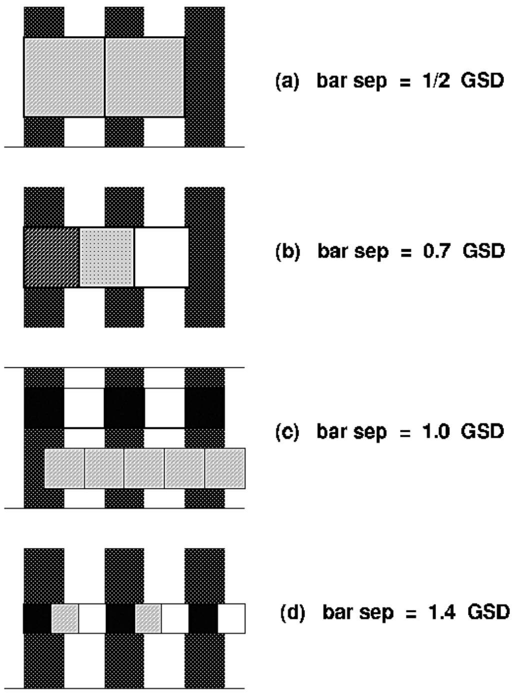


Figure E.1: Resolution of bar groups for various ground sampled distances (pixel sizes). *Source*: K. Kraus and W. Schneider, *Fernerkundung*, Vol. 1—Physikalische Grundlagen, Bonn: Dümmler, 1994.

The fundamental Sampling Theorem[4] tells us that if we consider one black bar together with one white bar as one wavelength, we need at least two samples for reproduction, i.e., a pixel size which is equal to the bar width: $SEP = 1.0\ GSD$. In Figure E.1c it can be seen, however, that such a sampling can fully retain the contrast (CTF = 1), but also fully destroy the contrast (CTF = 0), depending on the phase displacement between bar pattern and sampling pattern. Thus, with $SEP = 1.0\ GSD$, the detection of the bar pattern still depends on accident.

In order to guarantee a reliable reproduction of the bar pattern, we need a pixel size as fine as $GSD = 0.7\ SEP$ (Figure E.1d). In other words, we can only reliably detect bar patterns with a separation of $SEP = 1.4\ GSD$. In this case, a resolution of 30 centimetres requires a pixel size of $GSD = 0.21$ centimetres. Then we have an MTF-value of 80 per cent as the optimal case.

We have seen that "resolution" is not a sharply fixed quantity; rather, contrast gradually vanishes with decreasing separation.

In accordance with the Treaty, when we talk about bar separation *SEP* in the following, we always mean the width of the white gap between two black bars (of the same width as the gap); not the distance between the centres of the two black bars (common "ground resolved distance").

For the example of GSD = 30-centimetre-pixels we can summarize our considerations into the following rules of thumb:

With 30 cm GSD (pixel size)	• reliable detection of 42 cm separated bar patterns *SEP* = 1.4 GSD, ideal MTF = 81% • probable detection of 30 cm separated bar patterns *SEP* = 1.0 GSD, ideal MTF = 64% • possible detection of 21 cm separated bar patterns *SEP* = 0.7 GSD, ideal MTF = 37% • absolute resolution limit of 15 cm separated bar patterns *SEP* = 0.5 GSD, ideal MTF = 0%

These are theoretical best values assuming the absence of noise, optical distortions and atmospheric effects. The values cannot be bettered by any method of image "sharpening".

Note that so far we have discussed the detectability of single bars in continuous bar patterns. We have to keep in mind, though, that it may always be possible to detect objects which are much smaller than the pixel size (GSD) if only they exhibit a strong contrast to their background and if the background is uniform. For an example see Photo E.1.

It should be mentioned that the geometric resolution is in principle uniform across the image area for photographic film and images from CCD arrays or CCD lines (staring array or line camera). In contrast, the geometric resolution of line scanners (such as for infrared) degrades with increasing scan angle ($\sim 1/\cos^2\theta$).

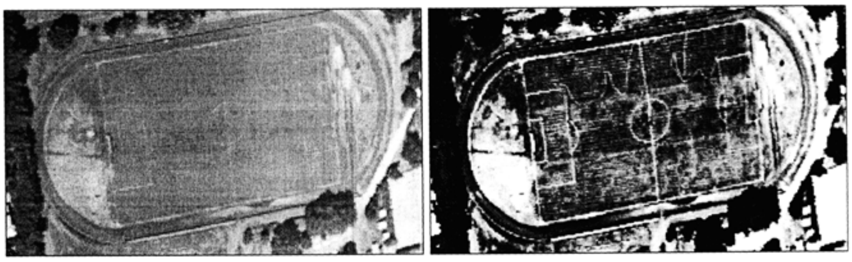


Photo E.1: Example for subpixel resolution: Left: Sportsfield as imaged by an airborne line scanner with GSD (pixel size) ≥ 70 cm. The white marking lines are still partially visible on the lawn of the sports field, although the pixel size is ≥ 70 cm and the marking lines are of only ≈ 10 cm width. Right: Image of the same scene taken by a camera of about 10 cm resolution.

Blur/The Point Spread Function

The MTF of a real sensor system will always perform significantly worse than the theoretical optimum of the "sinc-function".[5] The less than optimal modulation transfer is due to degradation by the detector, the optical system, the atmospheric effects, etc. The MTF of the camera itself can of course be determined by laboratory calibration measurements. However, the in-flight recorded images will also be blurred by stray radiation from neighboring pixels. The severeness of this adjacency effect depends on the atmospheric conditions such as aerosol content, haze and visibility. The image blur is described by means of the point spread function (PSF). A common mathematical model for the PSF is given by equation (E.1)

$$\mathrm{PSF}_{\sigma,\alpha}(x) \sim e^{-\frac{1}{\alpha}\left\|\frac{x}{\sigma}\right\|^{\alpha}}$$

where the halfwidth σ is a measure of the spread, and the exponent α describes the steepness of the PSF. The ideal PSF is a box function with $\sigma = 1/2$ pixel and $\alpha \to \infty$, so that the pixel intensity is just the mean intensity of the pixel's ground footprint. In Figure E.4, we see three different

PSFs (left-hand) and their respective MTFs (right-hand, which are the absolute magnitude of the Fourier-transform of the PSF). Considering the bars of the Open Skies calibration target, we see that the contrast at given bar separations depends very sensitively on the form of the PSF. For a halfwidth of $\sigma = 2$ pixel (Figure. E.4, bottom) we see that the contrast vanishes completely even for separations as large as $SEP = 1.4\ GSD$. In other words, with a strong blur (i.e., a wide PSF) the resolution is degraded and can be worse than what would be expected based on the GSD. Therefore, it seems advisable to determine the GSD as well as the actual PSF effective in the recording of a specific image. In the next section we will reconstruct the actual PSF/MTF of an Open Skies test image by means of the calibration target.

Computer Aided Automatic Resolution Measurement

The calibration target shown in Figure 4.2 (section 4.4) was recorded from 900 metres altitude. Eye appraisal shows clearly that the 10^{th} bar pair (the last bar group left of the second wedge) is the smallest resolved one. Thus, the resolution would—according to the Treaty—be estimated as 17.7 centimetres.

How could the resolution be determined in an automated fashion by a computer algorithm? Research in the field of Computer Vision provides the powerful tool for fitting a parametric model to an observed image. In our case, we begin by building an exact representation of the calibration target used in the calibration test. Then we simulate the image formation process by merging the model of the calibration target with the analytic model of the point spread function (equation E.1), and then sampling at the stepwidth of the GSD. Since we do not know the true parameters of the GSD, the PSF-halfwidth σ and its steepness α, we start with first-guess values. Next we repeat the process with varying parameter guesses, and each such simulated image of the calibration target is compared with the truly observed image. A numerical minimization scheme can thus determine the optimum parameter set, which can best resolve the observed image.[6]

This algorithm has been applied to the image in Figure 4.2, which was recorded with a digital video camera from 900 metres altitude. The best fitting parameters provide a simulation, which fits the observed intensity values almost perfectly (Figure E.3). The computer aided analysis tells us three things:

1. The GSD (pixel size) for this image (which was recorded for camera calibration purposes during a test certification procedure) is 17.3 centimetres. The GSD can be determined to a precision[7] of 1 millimetre. The GSD is the most important parameter since it determines the ultimately possible resolution. According to the above definition of probable detection, we take the resolution to be equivalent to a bar width of 1pixel = 1 *GSD* = 17.3 ± 0.1 centimetres.

2. The PSF halfwidth is $\sigma = 0.48 \pm 0.1$ pixel, with a steepness $\alpha = 2.2 \pm 1$, i.e., close to a Gaussian distribution. The determined PSF is plotted in Figure E.4b. It is very close to the ideal PSF-halfwidth of $\sigma = 1/2$. We see that the MTF of this point spread function retains the contrast quite well: we still obtain an MTF-value of 33 per cent for a bar width of one pixel.

3. The deviation between the simulation and observation is only 3 per cent, i.e., we have a very good signal-to-noise-ratio of $SNR \approx 30$.

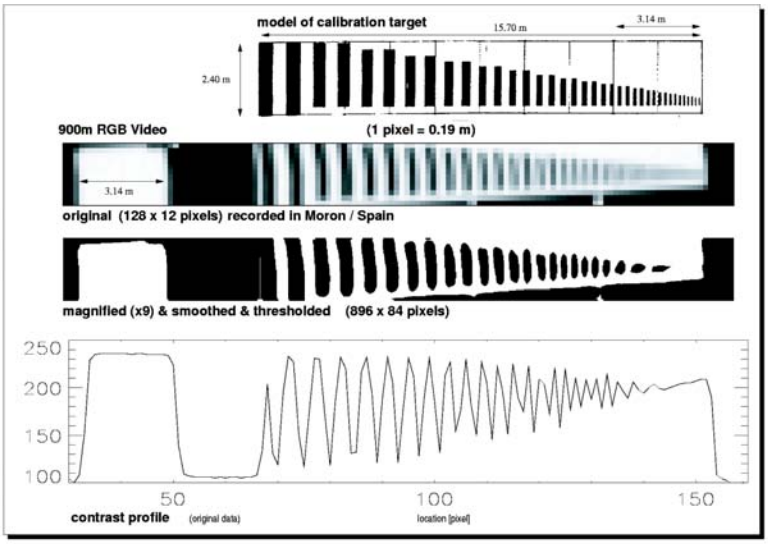


Figure E.2: The calibration target in various processing stages. From top to bottom: the model, the target as recorded from 900 m altitude, same data after magnification, and intensity profile.

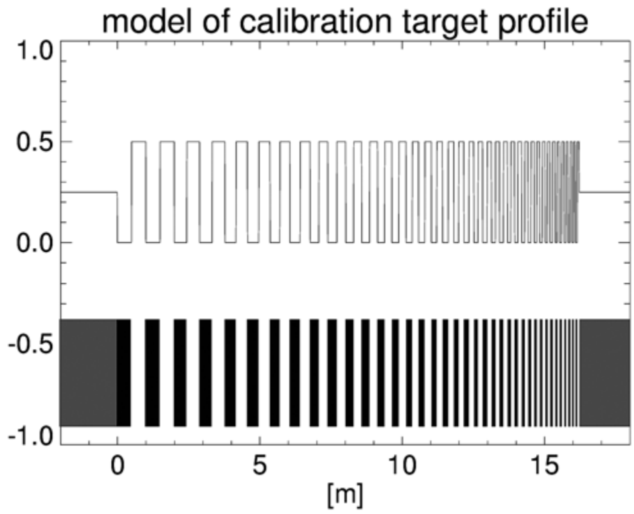
It may seem surprising that the PSF of this illustrating image (900 metres altitude) can be determined to a precision of 1 millimetre. This is made possible by fact the that the observed target intensity profile image is made up of approximately 80 pixels; hence a misestimation of the GSD value by 1 millimetre yields a final displacement of 8 centimetres, which is almost half a pixel size and appears clearly in the comparison of the simulated and the observed intensity profile.

Conclusion of Section E.1

From the previously discussed example, it is apparent that an operational software code could be employed which would automatically determine the image resolution from the calibration target with a very high precision. Fitting the model of the calibration target, with known ground dimensions, to its digital image yields the pixel size (ground sampled distance, GSD). The GSD is the central parameter that determines the lower boundary for the ultimately possible resolution.

Furthermore, an appropriate algorithm can automatically estimate the point spread function (PSF, and thus the MTF) from the comparison of the digital image of the calibration target with its model. If the width of the PSF turns out to be much larger than 1 pixel (σ » 0.5 pixel) then the apparent resolution of the image will be worse than expected from the GSD value, meaning that the image is blurred. In that case, the noise level is of interest, since for low noise it is sometimes possible to restore the image to a better resolution (see section E.2).

Even though a computer code for automatic resolution determination could be easily provided to the image analysts, it remains to be discussed if automatic resolution measurement would serve the *spirit* of the Treaty. Naturally, computer aided automation of resolution determination would ease the technical procedures required by the Treaty and yield more objective and more reproducible results. On the other hand, it might be just the simplicity of the eye appraisal by the analysts of the observing and observed state parties, which lends the procedure its credibility. *Thus, the automated determination of GSD and PSF should probably be recommended as a complementary procedure, without replacing the eye appraisal.*



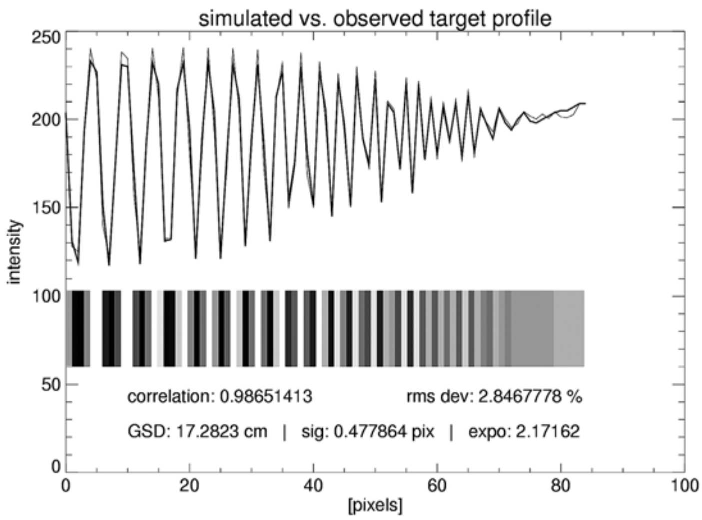


Figure E.3: Model of the calibration target profile (top), and simulated versus observed calibration target (bottom). The best-fitting PSF function is found by numerical optimization. The simulated profile (thin line) fits the observed intensity profile (thick line) almost perfectly (deviation 3%). The observed profile is extracted from Figure E.2.

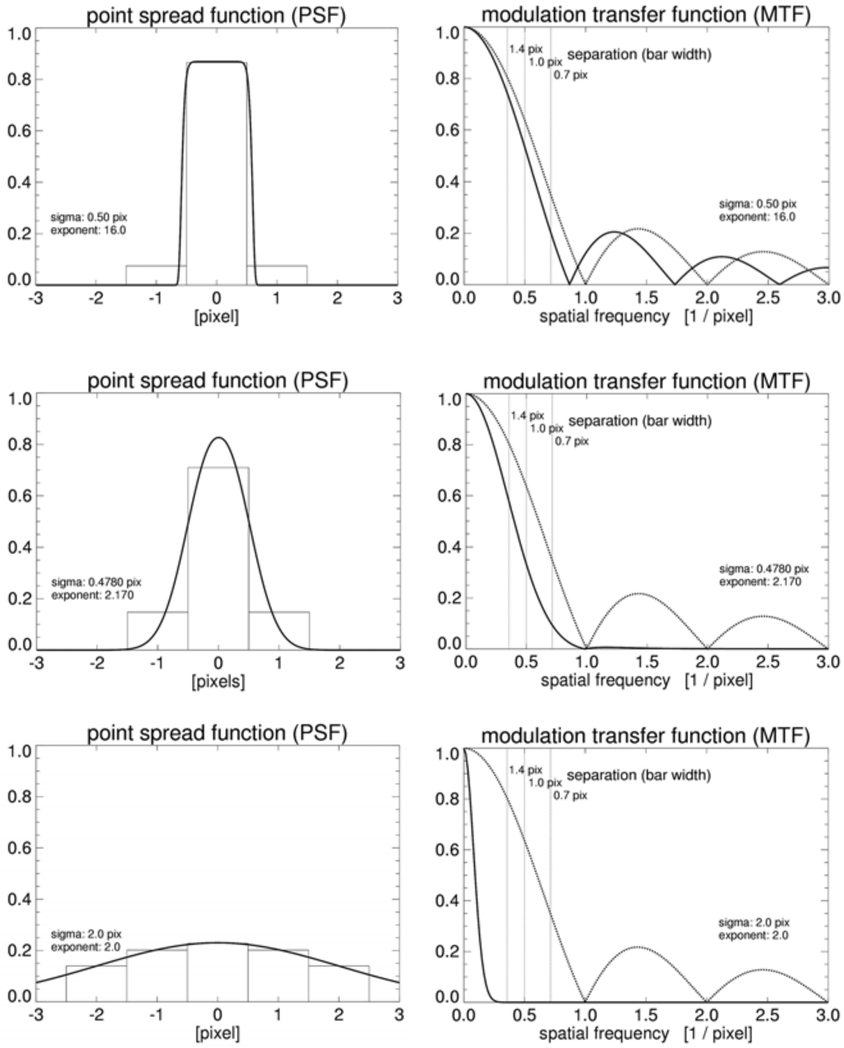


Figure E.4: Left row: The point spread functions (PSFs) modelled according to Equation E.1 for (**a**) *top* a near ideal box function, (**b**) *centre* one from 900 m imagery, and (**c**) *bottom* a blurred case. Right row: The corresponding modulation transfer functions (MTFs). The dotted line indicates the limiting case of the optimal MTFs, the "sinc-function". The contrast values for 0.7, 1.0 and 1.4-pixel separation (i.e., bar width) can be determined at the positions of the light dotted vertical lines.

E.2 CAN THE IMAGES BE "SHARPENED"?

Since so many of the technical provisions of the Treaty are motivated by the aim to limit the ground resolution of the images, the obvious question arises of whether the images can be "sharpened" afterwards in order to circumvent the Treaty limitations. This question—whether the resolution can be pushed beyond the limitation of the original data by means of digital image post-processing—will be discussed in this section.

Computer Aided Magnification and Enhancement

The images can of course be magnified in order to try to facilitate the eye appraisal. Often, however, the analysts work directly on photographic negatives, because the magnification does not necessarily improve the analysis. Magnification of photographic film will soon expose the grain structure of the emulsion, and magnification of digital data (video or digitalized negatives) will only show the pixel grid structure (see Photo E.2, top). However, using digital image processing, it is possible to resample the image to a larger number of pixels and to interpolate between the known grey values of the truly sampled pixels.[8] On the one hand, this certainly seems to enhance the image quality and to ease interpretation (as demonstrated in Photo E.2, bottom). On the other hand, it is evident that there is no new feature to be seen in the enhanced magnification, which was not already present in the coarser original. In other words, the interpolation between grey values is pure speculation and does not add any new information to the image content. It cannot disclose so far undetected features but it can aid the human eye.

Computer Aided Image "Sharpening"(Inverse/Wiener Filtering)

In textbooks on image processing we find astonishing examples of image restoration. A typical case is the removal of blur by inverse filtering in the (Fourier-transformed) frequency domain (Photo E.3, top row).

Why can this not be done with Open Skies imagery on a regular basis? Let us consider the example of Photo E.3. The original image (top left) is digitally blurred, using a PSF with $\sigma = 2$ and a steepness exponent of $\alpha = 2$ (Gaussian). The PSF can be inspected in Figure E.4, bottom row. The blurring convolution was performed by multiplication in the Fourier-transformed space (Convolution Theorem). With the perfect knowledge of the blurring PSF and in the absence of noise, the blurred image (top centre) can be restored to full resolution by inverse filtering in the Fourier space.

However, if the blur process is combined with even very low noise (the superimposed noise of 1 per cent is almost invisible to the eye), the simple inverse filtering fails completely, in that it mainly amplifies the noise (Photo E.3, second from top). Thus, in practice, Wiener filtering (or iterative restoration) or other more sophisticated methods of image restoration have to be employed. These techniques can restore some of the resolution, but the results remain clearly far from the original quality—depending on the noise level. Still, note that the four engines of the airliner are not distinguishable in the blurred image but are clearly visible after Wiener filtering. The crucial feature of this example is that the blur function was considerably wider than one pixel.

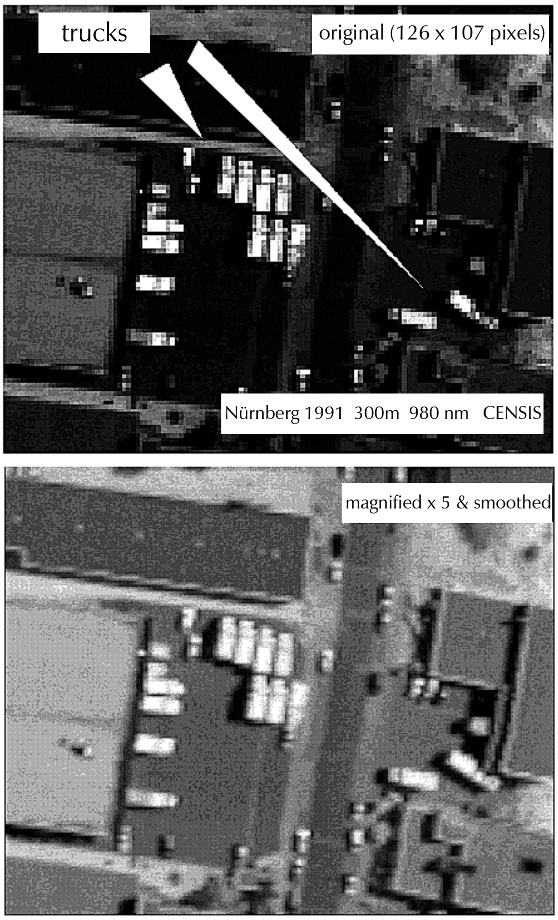


Photo E.2: Example of imagery from a multispectral line scanner: Trucks in approximately 1-metre resolution (at wavelength λ=980 nm). Source: R.Wiemker, University Hamburg.
Top: Original.
Bottom: The same image after resampling and interpolation between the known grey values of the truly sampled pixels.

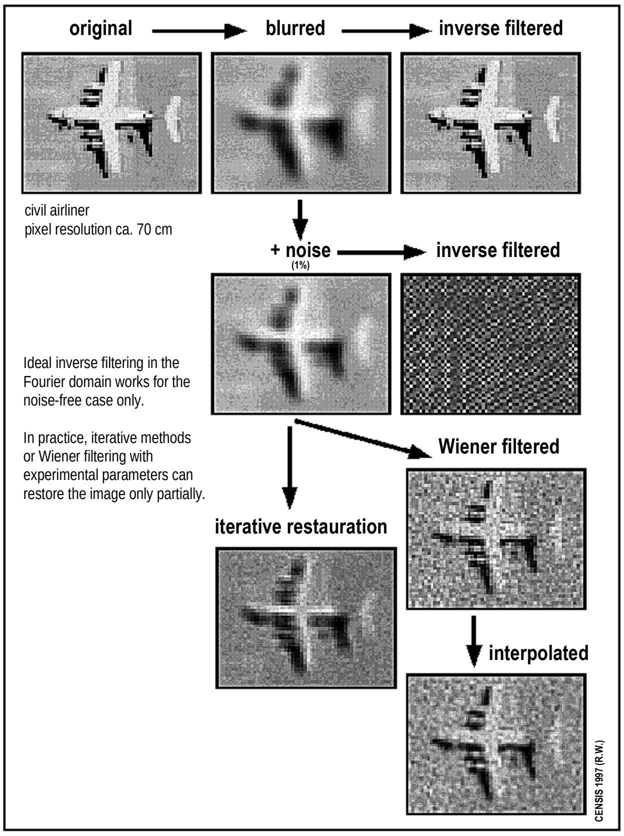


Photo E.3: An example of inverse filtering and Wiener filtering of simulated blur (Gaussian, $\sigma = 2$ pixel): In absence of noise (top); and with noise (below). Note that in this simulation the blur-PSF is perfectly known. (The original image of an airliner was recorded by an airborne multispectral scanner from 300 m altitude with a pixel size of ≈ 70 cm, Nuremberg airport 1995.) Source: R. Wiemker, University Hamburg.

In other words, the information of each pixel was smeared into the neighbouring pixels, and can be "re-concentrated" by digital image processing methods. The corresponding modular transfer function[9] in Figure E.4, bottom right, shows that the contrast vanishes for all three bar separations (0.7, 1.0, 1.4-pixel), which could be resolved as far as the GSD is concerned. Digital de-blurring can at best restore the contrast to the limiting optimal case (dashed line, the "sinc-function"). Thus the resolution of bar pairs at 0.7, 1.0, 1.4-pixel separation could be restored.

Now we come back to the PSF, which was determined by computer aid for the imagery of Figure 4.2. The PSF is shown in Figure E.4, centre left. The PSF is not wider than 1 pixel, and thus it is clear that even digital image processing means will not be able to restore the imagery to a better resolution. When looking at the corresponding MTF, centre right, it is apparent that the contrast of frequencies corresponding to 0.7, 1.0, 1.4-pixel bar separation is not zero. Image processing could only enhance the contrast (with the dotted line as the optimal limit), but no new details would become visible.

By eye appraisal it is not easy to decide whether an image can be sharpened or not. The safe criterion is given by the PSF and the noise level. In practice, both are not well known, and thus attempts of image restoration are often fruitless and rather speculative. With the ground calibration target,[10] however, we can determine the PSF to subpixel precision, assess the noise level, and make a well-founded statement about the possibility or impossibility of digital image sharpening.

Degradation filters

If the flight altitude is for some reason (weather conditions, requirements of other sensors, etc.) so low that the actually achieved ground resolution would be better than allowed by the Treaty, then an option is the use of degradation filters.

From the above-discussed image enhancement possibilities it becomes clear that it is not sufficient to simply blur (optically or digitally) the image with a blur characteristic (point spread function) that is uniform over the entire image. From the literature it is well known that such a uniform blur can be removed if the point spread function is known (provided a high signal-to-noise ratio).

Hence, it has to be made certain that:

(a) for digital degradation the image is not only blurred but resampled to a smaller number of pixels (undersampling), or

(b) for optical degradation filters that their influence cannot be removed, e.g., in the Fourier-transformed frequency domain. This can be achieved if the optical filter transparencies have local PSFs which vary over the image area, or enough noise is induced by the filtering.

By reconstructing the actual PSF from images of the ground calibration target, it can be determined in the same fashion as described in Section E.1 that degradation filters are indeed effective. For example, the German-manufactured optical degradation filters, which were used on the German Open Skies framing camera, were requested by the Russian side for extensive laboratory testing. The irreversibility of the degradation was confirmed.

Conclusion of section E.2

"Magnification"

Images can be magnified by some appropriate interpolation scheme. *However, this will* not reveal any new details to the subjective impression of the analyst, though it *may* permit a better eye appraisal.

"Sharpening"

The images can be sharpened only if:

- the PSF has considerable spread of more than 1 pixel and is spatially constant over the entire image area;
- the PSF is known or can be determined with good accuracy;
- the noise level is low enough.

The PSF of the camera/sensor can be optimized such that it covers only 1 pixel and thus no digital image sharpening is possible. This can be verified during the certification. The atmospheric conditions could superimpose a wider PSF during the actual recording flight, but such an atmospherically induced PSF will usually not be uniform across the image and thus preclude later sharpening. In any case, it would be technically possible to reconstruct the actual PSF from the calibration targets. If the spread of the PSF is not much larger than 1 pixel then it is verified that the imagery cannot be restored to better resolution later on.

E.3 The Trade-Off Between Resolution/Altitude/Ground Swath

The Treaty's definition of the minimum flight altitude $\boldsymbol{H}_{\text{min}}$ in function of the actual resolution clearly implies variances in the achievable data taking results. For example, flying on a clear day at high altitude with a fine-grained photographic film allows for the required ground resolution and for a large ground swath at the same time. In contrast, a cloudy day will require a low flight altitude, and—as a result—a coarsely-grained film in order not to violate the resolution limit, and a small ground swath. Thus, in the second scenario, the observing party is able to obtain a much smaller amount of data. The first scenario allows the inspection of much larger areas of the overflown state.

With regard to photographic cameras, the Treaty allows for a ground coverage of up to 50 kilometres on each side of the flight path.[11] In practice, the ground swath covered by photographic cameras will be smaller. For example, the panoramic camera KA-91C on board of the US Open Skies aircraft covers a ground swath of 10-23 kilometres at flight altitudes of 4.7-11.1 kilometres.

These considerations suggest that the Treaty was not designed primarily with large-area monitoring purposes in mind. It seems to be understood that the Treaty's objective is not the detection of unknown activities *somewhere*, but rather the recognition of specific activities and localized objects.[12] Otherwise, the Treaty would probably have been designed to guarantee equal territorial coverage rather than equal ground resolution. An alternative formulation of the Treaty provisions would fix the flight altitude such that with a given camera focal length and film format a certain ground swath size would not be surpassed.

Notes

1 Note that the bilateral Hungarian-Romanian Open Skies Agreement (see section 8.1 and Appendix H) works completely without either a minimum flight altitude or a ground resolution limit.

[2] With the discrete black and white bars of the calibration target (the sharp contours cause high frequencies in the Fourier-transform) it is more appropriate to talk about the *contrast* transfer function (CTF). See K. Kraus, *Photogrammetrie*, Vol. 1—Grundlagen und Standardverfahren, Bonn: Dümmler, 1994.

[3] Ibid.

[4] R. C. Gonzalez and R. A. Wintz, *Digital Image Processing*, Boston, MA: Addison-Wesley, 1987.

[5] As stated in section 4.4, a GSD of 30 centimetres corresponds in practice to a photogrammetric resolution (GRD) of approximately 60 centimetres.

[6] In practice, a number of other parameters have to be fitted as well, such as the observed contrast, the exact (subpixel) location of the target, etc. Simultaneous multi-parameter minimization is achieved by means of a Marquardt-Levenberg gradient descent method. See, e.g., S. Brandt, *Datenanalyse*, Mannheim, Leipzig, Wien, Zürich: BI-Wissenschaftsverlag, 1992.

[7] *Precision* means a high statistical confidence, i.e., low *statistical* error margins; whereas *accuracy* also implies the absence of *systematic* errors (see, e.g., B. Jähne, *Practical Handbook on Image Processing for Scientific Applications*, Boca Raton FL: CRC Press LLC, 1997).

[8] See, e.g., B. Jähne, op. cit.

[9] The modulation transfer function is related to the point spread function in that the MTF is the absolute magnitude of the Fourier-transform of the PSF.

[10] It may sometimes be possible to determine the PSF even without ground calibration target, but these are rather special or speculative cases. See I. Keller, "Extraction of the Point Spread Function with Subpixel Accuracy from Natural Scenes with Nonlinear Optimisation and Simulated Annealing Methods", *Proceedings of the Third International Airborne Remote Sensing Conference and Exhibition, Copenhagen, Denmark*, Environmental Research Institute of Michigan, Ann Arbor, Vol. I, 1997, pp. 499-506.

[11] Radar coverage is limited to a ground swath of 25 kilometres on one side of the aircraft within a 50 kilometres strip.

[12] Positions of locations of interest would be provided by other sources such as CFE on-site inspections, intelligence, etc.

APPENDIX F

BRIEF GLOSSARY OF OPEN SKIES TREATY TERMS

This glossary was compiled by the United States Defense Threat Reduction Agency.[1]

Active Quota
The number of observation flights that each State Party has the right to conduct as an observing Party. A Party's active quota may not exceed its passive quota. The initial distribution of such numbers is contained in Section II of Annex A of the Treaty and is subject to annual review in the Open Skies Consultative Commission (OSCC).

Alternate Airfield
An airfield to which an observation aircraft or transport aircraft may proceed when it becomes inadvisable to land at the airfield of intended landing. This category includes emergency airfields and airfields that may be used as a weather alternates if weather at the planned destination is unsuitable for landing.

Danger Area
An airspace of defined dimensions, within which activities dangerous to the flight of aircraft may exist at specified times. This is one of the three types of areas that are covered under the term "hazardous airspace," on the basis of the International Civil Aviation Organization (ICAO) Convention.

Escort
An individual from any State Party who accompanies the inspectors of another State Party.

1 See www.dtra.mil/news/fact/nw_os_glsry.html (January 2003).

Flight Crew
Individuals who perform duties associated with the operation or servicing of an observation aircraft or transport aircraft, including interpreters.

Flight Monitor
An individual who, on behalf of the observed Party, is on board an observation aircraft provided by the observing Party during the observation flight.

Flight Plan
A document elaborated on the basis of the mission plan agreed between the observing and observed Parties that is presented to air traffic control authorities. It must be in the format and contain the content specified by the ICAO.

Flight Representative
An individual who, on behalf of the observing Party, is on board an observation aircraft provided by the observed Party during an observation flight. The procedures for designating such individuals, as well as their privileges and immunities, are contained in Article XIII of the Treaty.

Ground Resolution
The minimum distance on the ground between two closely located objects at which they are distinguishable as separate objects. The methodologies for determining the capability of individual sensors to achieve a specified ground resolution, including the minimum altitude from which such a resolution can be achieved, were developed by the OSCC during the Treaty's period of provisional application.

Group of States Parties
Two or more States Parties that have agreed to form a group for purposes of the Treaty.

Hazardous Airspace
The prohibited areas, restricted areas and danger areas, defined on the basis of Annex 2 to the Convention on International Civil Aviation, that are established in accordance with Annex 15 to that Convention in the interests of flight safety, public safety and environmental protection and about which information is provided in accordance with ICAO provisions.

Infrared Line-Scanning Device
A sensor capable of receiving and visualizing thermal radiation emitted in the invisible infrared part of the electromagnetic spectrum by objects due to their temperatures and in the absence of artificial illumination. Line-scanning devices were selected instead of other types of infrared sensors to avoid technology transfer problems that might arise with more sophisticated systems.

Individual Active Quota
The number of observation flights that a State Party has the right to conduct each year over the territory of another State Party. These numbers are subject to annual review.

Inspector
An individual from any State Party who conducts an inspection of sensors or observation aircraft of another State Party.

Maximum Flight Distance
The maximum distance over the territory of the observed Party from the point at which the observation flight may commence to the point at which that flight may terminate. The maximum flight distance includes those route segments for intermediate stops, including refueling airfields.

Mission Plan
A document that is presented by the observing Party to the observed Party and forms the basis for the elaboration of the flight plan. The mission plan contains the route, profile (altitudes), order of execution and support required to conduct the observation flight.

Mission Report
A document describing an observation flight, which is completed after the termination of the observation flight by the observing Party and which is signed by both the observing and observed Parties.

Observation Aircraft
An unarmed, fixed wing aircraft designated and certified to make observation flights, registered by the relevant authorities of a State Party and equipped with agreed sensors.

Observation Flight
The flight of the observation aircraft conducted by an observing Party over the territory of an observed Party from the point of entry or Open Skies airfield to the point of exit or Open Skies airfield, as the flight of that aircraft is provided in the flight plan.

Observation Period
A period of time during an observation flight, specified by the observing Party, when a particular sensor installed on the observation aircraft is operating. There is no limit on the number or duration of such observation periods during an observation flight. Sensors may be operated for the entire duration of a flight, as long as the observation aircraft does not deviate from the agreed flight path and the flight altitude is appropriate for each sensor. Information on such sensor operating periods is required because the film or other recording medium has to be annotated with such information. Such information permits all Parties to know when and where data was collected, and permits third Parties to request data taken during specified periods.

Observed Party
The State Party or group of States Parties over whose territory an observation flight is conducted or over whose territory an observation flight is intended to be conducted.

Observing Party
The State Party or group of States Parties that intends to conduct an observation flight, or conducts an observation flight, over the territory of another State Party or group of States Parties.

Open Skies Airfield
An airfield designated by the observed Party as a point where an observation flight may commence or terminate. An Open Skies airfield may be a point of entry or a point of exit, or it may be a separate airfield designated solely as an Open Skies airfield.

Open Skies Consultative Commission (OSCC)
The body established to facilitate the provisional application and the implementation of the Open Skies regime and for handling any compliance issues that may arise.

Passive Quota
The number of observation flights that each State Party is obligated to accept as an observed Party. This number, unlike the distribution of active quotas, is not subject to annual review by the OSCC.

Pilot in Command
The pilot on board the observation aircraft who is responsible for the operation and safety of the observation aircraft and the execution of the flight plan.

Point of Entry
A point designated by the observed Party for the arrival of personnel of the observing Party on the territory of the observed Party. The observation flight may also commence at this point if it is also designated an Open Skies airfield.

Point of Exit
A point designated by the observed Party for the departure of personnel of the observing Party from the territory of the observed Party. The observation flight may also terminate at this point if it is designated an Open Skies airfield.

Prohibited Area
An airspace of defined dimensions, above the territory of a State Party, within which the flight of aircraft is prohibited, in accordance with specified conditions. This is one of the three types of areas that are covered under the term "hazardous airspace", on the basis of the ICAO Convention.

Refueling Airfield
An airfield designated by the observed Party to be used for fueling and functioning, operation and maintenance of the servicing of observation aircraft and transport aircraft.

Representative
An individual who has been designated by the observing Party and who performs activities on behalf of the observing Party during an observation flight on an observation aircraft designated by a State Party other than the observing Party or the observed Party.

Restricted Area
An airspace of defined dimensions, above the territory of a State Party, within which the flight of aircraft is restricted in accordance with specified conditions. This is one of the three types of areas that are covered under the term “hazardous airspace”, on the basis of the ICAO Convention.

Sensor
Equipment of a category specified in Article IV of the Treaty that is installed on an observation aircraft for use during the conduct of observation flights. The categories of equipment specified in Article IV are: optical and framing cameras; video cameras with real-time display; infrared line-scanning devices; and sideways-looking synthetic aperture radar.

Sensor operator
An individual from any State Party who performs duties associated with the functioning of the sensors on an observation aircraft. Such personnel could also be considered to be representatives, flight representatives or flight crew, depending on their duties.

Synthetic Aperture Radar (SAR)
Observation aircraft may be equipped with sideways looking synthetic aperture radar. SAR is a high resolution ground mapping technique which takes advantage of the forward motion of a vehicle that is carrying a pulsed radar to synthesize the effect of a large antenna aperture. In other words, the larger the radar antenna (aperture), the higher the radar picture's resolution. SAR uses a radar with a very small antenna (such as can be carried in an aircraft) that synthesizes a series of recurring radar pulse returns to simulate the effect of a much larger antenna aperture; thus, the name "synthetic" aperture. SAR is effective in detecting large objects day or night, even through cloud cover.

Taxi Option
A treaty provision that gives the observed Party the right to demand that its observation aircraft, along with its flight crew and sensors, be used to carry out an observation flight over its territory requested by an observing Party.

Territory
The land, including islands, and internal and territorial waters, over which a State Party exercises sovereignty.

Total Passive Quota
The total number of observation flights that a State Party is obliged to accept over its territory. Passive quotas are allocated by Annex A, Section II of the Treaty.

Transit Flight
The flight of an observation aircraft or transport aircraft over the territory of a third State Party en route to or from the territory of the observed Party.

Transport Aircraft
An aircraft other than an observation aircraft that conducts flights to or from the territory of the observed Party exclusively for the purposes of the treaty.

APPENDIX G

OPEN SKIES BASIC ELEMENTS

NATO Communiqué 14-15 December 1989

NATO Office of Information and Press
1110 Brussels

Annex to the Communiqué of the North Atlantic Council meeting
in Ministerial Session on 14th and 15th December 1989

'OPEN SKIES'
BASIC ELEMENTS

I. INTRODUCTION

1. On 12th May 1989, President Bush proposed the creation of a so-called 'Open Skies' regime, in which the participants would voluntarily open their airspace on a reciprocal basis, permitting the overflight of their territory in order to strengthen confidence and transparency with respect to their military activities.

This proposal expanded on a concept that had already been proposed during the 1950s but had failed to reach fruition because of the unfavourable international political climate prevailing at the time.

Today, this new initiative has been made in a very different context as openness becomes a central theme of East-West relations and the past few years have been marked by important advances in the areas of confidence-building and arms control.

2. The provisions for notification and observation of military activities specified in the Helsinki Final Act were strengthened and made obligatory by the Stockholm Document concluded by the CDE in 1986.

With respect to arms control, in 1987, the INF Treaty, apart from is immediate goals, represented a very important precedent because of the extent of its verification provisions.

All this leads one to expect today even more spectacular advances will be achieved in the near future. In particular, a two-pronged effort is under way in Vienna: on the one hand, to deepen the measures for confidence-building and transparency among the 35 countries of the CSCE, and on the other, to reach an unprecedented agreement between the countries of the Atantic Alliance and the Warsaw Treaty Organization on the elimination of large numbers of conventional arms.

Furthermore, one awaits important developments in other sectors of disarmament such as chemical weapons and the Soviet-American strategic arms negotiations.

3. All of these agreements will naturally require their own verification regimes, often of a highly intrusive nature. Moreover, the specific provisions of each verification treaty will be supplemented by the habitual means by which countries verify compliance with agreements (national technical means).

It seems useful, however, particularly in the prevailing context of improved East-West relations, to reflect on other ways of creating a broadly favourable context for confidence-building and disarmament efforts.

In this context, the Open Skies concept has a very special value. The willingness of a country to be overflown is, in itself, a highly significant political act in that it demonstrates its availability to openness; aerial inspection also represents a particularly effective means of verification, along with the general transparency in military activities discussed above.

This double characteristic of an Open Skies regime should make it a valuable complement to current East-West endeavours, mainly in the context of the Vienna negotiations but also in relation to the other disarmament efforts (START, chemical weapons).

It would seem desirable to focus now on the European region, while also including the entire territories of the Soviet Union, the United States, and Canada. Accordingly, we will be ready to consider at an appropriate time the wish of any other European country to participate in the Open Skies regime. This element could be complementary to their efforts at confidence-building and conventional arms control and would conform to the objectives of those negotiations.

4. To this end, the Open Skies Regime should be based on the following guidelines:

- The commitment of the parties to greater transparency through aerial overflights of their entire national territory, in principle without other limitations than those imposed by flight safety or rules of international law.

- The possibility for the participants to carry out such observation flights on a national basis or jointly with their allies.
- The commitment of all parties to conduct and to receive such observation flights on the basis of national quotas.
- The establishment of agreed procedures designed to ensure both transparency and flight safety.
- The possibility for the parties to employ the result of such overflights to improve openness and transparency of military activities as well as ensuring compliance with current or future arms control measures.

II. PURPOSE

The basic purpose of Open Skies is to encourage reciprocal openness on the part of the participating states and to allow the observation of military activities and installations on their territories, thus enhancing confidence and security. Open Skies can serve these ends as a complement both to national technical means of data collection and to information exchange and verification arrangements established by current and future arms control agreements.

III. PARTICIPATION AND SCOPE

Participation in Open Skies is initially open to all members of the Atlantic Alliance and the Warsaw Treaty Organization. All territories of the participants in North America and Asia, as well as in Europe, will be included.

IV. QUOTAS

1. Open Skies ‘accounting’ will be based on quotas which limit the number of overflights. The quotas will be derived from the geographic size of the participating countries. The duration of flights can also be limited in relation to geographic size. For larger countries, the quota should permit several flights a month over their territory. All of the parties will be entitled to participate in such observation flights on a national basis, either individually or jointly in co-operation with their allies.

2. Effective implementation of a quota system requires agreement that a country will not undertake flights over the territory of any other country belonging to the same alliance.

3. Quota totals for participating states should be established in such a manner that there is a rough correspondence between totals for NATO and the Warsaw Treaty Organization and, within that total, for the USSR and the North American members of NATO.

4. Every participant, regardless of size, would be obligated to accept a quota of at least one overflight per quarter.

5. Smaller nations, that is, those subject to the minimum quota, may group themselves into one unit for the purposes of hosting Open Skies overflights and jointly accept the quota that would apply to the total land mass of the larger unit.

V. AIRCRAFT

The country or countries conducting an observation flight would use unarmed, fixed-wing civilian or military aircraft capable of carrying host country observers.

VI. SENSORS

A wide variety of sensors would be allowed, with one significant limitation—devices used for the collection and recording of signals intelligence would be prohibited. A list of prohibited categories and types of sensors will be agreed among the participating states which will be updated every year.

VII. TECHNICAL CO-OPERATION AMONG ALLIES

Multilateral or bilateral arrangements concerning the sharing of aircraft or sensors, as well as the conduct of joint overflights, will be possible among members of the same alliance.

VIII. MISSION OPERATION

1. Aircraft will begin observation flights from agreed, pre-designated points of entry and terminate at pre-designated points of exit; such entry

and exit points for each participating state will be designated by that state and listed in an annex to the agreement.

2. The host country will make available the kind of support equipment, servicing and facilities normally provided to commercial air carriers. Provision will be made for refuelling stops during the overflight.

3. An observing state will provide 16 hours notification of arrival at a point of entry. However, if the point of entry is on a coast or at a border and no territory of the receiving state will be overflown prior to arrival at the point of entry, this pre-arrival period could be abbreviated.

4. The crew of the observation aircraft shall file a flight plan within six hours of its arrival at the point of entry.

5. After arrival and the filing of a flight plan, a 24 hour pre-flight period will begin. This period is to allow time to determine that there are no flight safety problems associated with the planned flight route and to provide necessary servicing for the aircraft. During this pre-flight period the aircraft will also be subject to intrusive but non-destructive inspection to prohibited sensors and recorders.

6. Prior to the flight, host-country monitors will be able to board the observation aircraft. During the flight they would ensure that the aircraft is operated in accordance with the flight plan and would monitor operation of the sensors. There would be no restrictions on the movement of the monitors within the aircraft during flight.

7. The flight will be from the agreed point of entry to an agreed point of exit, where the host country observers would depart the aircraft. The points of entry and exit could be the same. Loitering over a single location will not be permitted. Aircraft will not be limited to commercial air corridors. Observation aircraft may in principle only be prohibited from flying through airspace that is publicly announced as closed to other aircraft for valid air safety reasons. Such reasons would include specific hazards posing extreme danger to the aircraft and its occupants. Each country will make arrangements to ensure that public announcements of such hazardous airspace are widely and promptly disseminated; each country will produce for an annex to the agreement a list of where these public announcements can be found. The minimum altitudes for such flights may vary depending upon air safety considerations. The extent of ground control over aircraft will be determined in advance by agreement among the parties on compatible rules such as those recognized by ICAO. In the application of

these considerations and procedures, the presumption shall be on behalf of encouraging the greatest degree of openness consistent with air safety.

8. The operation of the Open Skies regime will be without prejudice to states not participating in it.

IX. MISSION RESULTS

The members of the same alliance will determine among themselves how information acquired through Open Skies is to be shared. Each party may decide how it wishes to use this information.

X. TRANSITS

A transit flight over a participating state on the way to the participating state over which an observation flight is to be conducted shall not be counted against the quota of the transited state, provided the transit flight is conducted exclusively within civilian flight corridors.

XI. TYPE OF AGREEMENT

The Open Skies regime will be established through a multilateral treaty among the parties.

XII. OPEN SKIES CONSULTATIVE BODY

To promote the objectives and implementation of the Open Skies regime, the participating states will establish a body to resolve questions of compliance with the terms of the treaty and to agree upon such measures as may be necessary to improve the effectiveness of the regime.

APPENDIX H

THE HUNGARIAN-ROMANIAN OPEN SKIES AGREEMENT

Agreement Between the Government of the Republic of Hungary and the Government of Romania on the Establishment of an Open Skies Regime[1]

The Government of the Republic of Hungary and the Government of Romania, hereinafter referred to as the Parties;

Recalling their commitments in the Conference on Security and Co-operation in Europe to promoting greater openness and transparency of their military activities and to enhancing security by means of confidence and security building measures;

Seeking to implement in their bilateral relations in addition to the provisions of the 1990 Vienna Document of the Negotiations on Confidence- and Security-Building Measures, further cooperative confidence and security building measures;

Reaffirming their desire to further contribute to the successful conclusion of the negotiations of the Open Skies Conference, as expressed in the Charter of Paris for a New Europe;

Convinced that a successful bilateral Open Skies regime provides valuable experience for the elaboration of an Open Skies Treaty, and the simultaneous functioning of the regimes will lead to enhanced confidence and security;

Noting that an Open Skies regime and its successful implementation would encourage reciprocal openness on the part of the States Parties, enhance the predictability of their military activities and strengthen confidence between them;

1 The agreement was signed on 11 May 1991 at Bucharest. It was submitted to the General Assembly/Security Council of the United Nations as document A/46/188, S/22638, 24 May 1991.

Convinced that the Open Skies regime will be implemented on a reciprocal and equitable basis which will protect the interest of each State Party;

Noting the possibility of employing the results of such overflights to improve openness and transparency, to enhance confidence and security building, and to improve the monitoring of, and thus promote compliance with, current or future arms control measures;

Noting that the operation of an Open Skies regime will be without prejudice to States not parties to this Agreement;

Believing that an effective Open Skies regime would serve to consolidate improved good neighbourly relations between the States Parties.

Have agreed as follows:

Article I. Definitions

For the purposes of this Agreement and its Annexes:

(1) The Term "Aircrew Member" means an individual from any of the two Parties who has been designated and accepted in accordance with Article XIX of this Agreement, and who performs duties associated with the operation or maintenance of the Observation Aircraft or its sensors, and participates as a member of the aircrew of the Observation Aircraft during the Observation Flight, or who is an Inspector Escort.

(2) The term "Observation Crew Member" means an individual from the Observing Party who has been designated and accepted in accordance with Article XIX of this Agreement, and who performs duties associated with the operation of the sensors of the Observation Aircraft of the Observed Party and who participates as an Aircrew Member of the Observation Aircraft of the Observed Party during the Observation Flight.

(3) The term "Flight Monitor" means an individual designated by the Observed Party to be on board the observation Aircraft during the Observation Flight and who performs duties in accordance with Annex D.

(4) The term "Flight Plan" means a flight plan of the Observing Party meeting the requirements of Article VI.

(5) The term “Hazardous Airspace” means areas of an Observed Party in which there are invisible or unusual dangers to the safety of the aircraft. Hazardous airspace include prohibited areas, restricted areas and danger areas, established in the interest of flight safety, public safety and environmental protection and published by the Observed Party in accordance with ICAO rules in the Aeronautical Information Publication (AIP).

(6) The term “Inspector” means an individual who is designated by the Observed Party or Observing Party to conduct inspections of the Observation Aircraft, its equipment, its sensors in accordance with Article IX and Annex C.

(7) The term “Inspection Team” means the group of Inspectors designated by the Observed Party or Observing Party to conduct the inspection of the Observation Aircraft, its equipment and its sensors in accordance with Article IX. and Annex C.

(8) The term “Inspector Escort” means a designated representative of the Observing Party or the Observed Party who has been authorized to monitor all activities of Inspectors and Inspection Team during inspections and perform other specified duties in accordance whit Article IX and Annex C.

(9) The term “Inspection” means activity described in and performed pursuant to Article IX and Annex C.

(10) The term “Period of Inspection” means the period of time during which the Inspection Team inspects the Observation Aircraft, its equipment and its sensors in accordance with Article IX and Annex C.

(11) The term “Observation Aircraft” means an unarmed, fixed wing aircraft, capable of carrying two Observed Party Flight Monitors in addition to its Aircrew Members. An aircraft is considered unarmed when it is not carrying any armament (munitions) of any type or equipment dedicated to armament operations.

(12) The term “Observation Flight” means a flight and any accompanying refuelling stops, conducted in accordance with the provisions and restrictions of this Agreement by an Observation Aircraft over the Territory of an Observed Party.

(13) The term “Observed Party” means a Party over whose Territory an Observation Flight is conducted.

(14) The term "Observing Party" means a Party conducting an Observation Flight.

(15) The term "Point of Entry" means the Airfield (s) in the Territory of each party that are designated in Annex B for the arrival of the Observation Aircraft at the Observed Party s Territory.

(16) The term "Point of Exit" means the Airfields(s) in the Territory of each Party that are designated in Annex B for the departure of the Observation Aircraft from the Observed Party's Territory.

(17) The term "Permitted Observation Equipment" means on-board observation equipment of the Observation Aircraft as described in Annex E.

(18) The term "Quota" means the number of Observation Flights that each Party undertakes to accept annually ("Passive Quota") and also the number of Observation Flights each Party shall have the right to conduct annually ("Active Quota"), as set forth in Annex A.

(19) The term "Arrival Fix" means the compulsory reporting point specified and promulgated by the Observed Party in Annex B through which the Observation Aircraft shall enter the territorial airspace of the Observed Party.

(20) The term "Departure Fix" means the compulsory reporting point specified and promulgated by the Observed party in Annex B through which the Observation Aircraft shall depart the territorial airspace of the Observed Party.

(21) The "ATS" Route means a specified route designed for channelling the flow of traffic as necessary for the provisions of Air Traffic Services.

Article II. Basic Rights and Obligations of the Parties

(1) Each Party shall have the right to conduct Observation Flights in accordance with the provisions of this Agreement.

(2) Each Party undertakes to permit Observation Flights over its Territory in accordance with the provisions of this Agreement.

(3) Each Party may conduct Observation Flights with its own Observation Aircraft or the Observation Aircraft of the other Party.

(4) Areas with Hazardous Airspace are excepted in accordance with the provisions of Articles I, VIII and Annex G.

Article III. Quotas of Observation Flights

(1) For the purposes of fulfilling objectives of this Agreement, each Party shall have the right to conduct and undertakes the obligation to accept an agreed number of Observation Flights in accordance with Annex A.

(2) The number of Observation Flights a Party shall be allowed to conduct shall be equal to the number of overflights it shall be required to accept.

Article IV. Observation Aircraft

While conducting flights under this Agreement the Observation Aircraft shall comply with the provisions of this Agreement.

Unless inconsistent with the provisions of this Agreement, the Observation Aircraft shall also comply with:

(a) the published standards and recommended practice of ICAO;

(b) published national air traffic control rules, procedures and guidelines on flight safety of the Observed Party;

(c) the instructions of the ATC authorities and the ground control services.

Article V. Pre- and Post-Observation Flight Procedures

(1) Upon entry into force of this Agreement, each Party shall provide the other Party with the following information:

(a) emergency airfields between its Arrival Fixes and Points of Entry and between its Points of Exit and its Departure Fixes;

(b) Instrument arrival and departure procedures:

- for its Points of Entry and Exit;
- for its alternate airfields near its Points of Entry and Exit;
- for suitable airfields along route of flight which may be used in an emergency.

(2) Each Party shall promptly notify the other Party of any updates and amendments to such information.

(3) A Party may change the location of its Points of Entry and/or Exit upon three months prior notification to the other Party.

(4) In order to conduct an Observation Flight, the Observing Party shall notify the Observed Party of the estimated time of arrival of its Observation Aircraft at the Observed Party's Point of Entry. Such notice shall be given less than 24 hours in advance of the estimated time arrival.

(5) The notification to the Observed Party shall also indicate the type and model of the incoming aircraft, its registration number and call sign, as well as the names, passport types and numbers and functions of each Aircrew Member.

(6) In case the Observing Party intends to use the Observation Aircraft of the Observed Party, it shall submit its request to do so 7 days in advance of the proposed time of the commencement of the Observation Flight.

(7) Upon completion of the Observation Flight, the Observation Aircraft shall depart the Territory of the Observed Party from the Point of Exit. The departure flight from the Point of Exit shall commence not later than 24 hours following the completion of the Observation Flight, unless weather conditions or the airworthiness of the Observation Aircraft do not permit.

Article VI. Flight Plans and Conduct of Observation Flights

(1) Within six hours following the arrival of the Observation Aircraft or the Observation Crew at the Point of Entry, the Observing Party shall submit a Flight Plan for the Proposed Observation Flight to the Observed Party. The Observed Party shall as soon as possible review and approve or amend and approve the proposed Flight Plan in accordance with the provisions of this Agreement.

(2) The Observation Flight shall be conducted in accordance with the approved Flight Plan and in accordance with clearances and instructions from the Observed Party's air traffic controllers.

(3) The Flight Plan shall have the content according to Annex 2 to the Convention on International Civil Aviation, signed in Chicago, 1944, and be in the format specified by ICAO Document 4444-RAC/501, Rules of the Air and Air Traffic Services, as amended or revised.

(4) The Flight Plan shall provide and require that:

(a) the planned duration of the Observation Flight shall not exceed the duration of Observation Flights that is set forth in Annex A;

(b) the Observation Flight commences not earlier than 16 hours and not later than 48 hours after delivery of the Flight Plan to the Observed Party;

(c) the observation Aircraft shall fly a direct route between the coordinates or navigation fixes designated in the Flight Plan, and shall visit each coordinate or navigation fix in the declared sequence set forth in the Flight Plan; and

(d) the Observation Aircraft shall not hold over, delay departure from or otherwise loiter at any point its approved Flight Plan route nor otherwise unreasonably disrupt the normal flow of air traffic except:

- as allowed for in the approved flight plan;
- as necessary for the purposes of arrival or departure at designated airfields when executing published procedures or the instructions of air traffic control;
- as instructed by air traffic control;
- as required for reasons of flight safety;
- flight tracks shall be permitted to intersect provided that no point of intersection is crossed more than once on any Observation Flight.

(5) The Observed Party shall ensure that Aircrew Members are given the Observed Party's most recent weather and safety information pertaining to the Flight Plan for each Observation Flight, including Notices to Airmen, IFR procedures and information about alternate and emergency airfields along the flight route stated in the approved Flight Plan.

(6) All Observation Flights shall be carried out in compliance with the provisions of this Agreement and ICAO standards and recommended practice, and with due regard for differences existing in national rules and regulations, published in AIP or in accordance with national flight and air traffic control requirements of which the Observation Aircraft's Aircrew shall be informed.

(7) In the event that the Observation Aircraft makes a deviation from the Flight Plan, as permitted under Article XIII of this Agreement, the additional flight time arising from such deviation shall not count against the duration specified in Annex A.

Article VII. Sensors

(1) Each Party may use during Observation Flights any sensor that is necessary for reaching the objectives of this Agreement listed in Annex E. Sensors not listed in Annex E are prohibited and shall not be on board of the Observation Aircraft.

(2) The Parties undertake to use the same types of sensors of comparable capability and to this end to facilitate access to such sensors for use by the other Party.

(3) The Observation Aircraft shall be equipped with the same sensors, when used upon request by the other Party.

(4) Data acquired by sensors during Observation Flights will remain encapsulated on board the Observation Aircraft until the termination of the Observation Flight. Sensor data link operations of any kind are prohibited.

(5) As provided in Paragraph 4 of Article XVI of this Agreement, a Party may utilize a type or model of sensor not listed in Annex E for or in connection with an observation Flight upon:

(a) receiving the approval of Hungarian-Romanian Open Skies Consultative Commission (HROSCC), and;

(b) making a representative type or model of such sensor available for pre–flight examination by the other Party in accordance with the provision of Annex E.

(6) Any Party operating an Observation Aircraft will ensure that the sensors function to specifications and also that their specifications conform with agreed requirements.

Article VIII. Hazardous Airspace

(1) Observation Aircraft may conduct Observation Flights anywhere over the Territory of the Observed Party in accordance with Article II and Article VI.

(2) Hazardous Airspace must be publicly announced. Such public announcements must specify the dangers to the Observation Aircraft and Aircrew Members. Each Party shall ensure that such public announcements of Hazardous Airspace are promptly provided to the Other Party by the source designated by the Party in Annex H.

(3) Particular Hazardous Airspace announced in Annex H must be taken into account by the Observing Party when preparing an Observation Flight Plan.

(4) Each Party may introduce amendments and additions to Annex H, giving notice thereof to the other Party.

(5) In case of need, the Observed Party shall inform the Aircrew Members during preparations for the Observation Flight of the new particular Hazardous Airspace, indicating the causes for the restrictions introduced.

(6) In the event that the Flight Plan of the Observing Party requests overflight of Hazardous Airspace of the Observed Party, the Observed Party shall approve the Flight Plan if it conforms with Article VI, but may amend it to specify the minimum safe altitude over the Hazardous Airspace. This minimum safe altitude shall be made part of the Flight Plan. If there is no minimum safe altitude available consistent with air safety requirements, the Observed Party shall propose an alternative flight routing as near to the Hazardous Airspace as is permitted by air safety requirements. Alternatively the Observed Party may propose that the time of arrival of the Observation Aircraft over the Hazardous Airspace be amended to a time consistent with flight safety requirements. Such alternative flight routing or timing shall be incorporated in a revised Flight Plan and approved the Observed Party.

(7) The Observing Party may elect either to conduct Observation Flight on the basis of an amended Flight Plan, avoiding the particular Hazardous Airspace, or to cancel the Observation Flight. In that latter event, the Observation Aircraft or the Observation Crew shall depart the Territory of the Observed Party in accordance with Article V and no overflight shall be recorded against the Quota of either Party.

(8) In the event the Observing Party informs the Observed Party that denial of access to any portion of the Hazardous Airspace of the observed Party was not justified on the basis of air safety considerations and in a further event that the matter is not resolved through diplomatic channels, the Observing Party may raise the matter for consideration in the Hungarian-Romanian Open Skies Consultative Commission pursuant to Article XVI of this Agreement.

Article IX. Aircraft and Sensors Inspections

When an Observation Flight is conducted using an Observation Aircraft of the Observing Party, upon delivery of the Flight Plan, unless otherwise mutually agreed to by the Observed and the Observing Party, the Inspection Team of the Observed Party may inspect the Observation Aircraft, accompanied by Inspector Escorts of the Observing Party, to determine whether there is any Prohibited Equipment on the Observation Aircraft. Such inspection shall terminate no later than three hours prior to the scheduled commencement of the Observation Flight set forth in the Flight Plan. All such inspections shall be conducted in accordance with Annex C.

Article X. Flight Monitors on Observation Aircraft

The Observed Party shall have the right to have two Flight Monitors on board the Observation Aircraft during each Observation Flight in accordance with Annex D. Such Flight Monitors shall have the right of access to all areas of the Observation Aircraft during the Observation Flight. Flight Monitors have the rights and obligations specified in Annex D. In discharging their functions, Flight Monitors shall not interfere with the activities of the Aircrew Members.

Article XI. Observation Aircraft Servicing and Maintenance

(1) The Observed Party shall, upon request, provide

(a) customary commercial aircraft fuelling, servicing, and maintenance for the Observation Aircraft at the Point of Entry or Exit and at any predesignated refuelling point specified in the Flight Plan; and

(b) meals and the use of rest facilities for Observation Aircraft Aircrew Members.

(2) On request of the Observing Party, further services will be agreed upon between the Parties in order to guarantee the effective realisation of the Observation Flight. Should unscheduled technical demand arise for the Observation Aircraft, the necessary support will be provided without delay by the Observed Party. A protocol about the obtained services will be established between the Inspector Escort of the Observing Party and a responsible officer of the Observed Party at the Point of Entry or Exit.

(3) The Observing Party shall reimburse the Observed Party for the ordinary and reasonable costs of such fuelling, maintenance, servicing, meals and use of rest facilities. The amount of reimbursement will be agreed upon by the Parties on a case-by–case basis and will represent a fair

estimate of the cost of such services at the time rendered, exclusive of taxes, fees, duties or other similar charges.

(4) The Observing Party shall reimburse the Observed Party for the use of the Observation Aircraft of the Observed Party. The Observed Party shall inform in advance the Observing Party of estimated cost of one flight hour by the Observation Aircraft.

(5) Such charges shall not be greater than that which the Observed Party would charge itself for the same service.

Article XII. Prohibition, Correction or Curtailment of Observation Flights

(1) The Observed Party, by notifying the Observing Party, may prohibit prior to its commencement, or correct or curtail in a non-harmful manner subsequent to its commencement, any Observation Flight:

(a) that is not permitted by the terms of Annex A;

(b) for which a Flight Plan has not been filed in accordance with this Agreement;

(c) that arrives at the Point of Entry less than 24 hours after the notification required by Article V. of this Agreement;

(d) that fail to arrive at the Point of Entry within 6 hours the estimated time of arrival set forth in said notification;

(e) that deviates from the Flight Plan, except as permitted by Article XIII of this Agreement;

(f) that is conducted by aircraft other than an Observation Aircraft; or

(g) that is otherwise in non-compliance with the terms, conditions, provisions and restrictions of this Agreement.

(2) The Observed Party may correct or curtail in its territorial airspace a flight to a Point of Entry or from a Point of Exit that deviates from the direct route required by Article VI.

(3) When an Observed Party prohibits, corrects or curtails an Observation Flight in accordance with this Article, it must provide in writing to the Observing Party through routine diplomatic channels an explanation for its action.

(4) An Observation Flight that has been prohibited shall not be recorded against the Quota of the Observed Party. A proposed Observation Flight that has been corrected or curtailed shall not be recorded against the Quota of the Observed Party.

(5) Disputes bearing on this Article may be submitted to the Hungarian-Romanian Open Skies Consultative Commission for resolution as stipulated in Article XVI of this Agreement.

Article XIII. Deviations and Emergencies

(1) Notwithstanding any other provisions of this Agreement deviations by an Observation Aircraft from a Flight Plan or from the routes to and from the Points of Entry and Exit, that are necessitated by: (a) adverse weather conditions, (b) air traffic control instructions related to flight safety, or (c) aircraft mechanical difficulty or other event beyond the control of the Observing party, shall not be deemed a violation of this Agreement and shall not be grounds for correction, curtailment or prohibition by the Observed Party of an Observation Flight, a flight arriving at a Point of Entry or a flight departing from a Point of Exit.

(2) Any Observation Aircraft declaring an emergency shall be accorded the Observed Party's full range of distress and diversion facilities in order to ensure the most expeditious recovery to the nearest suitable airfield. A full investigation of the declaration shall be conducted in accordance with the regulations of the Observed Party, with the participation of the Observing Party, at a place of the Observed Party's choosing.

(3) In the case of an accident involving the Observation Aircraft in the Territory of the Observed Party, search and rescue operations will be conducted by the Observed Party in accordance with its own regulations and procedures for such operations. A full investigation of the accident by the Observed Party shall be conducted in accordance with the regulations of the Observed Party, with the participation of the Observing Party at a place of the Observed Party's choosing. At the conclusion of the investigation, all wreckage and debris of the Observation Aircraft, equipment, and sensors if found and recovered will be returned to the Observing Party if so requested.

Article XIV. Non-Interference

No Party shall use any device or equipment to interfere with the operation of the Observation Aircraft, with the functioning of the sensors, or with the safe conduct of any Observation Flight.

Article XV. Use of Information

(1) Information acquired through Observation Flights shall be used exclusively for the attainment of the purpose of this Treaty.

(2) Both the Observing and the Observed Parties shall receive complete set of the data obtained as a result of processing of observation materials.

(3) Observation materials obtained as a result of an Observation Flight shall be processed in accordance with Annex H.

(4) Information obtained by a Party as a result of Observation Flights must not be used to the detriment of the other Party's security or other interests and must transferred to any third State.

Article XVI. Hungarian-Romanian Open Skies Consultative Commission

(1) To promote the objectives and implementation of the provisions of this Agreement, the Parties hereby establish the Hungarian-Romanian Open Skies Consultative Commission (hereinafter referred to as "the Commission").

(2) The Commission shall make decisions and undertake actions on the basis of agreement of the Parties.

(3) Each Party may raise before the Commission any issues concerning compliance with the obligations of this Agreement.

(4) The Parties shall meet within the framework of the Commission to:

(a) agree upon such technical and administrative measures, consistent with this Agreement, as may be necessary to ensure the viability and effectiveness of this Agreement;

(b) consider questions relating to compliance with the obligations assumed under this Agreement;

(c) agree on updates to the Annexes that so provide; and

(d) consider and act upon all matters referred to it by a Party pursuant to this Agreement.

(5) General provisions for the operation of the Commission are set forth in Annex F.

Article XVII. Notifications

Except as otherwise stipulated, the Parties shall provide the notifications required by this Treaty through diplomatic channels.

Article XVIII. Liability

A Party shall, in accordance with international law and practice, be liable to pay compensation for damage to the other Party, or to its natural or juridical persons or their property, caused by it in the course of the implementation of this Agreement.

Article XIX. Aircrew Members and Inspection Crew Members

(1) Aircrew Members and Inspection Crew Members shall be designated by each Party in the following manner:

(a) Within 30 days after signature of this Agreement each Party shall provide to the other Party for its review a list of proposed Aircrew Members and Inspection Crew Members who will conduct Observation Flights for that Party. This list shall not exceed 30 persons and shall contain the name, birth date, rank, function and passport type for each person on the list. Each Party shall have the right to amend its list of Aircrew Members and Inspection Crew Members. Each Party shall have to provide to the other Party its amended list of Aircrew Members and Inspection Crew Members.

(b) If any person on the original or amended list is unacceptable to the other Party, it shall, within 14 days, notify the Party providing the list that such persons will not be accepted as Aircrew Members and Inspection Crew Members. Persons not declared unacceptable within 14 days are deemed accepted as Aircrew Members and Inspection Crew Members. In the event that a Party subsequently determines that an Aircrew Member or an Inspection Crew Member is unacceptable, the Party shall so notify the Party that designated the Aircrew Member or Inspection Crew Member, which shall, not later than two working days thereafter, strike such person from its Aircrew Member and Inspection Crew Member list.

(2) In order to exercise their functions effectively, for the purpose of implementing the Agreement, Aircrew Members and Inspection Crew Members shall be accorded the inviolability and immunities as specified in Articles 29, 30, paragraph 2 with respect to papers and correspondence and 31 of the Convention on Diplomatic Relations done in Vienna on 18 April 1961. Such inviolability and immunities shall be accorded for the entire period from the arrival of the Aircrew Members or Inspection Crew Members to the Territory of the Observed Party until their departure from it, and thereafter with respect to acts previously performed in the exercise of their official functions as Aircrew Members or Inspection Crew Members. The immunity from jurisdiction may be waived by the Observing Party in those cases when it is of the opinion that immunity would impede the course of justice and that it can be waived without prejudice to the Agreement. Such waiver must always be express. Without prejudice to their inviolability and immunities or to the rights of the Observing Party under this Agreement, it is the duty of Aircrew Members and Inspection Crew Members to respect the laws and regulations of the Observed Party.

(3) Aircrew Members and Inspection Crew Members of a Party shall be permitted to bring into the Territory of the Observed Party, without payment of any customs duties or related charges, articles for their personal use, with the exception of articles the import or export of which is prohibited by law or controlled by quarantine regulations.

(4) In the event that either the Observing Party or the Observed Party considers that there has been a violation or an abuse of the inviolability or immunities accorded under this Article, that Party may forward a report specifying the nature of the issue to the Commission for consideration.

Article XX. Ratification, Entry into Force

(1) The present Agreement is subject to ratification in accordance with constitutional procedures of each Party.

(2) This Agreement shall enter into force upon the exchange of the instruments of ratification.

Article XXI. Amendments; Implementing Measures; periodic Review

(1) Each Party may propose amendments to this Agreement. Agreed amendments shall enter into force in accordance with the procedures set forth in Article XX governing the entry into force of this Agreement.

(2) Any decision taken by the Commission pursuant to subparagraphs (a) or (c) of Paragraph 4 of Article XVI shall be deemed not to be amendments to this Agreement.

(3) Within 60 days of the signature of a multilateral Open Skies Treaty a session of the Commission is to be convened to consider matters related to the further implementation of this Agreement.

Article XXII. Duration; Denunciation

(1) This Agreement shall be of unlimited duration.

(2) Each Party may denunciate this Agreement if it decides that extraordinary events related to the subject matter of this Agreement have jeopardised its supreme interests. A Party intending to denunciate the Agreement shall give notice of its decision to the other Party at least six months in advance of its denunciation.

(3) In the event that a Party gives notice of its decision to denunciate this Agreement in accordance with paragraph 2 of this Article, a meeting of the Commission shall be convened by the Parties within 30 days after such a notification has been received in order to consider practical matters related to the denunciation of the Agreement.

Article XXIII. Registration

This Agreement shall be registered pursuant to Article 102 of the Charter of the United Nations.

Article XXIV

This Agreement contains XXIV Articles and Annexes A-H, all of which form an integral part of this Agreement.

Done at ……………………….., this …………………… day of ……………………. 19……., in two copies, each in Hungarian and Romanian languages, all two texts being equally authentic.

Annex A

	Hungary	Romania
Number of Observation Flights per Year	4	4
Maximum Length of Observation Flights	3 hours	3 hours
Maximum Distance of Observation Flights	1200 km	1200 km

This Annex may be updated by the Commission. This update shall not be considered an amendment of the Agreement.

Annex B

	Hungary	Romania
Points of Entry and Exit:	Budapest-Ferihgy Szolnok	Bucharest-Otopeni Timisoara
Arrival and Departure Fixes:	All Arrival and Departure Fixes along the Hungarian-Romanian border published in the AIP.	
Air Routes to and from Points of Entry and Exit:	The International airways.	
Language to be used during briefings:	Hungarian	Romanian

This Annex may be updated by the Commission. This update shall be considered amendment of the Agreement.

Annex C – Inspections

The following procedures shall govern the inspection of the Observation Aircraft by the Inspection Team conducted to determine whether there is any prohibited equipment on the Observation Aircraft pursuant to Article IX of the Agreement.

(1) Upon arrival of the Observation Aircraft at the Point of Entry, the Inspection Team shall, if requested by the Inspector Escorts, provide the Inspector Escorts a briefing on how the Inspection Team intends to inspect the Observation Aircraft, including, but not limited to, any safety precautions pertaining to Inspection Team activities, and shall undertake the following measures:

(a) deliver to the Inspector Escorts a list of members of the Inspection Team, which shall not exceed 10 members, unless otherwise agreed to by the Observing Party and the Observed Party, and a statement of the general function during the inspection of each member of the Inspection Team; and

(b) deliver to the Inspector Escorts a list of each item of inspection equipment to be used by the Inspection Team in conducting the inspection, which shall be limited to the following items:

(i) flashlights;

(ii) still and video cameras;

(iii) notepads, inspection records, rulers, pens, and pencils;

(iv) hand-held audio recorders, the use of which shall be limited to recording inspection activities;

(v) passive infrared sensors;

(vi) ultrasonic equipment;

(vii) lens measuring devices;

(viii) borescopes;

(ix) other specialised measurement equipment approved by the Inspector Escorts and appropriate for inspection of the type of Observation Aircraft, equipment and sensors being inspected; and

(x) other equipment as approved in writing by the Inspector Escorts for that inspection; and

(c) with the participation of Inspector Escorts, conduct an inventory of each item inspection equipment set forth on the list delivered by the Inspection Team pursuant to subparagraph 1(b) of this Annex, and review with the Inspector Escorts the accounting procedures the Inspector Escorts shall follow pursuant to Paragraph 9 of this Annex to confirm that each item of inspection equipment brought aboard the Observation Aircraft by the

Inspection Team has been removed from the Observation Aircraft upon conclusion of the inspection.

(2) Upon delivery of the Flight Plan, unless otherwise mutually agreed to by the Observed Party and Observing Party, the Inspection Team of the Observed Party may inspect the Observation Aircraft, accompanied by Inspector Escorts of the Observing Party, to determine whether there is any Prohibited Equipment on the Observation Aircraft. All such inspections shall be conducted in accordance with Article IX and the Annex C.

(3) The Inspection Team shall be accompanied throughout the entire inspection of the Observation Aircraft by the Inspector Escorts to confirm that inspection is being conducted in accrdance with the provisions of this Annex. The Inspection Team shall facilitate the execution of this duty by the Inspector Escorts. The Inspector Escorts shall facilitate the inspection of the Observation Aircraft, its equipment, and its sensors by the Inspection Team.

(4) In conducting its inspection, the Inspection Team shall have full access to the entire exterior and interior of the Observation Aircraft and its equipment. Such access shall be provided to, but not limited to, the following:

(a) cockpit;

(b) cabin area;

(c) tail section;

(d) nose;

(e) wings;

(f) engines;

(g) fuselage; and

(h) cargo and storage areas.

(5) n conducting its inspection, the Inspection team shall have full access to sensors. All access to sensors and electronic equipment associated with such sensors connected to or protruding from the exterior or located within the interior of the Observation Aircraft shall be obtained through access panels, where such access panels are designed to be opened, removed, and re-emplaced.

(6) Notwithstanding the provisions of paragraphs 4 and 5 of this Annex, the inspection shall be conducted in a manner that does not:

(a) degrade or damage, or prevent subsequent operation of the Observation Aircraft, its equipment, or its sensors;

(b) alter the electrical or mechanical structure of the Observation Aircraft, its sensors, or its equipment; or

(c) impair the air-worthiness of the Observation Aircraft.

The Inspection Team may not open compartments on board the Observation Aircraft, remove aircraft, sensor, or equipment panels, or remove physical barriers to access to the Observation Aircraft, its equipment, or its sensors; provided, however, that the Inspector Escorts shall, upon request, do all such opening or removal, to the extent that compartments, panels and barriers in question are designed to be opened, removed, and re-emplaced. The Inspector Escorts shall equip themselves with necessary tools to fulfil all such requests promptly. The Inspector Escorts shall be provided sufficient time during the inspection to re-emplace and secure all components, panels and barriers that are opened or removed, so that at the end of the inspection all such components, panels, and barriers are re-emplaced and secured.

(7) Equipment not on the inspection equipment list delivered by the Inspection Team pursuant to subparagraph 1 (b) of this Annex may not be brought on board the Observation Aircraft by the Inspection Team, nor may the Inspection Team bring weapons of any kind on board the Observation Aircraft.

(8) The Inspection Team may make notes, photographs, video and voice recordings, sketches and similar records of the Observation Aircraft and sensors during the inspection, none of which shall be subject to any review or examination by the Observing Party.

(9) Upon completion of the inspection, which shall terminate no later than three hours prior to the scheduled commencement of the Observation Flight, and shall have a duration of not more than 8 daylight hours, unless otherwise agreed by the Parties, the Inspection Team shall:

(a) withdraw from the Observation Aircraft and its immediate area to a location not closer than 25 meters from any part of the observation Aircraft; and

(b) demonstrate to the Inspector Escorts that all inspection equipment on the list delivered pursuant to subparagraph 1(b) of this Annex has been removed from the Observation Aircraft.

The Inspector Escorts may use their own accounting procedures to confirm compliance with subparagraph (b) of this paragraph. If the Inspector Escorts are unable to confirm compliance with subparagraph (b) of this Paragraph, the Observed Party may prohibit the Observation Flight, and no Observation Flight shall be recorded against the Quota of either Party.

(10) The Inspection Team shall immediately inform the Inspector Escorts of any equipment suspected to be Prohibited Equipment located by the Inspection Team on board the Observation Aircraft. If the Observating Party is unable to demonstrate that the items in question are not Prohibited Equipment, the Observed Party may prohibit the Observation Flight pursuant to subparagraph 1(g) of Article XII of the Agreement, and the Observation Aircraft shall thereupon depart the Territory of the Observed Party.

(11) Information and briefings furnished by a Party pursuant to this Annex shall be provided in the language that is designated for that Party in the Annex B, unless the Party receiving the information or briefing otherwise agrees.

(12) The Observed Party shall, upon request, provide a suitable briefing room for briefings provided for by this Annex and for use by Inspector Escorts in preparing information in connection with inspections. The Observed Party shall also provide the assistance of clerical personnel to Inspector Escorts in connection with the performance of their responsibilities under this Annex.

(13) The Observed Party shall not disclose to non-Parties information about the Observation Aircraft, its equipment, or its sensors obtained pursuant to Article IX or this Annex without the express permission of the Observing Party.

(14) Upon entry into force of this Agreement, each Party shall notify to the other Party of each type and model of Observation Aircraft and sensor it intends to use for Observation Flights. Each time a Party intends to use for Observation Flights a new model of Aircraft or a new model of sensor of agreed types, it shall notify to the other Party the model of the Aircraft or sensor. Functional description and generic diagrams of the Aircraft, its equipment and sensors, to include all sensor components, shall be provided upon request.

(15) Within a period of 30 days after notification of each type and model of Observation Aircraft and sensor pursuant to Paragraph 14, each Party shall notify to the other Party of a 7 day period during which a representative type and model of each such Observation Aircraft and/or sensor shall be available for examination. The Party whose Observation Aircraft and/or sensors are being examined shall provide adequate facilities in which to conduct the examination.

(16) Examinations shall not exceed 48 hours in length without the consent of the Party whose Observation Aircraft and/or sensors are being examined.

(17) The representatives of Party conducting the examination shall be:

(a) identified to the Party whose Observation Aircraft and sensors are being examined in advance of the examination;

(b) nationals of the Party;

(c) accorded the inviolability and immunities enjoyed by diplomatic agents pursuant to Articles 29 and 31 of the Vienna Convention on Diplomatic Relations for the entire period of their presence in the Territory of the Party whose Observation Aircraft and sensors are being examined, and thereafter with respect to acts previously performed in exercise of their official functions;

(d) accorded the same treatment as is accorded to Aircrew Members and Inspection Crew Members under paragraph 2 of Article XIX of the Agreement regarding waiver of immunity, and under paragraphs 3 and 4 of Article XIX of the Agreement;

(e) governed by the provisions of paragraphs 1, 3-8, and 12 of this Annex to the extent that those paragraphs are applicable to Inspections Team members;

(f) accompanied during the examination by representatives of the Party whose Observation Aircraft and sensors are being examined; and

(g) required to identify specific inspection equipment, and, if requested by the Party whose Observation Aircraft and sensors are being examined, shall demonstrate that such equipment will not degrade, damage, alter or impair the normal operation of the Observation Aircraft and its sensors.

(18) The Party whose Observation Aircraft and sensors are being examined shall, prior to commencement of such examination, undertake the following measures:

(a) brief the Party conducting the examination on all necessary safety precautions for the examination of the Observation Aircraft;

(b) brief the Party conducting the examination on the procedures the Party whose Observation Aircraft and sensors are being examined intends to use to allow a thorough examination;

c) brief the Party conducting the examination on the configuration of the Observation Aircraft and on the location of sensors and associated equipment on the Observation Aircraft; and

d) use best efforts to answer questions of the Party conducting the examination pertaining to the examination.

(19) Pursuant to paragraph 17(e) of this Annex, the Party conducting the examination may not open compartments on board the Observation Aircraft, remove aircraft, sensor, or equipment panels, or remove physical barriers to access to the Observation Aircraft, its equipment, or its sensors; provided, however, that the Party whose Observation Aircraft and sensors are being examined shall, upon request, do all such opening or removal, to the extent that the compartments, panels, and barriers in question are designed to be opened, removed, and re-emplaced.

Annex D – Flight Monitors

(1) Obligation of the Parties

Each Party shall facilitate the mission of the Flight Monitors.

(2) Purposes of the Flight Monitors

The purposes of having Flight Monitors aboard the Observation Aircraft during the Observation Flight are:

(a) To represent the Observed Party;

(b) To monitor compliance by the Observing Party with the provisions of the Agreement;

(c) To ensure compliance with the Flight Plan;

(d) To monitor the operation of sensors and other equipment of the Observation Aircraft;

(e) To advise on national rules of the Observed Party (e.g., rules on flight safety) as requested by the Observing Party;

(f) In the event of an emergency, to facilitate communications as directed by the pilot in command of the Observation Aircraft.

(3) General Rules for the Conduct of Flight Monitors

(a) Two Flight Monitors shall have the right to board the Observation Aircraft at the Point of Entry and to remain aboard during the Observation Flight, including any stops for refuelling or emergencies.

(b) The Flight Monitors shall have the right to bring aboard the Observation Aircraft maps, flight charts, publications, equipment operating manuals, and other equipment, such as tape voice recorders.

(c) Except for flight safety reasons, the Flight Monitors shall have the right to move unencumbered about the Observation Aircraft, including the flight deck. In exercising their rights, the flight Monitors shall not interfere with the activities of the Aircrew Members.

(d) The Flight Monitors shall have the right to view the operation of the sensors by the Observing Party as well as all activities on the flight deck during the Observation Flight. This includes the right to listen to the communication of the Observation Aircraft (internal and external) and to monitor the flight and navigation instrument of the Observation Aircraft.

(e) The Flight Monitors are the representatives of Observed Party during the conduct of the Observation Flight. Flight Monitors may offer advice, communicate with air traffic controllers as appropriate, and may help relay and interpret communications, from the air traffic controllers to the Aircrew Members, about the conduct of the observation Flight. For this purpose, the Flight Monitors shall be given access to the radio equipment of the Observation Aircraft.

(f) Flight Monitors are responsible for knowing the position of the Observation Aircraft and the location of Hazardous Airspace along and near the route of the Observation Flight. If a Flight Monitor or air traffic control personnel of the Observed Party believes that the Observation Aircraft is deviating from its Flight Plan, the Aircrew Members shall be advised.

(g) Should the Flight Monitors determine that they are not being permitted to exercise their rights under the Agreement, the Observed Party shall forward a report specifying the nature of the issue to the Joint Open Skies Consultative Commission for consideration.

Annex E – Sensors

(1) The sensor package for Open Skies purposes may comprise any of the following types of sensors in any number and combination:

(a) Camera, Optical;

(b) Video Camera.

(2) The Hungarian-Romanian Open Skies Consultative Commission shall annually consider updates to this Annex.

(3) Signals intelligence collection from the Observation Aircraft is prohibited. Any device that can collect, process, retransmit, and/or record electronic signals related to communications, instrumentation, telemetry, and electronic non-communication signals is prohibited, except: (a) that equipment required for navigation and flight operations, and (b) those devices that are components of other sensors (e.g. recording equipment for onboard non-prohibited sensors). Such excepted equipment and devices shall not be used to perform any prohibited function.

(4) Data link (encrypted/unencrypted) equipment, such as that which could be used to transmit sensor data from the Observation Aircraft to a ground station, to other aircraft or to satellites, is prohibited.

Annex F – Commission

(1) The Commission shall undertake such action as is provided for in Article XVI of the Agreement.

(2) Each party shall appoint a Representative, assisted by such staff as that Party deems necessary, to the Commission.

(3) The Commission shall hold one regular session per calendar year unless it decides otherwise. Special sessions may be convened upon the request by a Party. Such a Party shall inform the other Party in advance of the matters to be submitted for consideration.

(4) The initial session of the Commission shall be held within sixty days of the entry into force of the Agreement. Thereafter, sessions of the Commission shall be held at the capitals of the Parties, and shall alternate between the two capitals every year. The Party at whose capital a session is held shall provide administrative support for that session. Sessions may also be held at such other places as the Parties may agree.

(5) At its initial session, the Commission shall establish its Rules of Procedure.

(6) The proceeding of the Commission shall be confidential. The Commission may agree to make its decisions public.

(7) Each Party shall bear the expenses incurred from its participation in the Commission. Expenses incurred by the Commission as a whole shall be shared equally by the Parties.

Annex G – Hazardous Airspace

The Hazardous Airspaces of the Parties are those that are published in the AIP.

Annex H – Processing of Materials of the Observation Flights

(1) Obligations of the Parties

(a) Each Party will in every possible way facilitate the timely and high-quality processing of the observation materials and their provision to the Observing Party.

(b) The Party carrying out the processing shall be responsible for the quality of the processing of the Observation Flight materials.

(2) (a) The initial processing (development) of Observation Flight materials shall be carried out in established ground facilities to be notified by the Parties upon entry into force of the Agreement, by mixed groups of specialists of the Observed and the Observing Parties and with the aid of agreed equipment.

(b) Whenever it is possible to install dual sensors on board of the Observation Aircraft, the Observing Party shall take home one set of observation materials while the other original set of observation material shall be retained by the Observed Party. If it is not possible to install dual sensors on board of the Observation Aircraft, the observation material shall remain with the Observed Party while the copy shall be taken home by the Observing Party.

APPENDIX I

TREATY ON OPEN SKIES—PREAMBLE AND CONTENTS

References, Preamble, Table of Contents

I.1 References to full text

The full text of the Treaty on Open Skies as signed on 24 March 1992 can be found, for example, at the following sources:

a) World Wide Web:
http://www.state.gov/www/global/arms/treaties/openski1.html,
http://www.osmpf.wpafb.af.mil (22 March 2002);
b) Printed version:
- Bundesgesetzblatt 2045 Teil II Z 1998 A, ausgegeben zu Bonn am 3. Dezember 1993, Nr. 43, Gesetz zu dem Vertrag vom 24. März 1992 über den offenen Himmel, Bundesanzeiger Verlagsgesellschaft mbH
- SIPRI, *Yearbook 1993*, pp. 653-71 (without Annexes), (in English)
- R. Hartmann and W. Heydrich, *Der Vertrag über den offenen Himmel*, Nomos: Baden-Baden, 2000 (in German).

I.2 Preamble and Article I of the Treaty

TREATY ON OPEN SKIES
Preamble

The States concluding this Treaty, hereinafter referred to collectively as the States Parties or individually as a State Party,

Recalling the commitments they have made in the Conference on Security and Co-operation in Europe to promoting greater openness and transparency in their military activities and to enhancing security by means of confidence- and security-building measures, Welcoming the historic events in Europe which have transformed the security situation from Vancouver to Vladivostok,

Wishing to contribute to the further development and strengthening of peace, stability and co-operative security in that area by the creation of an Open Skies regime for aerial observation,

Recognizing the potential contribution which an aerial observation regime of this type could make to security and stability in other regions as well,

Noting the possibility of employing such a regime to improve openness and transparency, to facilitate the monitoring of compliance with existing or future arms control agreements and to strengthen the capacity for conflict prevention and crisis management in the framework of the Conference on Security and Co-operation in Europe and in other relevant international institutions,

Envisaging the possible extension of the Open Skies regime into additional fields, such as the protection of the environment,

Seeking to establish agreed procedures to provide for aerial observation of all the territories of States Parties, with the intent of observing a single State Party or groups of States Parties, on the basis of equity and effectiveness while maintaining flight safety,

Noting that the operation of such an Open Skies regime will be without prejudice to States not participating in it,

Have agreed as follows:

Article I

GENERAL PROVISIONS

1. This Treaty establishes the regime, to be known as the Open Skies regime, for the conduct of observation flights by States Parties over the territories of other States Parties, and sets forth the rights and obligations of the States Parties relating thereto.

2. Each of the Annexes and their related Appendices constitutes an integral part of this Treaty.

I.3 Table of Contents of the Treaty on Open Skies

APPENDIX J

DECISIONS OF THE OPEN SKIES CONSULTATIVE COMMISSION (TITLES ONLY)

The full text of decisions 1-22 can be found at http://www.osmpf.wpafb.af.mil (22 March 2002).

1992-1997

DECISION ONE: Distribution of Costs Arising Under the Treaty on Open Skies as Decided in the Open Skies Consultative Commission on 29 June 1992 and Adopted by the Commission's Decision of 10 December 1992

DECISION TWO: Additional Non-Destructive Testing Equipment, 29 June 1992

DECISION THREE: Methodology for Calculating the Minimum Height Above Ground Level at Which Each Optical Camera Installed on an Observation Aircraft May Be Operated During an Observation Flight, 29 June 1992

DECISION FOUR: Minimum Camera Specification for an Observation Aircraft of an Observed Party Exercising its Right to Provide an Observation Aircraft for an Observation Flight, 29 June 1992

DECISION FIVE: Responsibility for the Processing of Film Used During an Observation Flight, 29 June 1992

DECISION SIX: Rules of Procedure and Working Methods of the Open Skies Consultative Commission, 1992

DECISION SEVEN: Methodology for Determining the Ground Resolution of Synthetic Aperture Radar (SAR), 10 December 1992

DECISION EIGHT: Intervals at Which Data Shall Be Annotated With Information, 16 July 1993

DECISION NINE: Codes Other than Alphanumeric Values to Be Used for the Annotation of Data, 16 July 1993

DECISION TEN: Scale of Distribution for the Common Expenses Associated With the Operation of the Open Skies Consultative Commission, 1993

2001 (Decisions were issued in 2001 without numbering)

OSCC Decision on the Working Modalities of the OSCC, 25 June 2001
OSCC Decision on Information Seminar on the Treaty on Open Skies, 17 September 2001
OSCC Decision on the Informal Working Groups of the Open Skies Consultative Commission, 29 October 2001
OSCC Decision on Rules of Procedure and Working Methods of the Open Skies Consultative Commission, 17 December 2001
OSCC Decision on Provisions for the Initial Certification Period, 17 December 2001

2002

DECISION No. 01/02	Fulfilment of the Requirements for the Czech Republic and Slovakia to Exercise the Rights and Fulfil the Obligations, 21 January 2002
DECISION No. 02/02	Accession of the Republic of Finland to the Treaty on Open Skies, 21 January 2002
DECISION No. 03/02	Accession of the Kingdom of Sweden to the Treaty on Open Skies, 21 January 2002
DECISION No. 04/02	Provisions for the Use of a Standard "Signature Page to the Certification Report", 18 February 2002
DECISION No. 05/02	Provision for the Use of "PG" as a Unique Identifier for Pod Group Sensor Configurations, 1 February 2002
DECISION No. 06/02	Procedures for Allocation of Observation Flight Reference Numbers, 18 February 2002
DECISION No. 07/02	Revision 1 of DECISION NUMBER ONE (Travel Expenses), 18 March 2002
DECISION No. 08/02 (REV1/Corr 1)	Guidelines for Accession to the Treaty on Open Skies, 22 April 2002
DECISION No. 09/02	Protection of Data Collected During Observation Flights and Transfer of Recording Media Containing this Data, 13 May 2002
DECISION No. 10/02	Revision 1 of DECISION NUMBER EIGHTEEN, 10 June 2002

DECISION No. 11/02	Revision 2 of DECISION NUMBER ONE, 10 June 2002
DECISION No. 12/02	Allocation of a Passive Quota to Sweden, 22 July 2002
DECISION No. 13/02	Allocation of Observation Flight Reference Numbers, 22 July 2002
DECISION No. 14/02	Revision 1 of DECISION NUMBER TWENTY, 22 July 2002
DECISION No. 15/02	Provision on Calibration Targets, 22 July 2002
DECISION No. 16/02	Mission Plan Submission and Review, 22 July 2002
DECISION No. 17/02	Accession of the Republic of Lithuania to the Treaty on Open Skies, 22 July 2002
DECISION No. 18/02	Accession of the Republic of Croatia to the Treaty on Open Skies, 22 July 2002
DECISION No. 19/02	Accession of Bosnia and Herzegovina to the Treaty on Open Skies, 22 July 2002
DECISION No. 20/02	Accession of the Republic of Latvia to the Treaty on Open Skies, 22 July 2002
DECISION No. 21/02	Scale of Distribution for the Common Expenses Associated with the Operation of the Open Skies Consultative Commission, 9 September 2002
DECISION No. 22/02	Procedures for Transit Necessary During a Segment of an Open Skies Observation Flight, 16 December 2002
DECISION No. 23/02	Allocation of a Passive Quota to Finland, 16 December 2002
DECISION No. 24/02	Revision 2 of Decision Number Twenty to the Treaty on Open Skies, 16 December 2002
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DECISION No. 03/03	Open Skies Aircraft Status, 24 February 2003

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The full text of the document is reprinted in R. Hartmann and W. Heydrich, *Der Vertrag über den offenen Himmel*, Baden-Baden: Nomos, 2000, pp. 359-550. It can also be found at http://www.osmpf.wpafb.af.mil (22 March 2002).

No. 500/A

Open Skies Consultative Commission 26 May, 1997
Informal Working Group on Sensors GTOCL.DOC

GUIDANCE FOR CERTIFICATION OF OPEN SKIES SENSORS INSTALLED ON
OBSERVATION AIRCRAFT AND THEIR ASSOCIATED PROCESSING, DUPLICATING, AND ANALYSIS EQUIPMENT AND THE CONDUCT OF DEMONSTRATION FLIGHTS

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SELECTED BIBLIOGRAPHY

Armstrong, D. G., "Technical Challenges Under Open Skies" in *Proceedings of the First International Airborne Remote Sensing Conference and Exhibition*, Strasbourg, Ann Arbor: Environmental Research Institute of Michigan, Vol. I, 1994, pp. 49-60.

Arnold, K., *Der Vertrag über den Offenen Himmel: Ein Konzept zur Aktualisierung des Vertrages*, SWP Studie, Stiftung Wissenschaft und Politik, Berlin, June 2002.

Baker, J. C., K. M. O'Connell and R. A. Williamson (eds), *Commercial Observation Satellites*, Santa Monica and Bethesda: Rand and ASPRS, 2001.

Britting, E., *Rüstungskontrolle im "Offenen Himmel" Europaische Sicherheit*, No. 6, 2000, pp. 15-17.

Britting, E. and H. Spitzer, "The Open Skies Treaty", in Poole, J. B. and R. Guthrie (eds), *Verification Report 1992*, VERTIC, London and New York: The Apex Press, 1992, pp. 223-38.

Clark, J., "Open Skies", in M. Slack and H. Chestnutt (eds), *Open Skies—Technical, Organizational, Operational, Legal and Political Aspects*, Toronto: Centre for International and Strategic Studies, York University, 1990.

Gabriele, M. D., *The Treaty on Open Skies and its Practical Applications and Implications*, Santa Monica, CA: RAND, 1998.

Hartmann, R., *Inkrafttreten des Vertrags über den Offenen Himmel*, SWP Aktuell 25, Berlin, Stiftung Wissenschaft und Politik, December 2001, p. 4.

Hartmann, R. and W. Heydrich, *Der Vertrag über den Offenen Himmel*, Baden-Baden: Nomos Verlag, 2000.

Hawes, J. A., *Open Skies: Beyond "Vancouver to Vladivostok"*, Occasional Paper No. 10, Washington, DC: The Henry L. Stimson Center, December 1992.

Jones, P. and M. Krasznai, "Open Skies: Achievements and Prospects", in Poole, J. B. and R. Guthrie (eds), *Verification Report 1992*, VERTIC, London and New York: The Apex Press, 1992.

Jones, P., "Open Skies: A Review of Events at Ottawa and Budapest", in J.B. Poole (ed.), *Verification Report 1991*, VERTIC, London and New York: The Apex Press, 1991.

Jones, P., "Open Skies: Events in 1993", in Poole, J. B. and R. Guthrie (eds), *Verification Report 1993*, VERTIC, London and New York: Brassey's, 1993.

Koulik, S. and R. Kokoski, *Conventional Arms Control—Perspectives on Verification*, SIPRI: Oxford University Press, 1994.

Krepon, M., P. Zimmerman, L. Spector and M. Umberger (eds), *Commercial Observation Satellites and International Security*, New York: St. Martin's Press, 1990.

Krepon, M., and A. E. Smithson (eds), *Open Skies, Arms Control, and Cooperative Security*, New York: St. Martin's Press, 1992.

Krepon, M. (ed.), *A Handbook of Confidence-Building Measures for Regional Security*, Washington, DC: The Henry L: Stimson Center, 1995.

Lillesand, T. M. and R. W. Kiefer, *Remote Sensing and Image Interpretation*, New York: John Wiley, 1987.

Lysyshyn, R. J., "Open Skies Ahead", *NATO Review*, Vol. 40, No. 1, February 1992, pp. 23-26.

Jia, X, J. A. Richards and D. E. Ricken (eds), *Remote Sensing Digital Image Analysis*, Heidelberg and New: York Springer, 1993.

Rostow, W. W., *Open Skies*, Austin: University of Texas Press, 1982.

Simmons, S. P., "When Better Resolution Is Not Good: The Treaty on Open Skies", in Proceedings of the Second International Airborne Remote Sensing Conference and Exhibition, San Francisco, Ann Arbor: Environmental Research Institute of Michigan, Vol. I, 1996, pp. 403-10.

Slack, M. and H. Chestnutt (eds), *Open Skies: Technical, Organizational, Operational Legal and Political Aspects*, Toronto: Centre for International and Strategic Studies, York University, 1990.

Spector, L. S., "The Not-So-Open Skies," in Krepon et al. (eds), *Commercial Observation Satellites and International Security*, New York: Macmillan, 1990, pp. 165-66.

Spitzer, H., "Technical Potential for Monitoring from Air and Space", in Altmann, J., H. J. van der Graaf, P. Markl, and P. Lewis (eds), *Verification at Vienna—Monitoring Reductions of Conventional Armed Forces*, New York: Gordon & Breach, 1992, pp. 125-139.

Spitzer, H., "The Open-Skies Treaty as a Tool for Confidence Building and Arms Control Verification", extended contribution to the 18th ISODARCO Summer Course, Siena, July 1996, Technical Report, CENSIS-Report-23-96, University of Hamburg, Luruper Chaussee 149, D-22761 Hamburg, 1996.

Treaty on Open Skies: Message from the President of the United States Transmitting the Treaty on Open Skies with Twelve Annexes, Signed at Helsinki on March 24, 1992, Washington, DC: US Government Printing Office, 1992, pp. 267.

Treaty on Open Skies, Report to Accompany Treaty Doc. 102-37, Washington, DC: US Government Printing Office, 1993, pp. 174.

Tucker, J. B., "Back to the Future: The Open Skies Talks", *Arms Control Today*, Vol. 20, No. 8, October 1990, pp. 20-24.