The Open-Skies Treaty as a tool for confidence building and arms control verification[1]

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Abstract

The Treaty on Open Skies, signed in Helsinki on March 24th, 1992, represents the most wide-ranging multinational effort so far to enhance military transparency and confidence building through mutual aerial observation flights. Its purpose is to facilitate the monitoring of compliance with existing or future arms control treaties and to strengthen the capacity for conflict prevention and crisis management. The preamble addresses also "the possible extension of the Open-Skies regime to additional fields, such as the protection of the environment". The treaty measures are both intrusive and cooperative: Virtually the full territory of each state party is open to overflights; flights are accompanied by joint teams and the image data can be shared. So far 27 states have signed the treaty including 16 NATO states as well as Belarus, Bulgaria, the Czech Republic, Georgia, Hungary, Kyrgyzstan, Poland, Romania, Russia, Slowakia and Ukraine. Although ratification of the treaty is still pending in Belarus, Russia and Ukraine, preparations for implementation including many test flights have advanced. This report covers the technical aspects of the treaty (sensors, aircraft, procedures) as well as its political dimensions and future perspectives.

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1 Introduction: Scope of the treaty and negotiation history

Origins and scope

The origins and scope of the Open-Skies Treaty are representative of the last stage of the Cold War. It is a product of Cold War suspicion and of the attempt to overcome this suspicion by mutually agreed openness. Based on the spirit of the Stockholm agreements on confidence and security building measures in Europe of 1986, it has been actively promoted by far-sighted and dedicated officials in the governments of Canada and Hungary. But it would not have become reality without US initiative and substantial compromising both on the part of the US and the USSR/Russian governments as well as through continued cooperation of other state parties.

In the spring of 1989 - half a year before the revolutionary changes in Central-Eastern Europe - President Bush was in the first hundred days of his presidency. His public ratings were meager and he was looking for a foreign policy initiative, which would allow him to gain ground and to test Gorbachev on his claim of greater openness (Glasnost). He ordered his National Security Council Staff to prepare a wide-ranging review of arms control initiatives available to him. One of several such initiatives was Open Skies. Canadian officals became aware that Open Skies was being considered within the National Security Council in April 1989 and were attracted by the idea. They began to encourage their American counterparts to consider the subject sympathetically. During a visit to Washington in early May 1989 the Canadian Prime Minister Mulroney, who had been briefed correspondingly, and his foreign minister Clark urged President Bush and Secretary Baker to respond positively to Open Skies [CLARK 1990].
Bush picked up on the idea, which goes back to a proposal launched by President Eisenhower in 1955.[2] On 12 May 1989 Bush proposed that an Open-Skies initiative be considered by the states of NATO and the Warsaw Treaty Organization (WTO):

> "Now, let us again explore that proposal [Open Skies] but on a broader, more intrusive and radical basis - one which I hope would include the allies on both sides. We suggest that those countries that wish to examine this proposal meet soon to work out the necessary operational details, seperately 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." [JONES 1991, p.73]

The two main goals of the initiative apparently have been to increase mutual confidence through increased scrutiny of each others activity, and to test General Secretary Gorbachev's commitment to Glasnost. Obviously the territories to be covered by overflights would have to include all of North America and Siberia, which are excluded from inspections under the Treaty on Conventional Forces in Europe (CFE).

[2] An evaluation of the Eisenhower proposal and subsequent diplomatic exchanges between the USA and the USSR is given in [KOULIK 1994, p. 156-163]

For Canada one of the main goals was to allow smaller states of the two alliances which did not have reconnaissance satellites of their own, an opportunity to monitor events of interest. Canada also wanted to demonstrate to the European NATO countries that the North American allies were willing to share the burden of intrusive inspections of their territories [CLARK 1990].

Unfortunately these far reaching goals did not give the negotiators a sufficiently quantifiable set of criteria upon which to design the regime. It took almost three years of political manoeuvering, technical discussions and searching for compromise positions until the Open-Skies Treaty could be signed on 24 March 1992 in Helsinki. Since crucial technical details of sensor calibration and aircraft certification were not settled in time, the Open-Skies Consultative Commission had to deal with them in the following years. In particular, procedures had to be agreed upon, which ensure compliance with the resolution limits of the treaty. As a result the Open-Skies Treaty is technically much more complicated than the Treaty on Conventional Forces in Europe (CFE).

Negotiation history

The Soviet reaction to the Open-Skies proposal was generally positive. On 23 September 1989 Soviet Foreign Minister Eduard Shevardnadze and US Secretary of State James Baker issued a joint statement, which called for an international conference on Open Skies. Two such conferences were held in Ottawa (February 1990) and Budapest (April/May 1990), involving all member states of NATO and the Warsaw Treaty Organization. While a basic political consensus on the principles of an Open-Skies Regime was obtained at Ottawa, many crucial technical questions remained unresolved after the Budapest conference. This led to a stalemate of formal negotiations. In April 1991 NATO states offered compromise proposals to the USSR. As a consequence negotiations were resumed in September 1991 in Vienna and completed in an intense negotiation period in Vienna from November 1991 to March 1992.

The negotiations went through many ups and downs. Surprisingly the dissolution of the Soviet Union on 31 December 1991 had little impact. Russia tried to reassert herself as a great power and was understood to act as the successor of the Soviet Union in the negotiations. Other republics were invited to join.[3] The former Soviet head of delegation Yevgeny Golovko continued as Russian Open-Skies ambassador. Trial flights which were arranged by Canada and Hungary already in January and February of 1990 and the conclusion of Hungarian-Romanian bilateral Open-Skies Treaty in May 1991 (discussed below) had a stimulating effect on the negotiations. A lively account of the negotiation history is given by [JONES 1991], [JONES 1992] and [JONES 1993]. Another interesting, largely complementary description of the negotiation history can be found in [KOULIK 1994, p. 163-175].

Objectives and treaty issues

Already in 1990 the state parties (i.e. all NATO states and the states of the dissolving WTO) were able to agree on the *initial objective* of the treaty. The treaty was meant

[3]Belarus and Ukraine joined the negotiations immediately. Georgia and Kyrgyzstan signed the treaty, but will not take part in the initial implementation phase.

to enable participants to identify rapidly massing military formations by the generic types of vehicles within them. In other words: to be able to differentiate a tank from a truck, though not necessarily to identify exactly what type of tank or truck might be involved [JONES 1991, p. 74]. They also agreed on a 24-hour, all-weather sensor capability. This essentially paved the way for the choice of sensor types and capabilities of the treaty. In the end the parties compromised on having *imaging sensors* only, in particular

- optical panoramic and framing cameras with a ground resolution of 30cm
- video cameras with real-time display and a ground resolution of 30cm
- thermal infrared imaging sensors with a ground resolution of 50cm at $\Delta T = 3^oC$ (temperature resolution), and
- imaging radar (Synthetic Aperture Radar, SAR) with ground resolution of 300cm.

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 50km on each side of the flight path.[4] Radar coverage will be limited to a ground swath of 25km on one side of the aircraft. The transverse ground distance of this swath from the flight track can be chosen freely. Fig. 2 (below) illustrates the ground swaths covered the US Open-Skies aircraft. 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.

These capabilities are meant to match the initial intentions of the treaty, as stated in the *preamble*:

The state parties "wish to contribute to the further development and strenghtening of peace, stability and cooperative security in that area [from Vancover to Vladivostok]."
In particular the Open-Skies regime can be applied

- "to improve **openness and transparency**,
- to facilitate 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 (CSCE) and in other relevant international institutions."

The preamble envisages also "the possible extension of the Open Skies regime into additional fields, such as the **protection of the environment**."
Many other difficult issues had to be addressed during the negotiations including

- aircraft ownership/crew origin
- data sharing
- flight quotas

[4] In practice, the ground swath covered by photographic cameras will be smaller. E.g. a Russian-made panoramic camera A-84 on board of the German Open-Skies aircraft (opening angle 143^o) will cover a ground swath of 20-40km at flight altitudes of 4000 to 8000m.

- territorial restrictions

These issues were eventually resolved until March 1992.

2 Treaty provisions

Flight quotas
According to the treaty[5] 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). The total active quota of a state shall not exceed its passive quota. The allocated passive quotas are given in Table 1. I.e. Germany and Italy have to receive 12 overflights per year each, Russia (including Belarus) and the USA 42 overflights each. The active quotas of a state are the same. During the first three years of operation up to 75% of the quotas apply. When trying to allocate the individual active quota entitlements, problems occurred since 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, which is considerably below the 75% line.

Territorial restrictions
One important provision of the treaty is that the full territory of each state party can be overflown except for a ten-kilometer zone next to the state borders of non-state parties. This implies that the vast territories of North America and Siberia which were hitherto "off limits" to inspections under the CFE Treaty will now be accessible to Open-Skies flights. Each flight over a particular country, however, will be restricted to a maximum flight distance, as specified in Table 1.

Whose aircraft to use?
Upon insistence of 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 observing state (the taxi option). This provision goes back to the Soviet hesitance about fully opening its airspace to foreigners. Since Russia pushed the taxi option, the United States and others insisted that a taxi aircraft would have to be equipped with all allowable sensors operating at treaty resolution. Demonstration of that capability became an issue.

Demonstration of sensor resolution
The treatment of sensor resolution is indicative of the treaties dual character between Cold War military thinking and a new openness. Whereas civilian remote sensing practitioners will be happy when a sensor exceeds the design resolution, Open-Skies negotiators desperately tried to avoid this. A lot of effort has to be spent in proving that a sensor **does not** exceed the resolution specified by the treaty. This is to be accomplished in an initial seven-day *certification* of each Open-Skies aircraft and by a short *demonstration flight* at the beginning of an Open-Skies observation mission if requested. During these tests certain calibration targets (e.g. panels with black and white bars in case of optical cameras) are displayed on the ground and recorded by the sensors on board the overflying aircraft. Subsequent processing and analysis has to prove that the resolution goals have been met.

It should be noted that the specified resolution of 30cm for photographic cameras is not

[5]The text of the treaty can be found (without Annexes) e.g. in SIPRI Yearbook 1993, p. 653-671

defined as the standard photographic resolution but rather as a kind of pixel resolution, as explained in the following:

> "Article IV of the Treaty limits the "ground resolution" of optical cameras to 30cm. Ground resolution is defined in the Article II of 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 III, 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] which can be distinguished as separate bars, in centimeters." Since ground resolution is most often explained in terms of Ground Resolved Distance (GRD), or the width of a (black) bar and a (white) space in a resolution target, 30cm ground resolution per Article II is in reality 60cm GRD. Many participants in Open Skies were disappointed to learn that. What they had thought the potential image quality to be, would be significantly less." [ARMSTRONG 1994, p. 1-56]

However, this resolution will still allow the detection of standard military vehicles from their dimensions. Fig. 1 shows as an example an image of a non military site at 70cm pixel resolution (about a factor 2 worse than the ground resolution as defined in the treaty. Parked cars and delivery trucks (indicated by arrows) can be easily recognized.

For optical cameras, Decision III to the treaty is the foundation for establishing the flight altitude H_{min} at which the cameras achieve exactly 30cm of resolution. Decision III defines H_{min} as the average of at least five test measurements (n=5) using pictures taken from a ground resolution target according to the following equation [SIMMONS 1996, p. I-405]:

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

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 30cm;
- L_i is the measured ground resolution, in centimeters;
- K_a is the agreed modulation contrast of 0.4 at which the ground resolution is defined;
- K_i is the effective modulation contrast (see equation below);
- m is the agreed corrected exponent value of 0.45 as derived from laboratory examinations of several different camera lenses,

and

$$K_i = \frac{C-1}{C+1} \text{ and } C = 10^{\Delta \log E},$$

E = exposure response of film.

$\Delta \log E$ = difference of the logarithms of E from black and 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) [ARMSTRONG 1994].[6] 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 [SIMMONS 1996, p. I-405].

Another important part of certification is the checking of film processing conditions required for achieving the treaty resolution [see e.g. SIMMONS 1996, p. I-409].

Data sharing and openness of data

It was the Soviet Union which from the beginning insisted on "equality in acquiring and in access to information". This proposal of data sharing was not met with enthusiasm by several state parties. After considerable manoeuvering the state parties finally agreed on the sharing of the image data. I.e. after an Open-Skies observation flight any state party can request to receive a first generation copy of the image data taken.[7] In the case of photographic film this data (a copy of the film negative) represents nearly the full information in easy-to-analyse form. In case of thermal infrared line scanners and SAR more systemic knowledge is necessary in order to fully exploit the information content of the images.

The option and right of data sharing is one of the most innovative features of the treaty, emphasizing its cooperative character. However, althouth 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 to the author in view of the upcoming commercial US photo-satellites which will provide black and white pictures with one meter ground (pixel) resolution worldwide.[8]

Time sequence of observation events and flight path

The time sequence of observation events is analogous to on-site-inspection procedures of the CFE-treaty. The party requesting an overflight must inform the party to be overflown of its intention 72 hours before the arrival of its aircraft at a designated point of entry; the party to be overflown must acknowledge receipt within 24 hours and state whether it would allow the overflying country to bring its own aircraft or would exercise its right to provide an aircraft; after arrival, the aircraft and sensors might be inspected, and the proposed mission plan will be handed over to the host country. After acceptance of the mission plan, host country officers have to coordinate the flight with the national air control agencies. Open-Skies flights have priority over

[6] In addition the determination of flight altitude based on air pressure is affected by uncertainties. In practice, it was agreed to tolerate a resolution range of 25-35cm.

[7] Radar data can be exchanged either as raw data or as processed image data.

[8] At least two satellite projects are scheduled for launch in 1997 and 1998. See e.g. [DOYLE 1996].

any regular air traffic. The mission plan specifies all target areas to be overflown. Due to the time sequence the observed state has a minimum of 24 hours advance notice between learning about the mission plan and the observation flight.

Each overflight may vary in actual flight path and timing. Flight paths may be unique for every overflight following any path from straight line to serpentine. 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. The time the observing party allocates to execute the flight plan is largely at their discretion. They have a total of 96 hours from the time they arrive at the point of entry to complete their observation overflight. At any point during their overflight, the observing party may also stop at agreed airfields for rest or refueling (any airfield is eligible to be designated as a weather alternate or emergency divert). Thus, the actual time spent collecting data during an Open-Skies observation overflight will vary with each occurrence [HERIC 1996, p. 279]. A typical observation event might proceed as follows:

day 1: - arrival
- point of entry procedure
- preflight inspection

day 2: - demonstration flight
- handing over of mission plan
- discussion and agreement on mission plan
- and subsequent filing of flight plan

day 3: - observation flight

day 4: - continuation of observation flight, if required

day 5: - drafting of mission report
- departure

3 The work of the Open-Skies Consultative Commission since 1992

The treaty foresees the formation of an Open-Skies Consultative Commission (OSCC). This body is responsible for the reallocation of active quotas on an annual basis. It will 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 [JONES 1993, p. 155]. 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 (OSCE) in Vienna.

The OSCC has established four *working groups*. The themes of the groups are: costs; sensors and calibration rules; notification procedures and formats; and flight rules and

procedures. Based on the results of the working groups the OSCC establishes legally binding *Decisions* to the treaty. Such decisions can be further elaborated by *Guidance Documents*, which are open to continuing discussion.

The OSCC and its working groups started intensive work 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 meetings several decisions were taken concerning: (a) how to calculate the minimum permissible flight altitude when using optical and video cameras; (b) how to calculate the minimum height 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 storing and sharing data recorded during an observation flight. These decisions were considered important milestones in the technical and procedural elaboration of the Treaty provisions [BAILER 1995].

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 undermined 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 the entering into force. Work on drafting a Guidance Document for aircraft and sensor certification continues.

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

4 Trial flights and preparations for implementation

The state parties have been quite forthcoming in arrranging mutual *trial flights* in order to develop and test procedures and for training purposes. Pioneering and groundbreaking trial flights were those carried out by Canada and Hungary in January and February 1990 and by Romania and Hungary on 29 June 1991. Germany and the United States were particularly active in the subsequent years. Table 3 shows as an example the trial flights involving Germany in 1995. A short record of the overall trial flights undertaken in 1992 - 1994 can be found in the SIPRI Yearbooks 1993-95 and in [KOULIK 1994, p.187/188].

Most of the signatory nations have established an Open-Skies *operation cell* even though the treaty has not entered into force. These active nations have pursued a training program that is intended to prepare equipment and train personnel for treaty operations. Several nations have *aircraft* modified specifically for Open-Skies use, in particular:

Bulgaria	1 AN30, a medium sized twin engine aircraft, with range of about 1200km, operational
Czechia and Slovakia	1 AN30, in operation (joint aircraft)
Germany	1 TU 154M, in operation (observation range < 6500km) (Ironically, this Soviet made aircraft had been purchased by the GDR in order to serve as the official aircraft of GDR president Erich Honecker. It has been converted since.) 1 TU 154M, option for conversion for OS use
Hungary	1 AN26, operational
Romania	1 AN30, operational
Russia and Belarus	3 AN30, operational 3 AN30, operational for use beyond the Urals 1 TU154, under discussion
Turkey	2 CN235 CASA twin engine aircraft (range about 1200km), planned
Ukraine	1 AN30, operational for flights abroad 1 AN30, operational for flights in Ukraine (taxi option)
United Kingdom	1 Andover PR MK1, a twin engine turbo prop aircraft with range of about 1200km, operational
United States	1 OC-135, operational 2 OC-135, in preparation This is a military version of the "historic" Boeing 707 (observation range > 3000km)

Ten countries (Belgium, Canada, France, Greece, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain) have jointly pursued the development of a sensor pod to be installed under a C-130 Hercules aircraft. This concept allows for any like model C-130 to be used for Open-Skies observation missions, thereby saving the large expense of dedicating aircraft exclusively to Open-Skies use. The pods are boxes containing initially optical and video cameras only.

All participating aircraft will be equipped with photographic framing cameras. Several states will also use a wide-angle panoramic camera. Germany, Russia, and the United States are testing or planning also *thermal infrared line scanners*, which can produce thermal images.[9] Germany and Russia are jointly developing a Russian-made *synthetic aperture radar system* (SAR), whereas the US is refurbishing an older SAR system of their own [FORTNER 1996]. As a rule, sensors used under Open-Skies have to be unclassified and commercially available.

Fig. 2 shows as an example the sensor suite planned for the US Open-Skies aircraft and the ground swaths to be covered. Fig. 3 and 4 show photographs of the US Open-Skies

[9]Infrared line scanners can be used for treaty application only three years after its entry into force.

aircraft and of a framing camera mounted in that aircraft. Fig. 5 shows the German Open-Skies aircraft and three framing cameras mounted. Table 4 gives technical parameters of the sensor suite of the German Open-Skies aircraft.

Fig. 6 shows the flight route of a German-Russian test flight over Siberia. Image analysis of pictures taken demonstrated that weapon systems like tanks, missile transporters and armoured personnel carriers can be identified by generic type and counted if stored in the open [SPERLING 1996].

Fig. 7 is a photograph of the city of Heidelberg, Germany, taken by the German Open-Skies aircraft. The scene shows the main railway station and various bridges. The picture shown has been blurred somewhat by the reproduction process.

Because Open-Skies observation missions are flown in all types of weather, most countries have more than one camera system and more than one type of film. The lower-resolution systems allow the aircraft to operate below the clouds and still abide by treaty resolutions while the high resolution systems allow for wide-area observation when the weather is good. Germany and the UK have introduced resolution degrading optics to lower permissible flight attitude for sensor operation in accordance with the treaty without the expense of another camera system. Analogous to a low-pass filter, these degrading optics are intended to reduce the resolution in a way that cannot be reversed or later enhanced [SIMMONS 1996, p. I-406].

5 Ratification problems and prospects

Most of the signatories have ratified the treaty and deposited the instruments of ratification with the two depository states of the treaty, Canada and Hungary, so far (see Table 5). However, the treaty can only enter into force when Belarus, Russia and the Ukraine have completed their ratification process. Here a major problem has arisen because the Russian Duma seems to be quite reluctant to take action on Open Skies, as well as on the ratification of the START II Treaty and the Chemical Weapons Convention (CWC).

Critical voices within the Duma claim that the treaty is discriminating against Russia for the following reason: Because the 16 NATO states show little interest to overfly each other, a disproportionately higher fraction of data is being generated by overflights over Russia (initially 28 flights per year) than over any other state. For comparison the initial passive quotas of Germany and the USA will be 5 and 4, respectively (see Table 2). The states of the Western European Union and some other state parties reacted to this in 1995 by offering to all other interested states additional active quotas on a voluntary basis. But some asymmetry remains.

Seen from a wider perspective the outlook for Open-Skies treaty ratification by the Duma appears to be quite dim at present. Open Skies seem to be part of a great power game and Russian ratification is dependent on how the country feels that security is the

tool it can use. For many Western states ratification of START II and the CWC clearly is higher on the agenda of political priorities and diplomatic efforts. In the Duma itself a substantial majority of parlamentarians is critical of the West and of anything which is perceived as weakening Russia's military strength. On the other hand, parts of the Russian government and the military system seem to have accepted Open Skies as an endeavour of mutual benefit. E.g. from a Russian point of view Open Skies can ease suspicion and prevent military tension in relation to the states applying for admission to NATO.

Ratification in the Ukrainian Rada failed on 16 January 1996 "for financial reasons" and a second time in September 1996. The treaty will be resubmitted to the Rada in early 1997. It is assumed that Belarus will ratify the treaty once Russia has done so.

6 A success story: The Hungarian-Romanian Open-Skies Treaty

Much more than any trial flight, the joint experience of Hungary and Romania has demonstrated convincingly the success of an Open-Skies regime in confidence building between and within states. The two countries have also demonstrated that an Open-Skies Treaty can be executed in a very cost-effective way.

Treaty provisions and initial experience [JONES 1992, p. 53-55]
On 24th July 1990 - soon after the Budapest Open-Skies conference - Romania proposed to Hungary to start negotiations on a bilateral Open-Skies agreement as part of a larger package for development of bilateral relations. Serious negotiations began in February 1991. Taking into account the experience of the prior Open-Skies conferences in Ottawa and Budapest, the delegations led by ambassadors Marin Buhoara (Romania) and Marton Krasznai (Hungary) succeeded in finalizing the bilateral agreement practically in four days (two in Budapest and two in Bucharest). The two delegations aim was to *create a simple and cost-effective regime*, matching the financial and technical resources of the parties. It was agreed that in the initial stage of implementation of the Agreement both parties would use only those aircraft and sensors which they had at the time of the negotiations. According to the Quota Annex, Hungary and Romania will have the right to carry out four observation flights per year in each other's airspace. This figure may seem low, but it is quite substantial if one takes into account that the bilateral regime will continue functioning after the entry into force of a multilateral Open-Skies Agreement. Flight duration is limited to 4 hours and 1600km maximum (as agreed in 1994, initially the values were somewhat lower lower).

The Sensor Annex permits the use of film and video cameras, without limiting their performance. **Neither the focal length nor the ground resolution of the sensors are limited.** This makes it possible for the parties to use the best equipment they have and fly as low as they wish, but without breaking the rules of flight safety. It also saves lengthy and costly procedures of sensor certification.

Information-sharing is ensured by the use of dual cameras. The two negatives are developed in an established ground facility of the observed party. One negative is taken home by the observing party and the observed party retains the other. When videocameras are used, the videotape is copied. The original remains with the observed party and the observing party may take home the copy.

The treaty was signed in Bucharest on 11 May 1991. The first demonstration flight took place on 29 June 1991 using a Romanian aircraft, which was equipped with a French-made OMERA 33 dual camera. The camera has a focal length of 200mm and takes two identical black-and-white pictures at a time. The demonstration flight proved fully the technical feasibility of a cost-effective, cooperative procedure.

Operations in 1992-1996 and political effect [KRASZNAI 1996]
The Hungarian-Romanian treaty entered into force on 27th February 1992 and has been in regular practice since. Each state has performed an average of three flights per year out of the four foreseen by the agreement, still using the OMERA 33 dual camera and a video system mounted on AN26 and AN30 aircraft, respectively. The flights provide pictures with a typical **ground resolution of 30cm and a ground swath of 3km.**[10] Due to careful planning - considering the weather conditions - 90% of the pictures taken are of good or excellent quality. So far the full territories of both states have been mapped twice. Recent flights are being made to confirm that there is no change in the military postures. Three to four flights per year - performed in different seasons - have proven to be sufficient for that purpose.

The *costs* of the flights are kept as low as possible. Aircraft crews use the Open-Skies flights as part of their regular training. Hungary spends about DM 10t,000 per flight for aircraft operation costs (mostly fuel) and the per diem of two camera technicians. The film is surplus material from France that is close to expiration date provided at no cost.

The *political impact and success* of the treaty have been enormous. The military and the political establishments of both countries are very pleased with the results. The bilateral Open-Skies Treaty is regularly mentioned in speeches of key politicians when talking about the Hungarian-Romanian relations. The treaty has received very good publicity in the general public through newspaper and television coverage. Both to politicians and to men and women on the street the mutual opening of the airspace of the other state for observation of military sites is probably the most convincing reassurance of their peaceful intentions. This is a non-trivial result, in view of the conflict potential around the Hungarian minorities in Romania and the scars left by past history. One might conclude that the mutual Open-Skies flights have contributed to the prevention of violence or military tension between the two states. It also helped the general public in overcoming or reframing enemy images. The treaty can serve as a role model for bilateral Open-Skies agreements in other parts of the world. Hungary and Romania have started to invite observers from other states in order to demonstrate the effectiveness

[10] This performance is achieved under fair weather conditions for flight altitudes of 3km. Occasional flights at lower altitudes resulted in ground resolutions down to 5cm.

and confidence building potential of the treaty.

7 Potential for an extension of the Open-Skies treaty

The treaty holds an interesting potential for extension on several levels:

a) Inclusion of additional state parties
Six months after the treaty has entered into force any other OSCE state may apply for accession. The Open Skies Consultative Commission may also consider accession of further states willing to join the Treaty. Several of the so called non-aligned states like Austria, Finland, Ireland, Sweden and Switzerland have expressed strong interest. They have been attending the Open Skies and OSCC plenary sessions in an observer role. In addition it would be a good idea to include Albania, the Baltic States, Croatia, Macedonia, Montenegro, Serbia, Slovenia and the three political camps of Bosnia in some kind of Open-Skies regime.

b) Additional fields of application
Two additional fields of application beyond military confidence building are mentioned in the preamble of the treaty: crisis management in the framework of the CSCE/OSCE and protection of the environment. It seems to be common understanding among most state parties, in particular most NATO states, that these issues can only be brought on the negotiation table after entry into force (i.e. full ratification) of the treaty. This position is debatable in view of the situation in Bosnia and the obvious need for confidence building measures in former Yugoslavia and in the Caucasus region.

When it comes to *environmental monitoring* using Open Skies, a spectrum of interests emerges. Many NATO states have sufficient civilian infrastructure for remote sensing of the environment. In contrast some of the Central-East European states, in particular Hungary, seem to be interested in making dual use of their Open-Skies aircraft for environmental monitoring. Certainly there is a sufficient number of border-crossing environmental problems, like river pollution, which require a joint approach. Observation flights for environmental purposes would probably have to be arranged seperately from flights over military sites, in order to ease the open and free use of the pictures taken. On the sensor side, photographic cameras equipped with false-colour (infrared sensitive) film and thermal infrared line scanners are very useful tools for environmental monitoring.

c) Additional types of sensors
The treaty allows for the inclusion of additional types of sensors at a later stage. Obvious candidates are multispectral imaging sensors for environmental monitoring [RYAN 1996] and air probe samplers for monitoring of radioactivity in case of reactor accidents.

8 Conclusion

In spite of the rapid changes in Europe since 1989, the architecture of the Open-Skies treaty still holds an important potential for military and political confidence building in unstable areas of Europe and beyond. The best proof of this capability has been presented by the experience with the Hungarian-Romanian bilateral Open-Skies Agreement. Open Skies can also support the verification of present and future arms control agreements. One area which has been neglected so far is the support of the verification of the Chemical Weapons Convention, of the Non-Proliferation Treaty and of the Comprehensive Test Ban Treaty by airborne observation. Open Skies could play a role in each of these [CLEMINSON 1996].

Although the Open-Skies treaty still contains remnants of Cold War suspicion, it promotes confidence building and cooperative security structures in a powerful way. In particular the elements of *equity* (equal data access for all parties) and *symbolic cooperative action* (joint flight preparation and execution) can pave the way towards a more peaceful future between participating states. Both the military and the general public can learn how to prevent wars or military tension by mutual openness and cooperation. Many other regions in the world would profit from Open-Skies regimes, adapted to regional conditions.

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Country	**Quota**[1]	**Maximum flight distance (km)**
United States	42	4900
Russia-Belarus Group	42	6500
Canada	12	6150
France	12	1400
Germany	12	1300
Italy	12	1830
Turkey	12	1500
Ukraine	12	2100
United Kingdom	12	1500
Norway	7	1700
Benelux Group[2]	6	945
Denmark	6	5600[4]
Poland	6	1400
Romania	6	900
Bulgaria	4	660
Czech Republic	4	960
Greece	4	1100
Hungary	4	860
Iceland	4	1500
Slovak Republic	4	1300
Spain	4	1300
Portugal	2	1700
Georgia[3]	-	-
Kyrgyzstan[3]	-	-

Notes:
(1) These numbers apply to the period of full implementation. Signatories are only obliged to receive 75 percent of their passive quota in the first three years of operation.
(2) Belgium, The Netherlands and Luxembourg.
(3) Georgia's and Kyrgyzstan's passive quotas will be decided by the first OSCC.
(4) Including Greenland.

Table 1
Open-Skies allocation of passive quotas and maximum flight distance of observation flights (source: [JONES 1993, p. 150] and Zentrum für Verifikationsaufgaben der Bundeswehr, Geilenkirchen, 1996)

Table 2
Initial distribution of active quotas [JONES 1993, p. 152]
The active quota of the former Czechoslovakia has been divided as follows: One flight by the Czech Republic over Germany. One flight of Slovakia over Ukraine.

German Test Flights 1995

Participants	Observation Area	Aircraft	Time
Germany/Spain	Spain	TU 154M	24.04.-28.04.1995
Germany/Portugal	Portugal	TU 154M	08.05.-12.05.1995
Ukraine/Germany	Germany	TU 154M	29.05.-02.06.1995
Germany/USA	USA	TU 154M	17.06.-23.06.1995
Germany/Canada	Canada	TU 154M	26.06.-02.07.1995
USA/Germany	Germany	OC-135	17.07.-21.07.1995
Germany/Ukraine	Ukraine	TU 154M	07.08.-11.08.1995
Russia/Germany	Germany	AN-30	11.09.-15.09.1995
Germany/Poland	Poland	TU 154M	25.09.-28.09.1995
Germany/Russia	Russia	TU 154M	09.10.-18.10.1995
Poland/Germany	Germany	TU 154M	23.10.-27.10.1995
Germany/Romania	Romania	AN-30	06.11.-10.11.1995

German Observers on Test Flights

Romania/WEU/Germany	Benelux, Germany	19.03.-24.03.1995

National Training Flights

	Germany	3 x, second quarter
	Germany	1 x, third quarter
	Germany	1 x, fourth quarter

Table 3
Open-Skies trial flights involving Germany in 1995 (source: "Implementierung von Rüstungskontrollabkommen durch die Bundeswehr im Jahre 1995", Bundesministerium der Verteidigung, FüS III 4, POB 1328, D 53003 Bonn, 15. April 1996, and: Information from "Zentrum für Verifikationsaufgaben der Bundeswehr, Geilenkirchen")

	Sensor	Focal Length	Film Format	Operation Altitude	Ground Resolution at Operation Altitude	Ground Swath covered at Operation Altitude
1.	3 Framing cameras LMK2015 (Zeiss, Jena)	152mm	228 x 228mm^2	1600-5900m	30cm$^{(1)}$ (with degrading filters)	8.3-32.5km (3 cameras)
2.	3 Video cameras, 3 colours VOS-60 (Zeiss, Oberkochen)	60mm	3 x 6000 pixels pixel size 0.012mm	1500-5000m	30-100cm$^{(1)}$	5.9-19.5km (3 cameras)
3.	Panoramic camera A-84 (Zenit, Moscow)	300mm f/4.5	130 x 127mm	4000-8000m	30-60cm$^{(1)}$	20-40km
4.	Thermal infrared line scanner AN/AAD-5 (Honeywell, USA)	angular res.: 0.25mrad thermal res.: 0.2K digitization : 8 bits		1500m	50cm$^{(1)}$	5.2km
5.	Synthetic Aperture Radar ROSSAR (Kulon, Moskau; Dornier)			$\geq$ 1000m	300cm$^{(2)}$	25km$^{(3)}$ (sideways)

Notes (1): Optimum ground resolution will only be achieved in the vertical direction.
(2): This is the ground resolution transverse to the flight direction.
(3): The ground swath can be moved sideways from the flightline.

Table 4
Technical parameters of the sensors of the German Open-Skies aircraft. Sensors 3-5 will be operational in 1999. Two framing cameras and two video cameras are mounted obliquely at 33^o relative to the vertical direction (source: [WEITZEL 1996] and information from "Zentrum für Verifikationsaufgaben der Bundeswehr, Geilenkirchen")

SIGNATURE	RATIFICATION(r)/ ACCESSION(s)	DEPOSITION OF THE INSTRUMENTS OF THE RATIFICATION
Belarus	24 March 1992 (s)	
Belgium	19 May 1995 (r)	28 June 1995
Bulgaria	1 March 1994 (r)	15 April 1994
Canada	4 June 1992 (r)	21 July 1992
Czech Republic	26 November 1992 (r)*	21 December 1992
Denmark	19 December 1992 (r)	21 January 1993
France	21 July 1993 (r)	30 July 1993
Germany	3 December 1993 (r)	27 January 1994
United Kingdom	27 October 1993 (r)	8 December 1993
Georgia	24 March 1992 (s)	
Greece	25 August 1993 (r)	9 September 1993
Hungary	18 June 1993 (r)	11 August 1993
Iceland	15 August 1994 (r)	25 August 1994
Italy	20 September 1994	31 October 1994
Kyrgyzstan	15 December 1992 (s)	
Luxembourg	20 December 1994 (r)	28 June 1995
Norway	18 May 1993 (r)	14 July 1993
The Netherlands	15 January 1994 (r)	28 June 1995
Poland	17 February 1995 (r)	1996
Portugal	17 September 1994 (r)	22 November 1994
Romania	16 May 1994 (r)	27 June 1994
Russian Federation	24 March 1992 (s)	
Slovak Republic	26 November 1992 (r)*	21 December 1992
Spain	25 October 1993 (r)	18 November 1993
Turkey	18 May 1994 (r)	30 November 1994
Ukraine	24 March 1992 (s)	
United States	2 November 1993 (r)	3 December 1993

* as Czech and Slovak Federal Republic

r - ratified / s - signed

Table 5
Status of Open-Skies treaty ratification as of 1 January 1997

Figure Captions

Figure 1
Aerial image of an industrial site near Nürnberg, Germany, taken with a multispectral scanning sensor Daedalus AADS 1268. The images displayed were taken in the wave length band 910-1050nm. Cars and trucks are marked by arrows. (Image taken by Deutsche Forschungsanstalt für Luft- und Raumfahrt DLR, Oberpfaffenhofen, for CENSIS / University of Hamburg).

Figure 2
The sensor suite of the US Open-Skies aircraft and ground swaths to be covered by the sensors. The ground swaths of the Radar system (SAROS) are shown for three different modes of operation [RYAN 1996, p. I-402].

Figure 3
The US Open-Skies aircraft displayed at the Second International Airborne Remote Conference and Exhibition, San Francisco, 24 June 1996 (photo of the author).

Figure 4
A framing camera mounted on the bottom of the US Open-Skies aircraft. The two film cassettes can be recognized (photo of the author, 24 June 1996).

Figure 5
The German Open-Skies aircraft (top) and a set of three framing cameras (ZEISS-Jena LMK-2015 aerial camera) on board of that aircraft (bottom). (Source: Brochure of the Company IGI GmbH, P.O. Box 1207, 57260 Hilchenbach, Germany).

Figure 6
Flight route of a German-Russian test flight over Siberia using the German Open Skies aircraft (9-17 October 1995) [SPERLING 1996]

Figure 7
Detail from a picture taken with the vertical fraiming camera of the German Open-skies aircraft over the city of Heidelberg (source: "Zentrum für Verifikationsaufgaben der Bundeswehr, Geilenkirchen")