

**Aerial Photography, Photogrammetry and Microwave Remote Sensing  
Instruments in the Verification Activities of the Open Skies Treaty  
Case Study of the Jan.1992 Hungarian-Canadian Trial Overflight**

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**ABSTRACT**

The Open Skies regime, beside its traditional aims - confidence building and enhancement of verification of existing and future arms control treaties - now takes on additional functions: it could play an important role in conflict prevention and crisis management. Observation aircraft flying Open Skies missions shall carry a variety of sensors: aerial metric cameras, electro-optical devices, infrared line-scanners and synthetic aperture radar (SAR).

The Canadian-Hungarian trial overflight over Canada in January 1992 offered an unique opportunity to test the use of these remote sensing techniques for Open Skies purposes.

**KEYWORDS:** Open Skies, Remote sensing, Photogrammetrie, Sensors, Peaceful application

**1. INTRODUCTION**

In september 1989, Prime Minister Brian Mulroney announced that Canada would host the first international conference with the purpose of negotiating an Open Skies regime. The conference on Open Skies was scheduled to begin in Ottawa on 12th February 1990, and was opened by foreign ministers from 23 nations of NATO and the WTO nations of that time. In preparation for this conference, Canada and Hungary conceived the idea of a trial overflight of Hungary.

This first Canadian-Hungarian Open Skies flight took place on 6 January 1990. A Canadian Forces CC130 Hercules transport aircraft flew a large figure eight pattern over Hungary covering a number of Hungarian and Soviet military facilities. It was agreed, by both sides, that a reciprocal flight would occur, in Canada, when there would be significant progress in the negotiations.

A second conference, hosted by the Hungarian government was held in Budapest from 23 April to 10 May 1990.

Although a number of fundamental principles were agreed at these conferences, substantial differences persisted in certain areas and the pace of negotiations slowed considerably.

Canada and Hungary continued to coordinate their efforts in promoting a new round of negotiations, which began in Vienna in September 1991.

On 6 December 1991, the Secretary of State for External Affairs invited Hungary to conduct a reciprocal trial overflight of Canadian territory involving an enhanced technical program. This would include the use of sophisticated sensors such as Synthetic Aperture Radar (SAR), low light level television (LLTV) and fixed optical camera. The Hungarian delegation arrived in Ottawa on 13 January 1992 to commence a one week program.

Not very long after completing this joint effort the finalized Open Skies Treaty was signed by the participating delegates of 25 parties in Helsinki, March 1992.

**2. BASIC SENSOR CATEGORIES FOR THE OPEN SKIES REGIME**

- handheld cameras
- topographic metric cameras
- video-systems
- radar-systems

2.1. **Handheld cameras** from traditional amateur ones to the professional types (e.g. Hasselblad). The aerial photos can be produced by camera, built into the floor (bottom) of the airplane (vertical axis) or from handheld camera (oblique axis), or perhaps from a built-in tripod.

2.2. **Topographic metric cameras**

Their features:

- large-size photos: 23 cm x 23 cm,
- distortion-free optics of various focal lengths,
- geometrically known internal orientation data,
- good geometric resolution,
- electronic function,
- automatic overlapping-regulation,
- image-motion compensation, in case of up-to-date cameras,
- optics corrected to visible and infrared regions.

The geometric resolution is depending on the surveying scale, i.e. the flight height, the focal length and the quality of the film. At present, applying usual films and cameras, in case of an airphoto at scale of 1:10 000, made at an altitude of 1500 m a ground-resolution of 10-15 cm; in case of scale 1:60 000 and height of 9000 m a 60-90 cm can be reached. According to our present knowledge these sensors provide the best resolution, which - together with the opportunity of the precise geometric determination - is the richest data source. (By the help of an airphotographic stereo-pair at scale 1:10 000, made from a height of 1500 m, the sizes of an object both in horizontal and vertical meaning can be determined with an accuracy of +10-15 cm; in a stereophotogrammetric instrument can be watched as a "model", in this way one can determine for example the type of an airplane standing on the ground as well.)

2.3. **Video-systems**, divided into traditional, infrared and highly sensitive videocameras: The traditional videocameras: can be used as additional instruments when collecting information (e.g. radar survey, microwave survey). Their disadvantage is that they can

be applied by sunshine and in case of cloud-free weather only. The pictures registered on videotape do not need any special processing, they can be played back in a traditional way at once.

The infrared television sets are sensibilized in thermal regions, two types of them are known: Thermal cameras functioning in bands 35-56 nm, and the other type in 80-120 nm bands, which allow to perform survey during nighttime. The disadvantage of the cameras belonging to the first group is that they cannot separate the emitted and reflected thermal data and so in the values detected by them both the Sun-emitted and from the objects reflected thermal energy is brought together. Therefore they can successfully be applied under closed cloud-cover, before sunrise or after sunset only. The thermal values detected by cameras functioning in the second channel are free of the effects of sunshine, so they can be used also by daylight. The resolution of the up-to-date thermovisions reaches the value of 0,2-0,5 °.

By the help of low light level videocameras - these can be purchased in the trade as well - survey can be performed also in case of light equal to a quarter of moonlight, their ground resolution is about 1-2 m.

- 2.4. The digital imaging spectrometers bring a new surveying technique, the basis of which is given by the high-resolution CCD camera and the programmed band-selection option. This latter one allows to make images in a very narrow bandwidth (3-5 nm) and in many (100-200) channels; of course it opens new perspectives for aerial data acquisition, the area of applications of which has not totally been investigated yet.

#### 2.5. Radar-systems

For open skies, the accepted radar sensors can be any sideways-looking SAR instruments, which does not have ground resolution better than three meters, regarding the impulse response (IPR) of the system to a point target. To use these instruments high quality navigation instruments, continuous registration of aircraft attitude and precise positioning of the SAR antenna are required. The resolution of state-of-the art systems can be much better today, but it needs further steps in the Open Skies Treaty to achieve change of this restriction. The given 3 m IPR resolution does not give suitable amount of information, but at the same time only radars have the daytime independent all-weather capability.

The main condition of the up-to-date aerial photographic survey is the high-precise navigation which needs computer control. The modern navigation systems (GPS, INS) allow not only the precise flight of the plane over the object, but by the help of airborne data they provide basis, needed to the subsequent computerised data-processing (geometric correction).

#### 3. AIM OF THE SECOND CANADIAN-HUNGARIAN OVERFLIGHT

The aim of this joint program was to contribute to the negotiations by demonstrating some of the sensor capabilities and limitations, by simulating the exchange of flight recorded data, and by presenting the results to negotiators in Vienna. It also provided a unique opportunity to test some operational Open Skies procedures that were under negotiation in Vienna.

The Hungarian notification for the Open Skies trial overflight was sent to Canada through the CSCE communication network. The mission plan was submitted by Hungary and accepted by Canada.

#### 4. TRIAL OVERFLIGHT PROGRAM

Preceding the airborne part of the program were two days of briefings, technical discussions and

demonstrations that helped set the stage for the flights. These discussions served the exchange of views and further development of mutual understanding of the representatives of both participating sides.

The subjects of the various presentations concerned aerial photography, SAR, mission planning, sensor development and aircraft modification engineering.

The airborne part of the program involved two flights. The first one, on 15 January 1992, was an orientation flight carried out using a CCl15 Buffalo transport aircraft. It flew the same routing as the sensor flight of the next day and allowed for visual observation and recognition of the sensor targets. A total of fourteen observers from both countries participated. This flight also tested procedures for the notification and clearance of restricted areas. The aircraft overflew Canadian Forces Air Base Trenton, Canadian Forces Army Base Petawawa, two commercial nuclear power plants and a major industrial automobile manufacturing facility in Oshawa.

The flight planning for the second, sensor-equipped flight was executed by the Canada Center for Remote Sensing (CCRS) based upon the agreed mission plan. Routings and altitudes were modified by CCRS to make optimum use of the sensor capabilities and aircraft restrictions. The Convair 580 aircraft was equipped with the CCRS 5.4 GHz SAR, an RC-10 optical camera with 152 mm lens, an RCA TC 1030/H LLLTV camera and a standard color video camera.

The observation aircraft carried five CCRS crew members consisting of two pilots, one mission manager and two sensor specialists. Flight representatives included one cockpit/navigation observer from Hungary, and two Hungarian and one Canadian sensor specialists as observers.

This overflight was conducted on 16 January 1992 from Ottawa. The aircraft took off from Ottawa International Airport at 11.35 am and landed at the same airport at 2.40 pm. Measures were taken during the overflight for testing of the film to ensure optimum quality. An additional fifteen photo exposures were taken after the last photo line to provide for initial calibration and verification of the processing. Several frames of unexposed film were used for photolab exposure of step wedges.

SAR data collected during the overflight was recorded onto a high density digital tape, and real time quick look images were produced to supply the evaluation procedure.

Intra Kenting (SAR) and IMc Photographic Services Inc. (photography) were responsible on a commercial basis for the less than 24 hour turnaround time processing of the final products.

#### 4. DISCUSSION OF THE COLLECTED IMAGES

Below is a brief analysis of the information retrievable from the panchromatic stereo aerial photos and hardcopies of the C-band SAR images of three distinguished areas.

##### 4.1 General Motors Assembly

The resolution in the aerial photos agrees very well with the predicted 15 cm. The smallest interpretable elements are the windscreen of the cars parking around the GM plant. Additional information, such as terrain shapes, roads, paths, trucks, railways, rail coaches and even railway-sleepers can be extracted from the stereo pairs.

The corresponding C-band (5.3 GHz) HV polarized SAR image shows the same area with 6 m ground resolution. The images at this resolution only give a somewhat general view of the area, and mostly useful for supporting the interpretation of the aerial photos, but very rarely enhance the information, retrieved from the optical images. In some cases the SAR image draws attention to a feature, which appears with high resolution in the stereo pairs, but because of the lower optical contrast they are easy to miss.

#### 4.2 Rockliffe Airbase

The aerial photo of this area has many exciting details. The airplanes around the buildings are good examples of the objects, which are highly resolved, even enough for type identification. These objects appear as small, perhaps only one pixel dots in the SAR image. It is interesting to note, that the radar image enhances all those features, which has an edge or reflecting corner perpendicular to the flight path.

#### 4.3. Pickering Nuclear Power Plant

This image is also very rich in details, and most of the elements of interest within the plant can be resolved. Making use of the capabilities of the metric camera, the geometric extends of the individual objects can support the identification. The thermal water turbulence appear clearly in the panchromatic aerial photos.

#### 5. CONCLUSIONS

(1) Because of the sophisticated navigation systems such as the ones used in this experiment the countries possessing them enjoy more advantageous situation than those who do not have such instruments.

(2) The metric camera applying 240 mm film has the benefits, that the number of photos to be handled is as minimum quarter times less than that is for a twin camera applying 110 mm film and also the navigation during the flight is more reliable using the 240 mm camera.

(3) To use a single metric camera with 240 mm film it is necessary to make contact transparency copy of the original image. It seems to be a disadvantage compared with the twin camera for data sharing but using good quality contrast enhancing copying techniques it can be avoided.

(4) For operational application of high resolution object classification and identification, the 6 m ground resolution of the SAR is a bit low, so the information content of the SAR images can be too little for the purposes of the Open Skies Treaty, not overwriting the fact, that radars have the all-weather daylight independent imaging capability.

(5) Color photoprints from 35 mm handheld cameras can also help the interpretation of different types of images.

(6) The data sharing takes also a substantial time at the end of Open Skies flights, so it must be inserted in the initial timetable.

(7) The relatively high costs of aircraft and sensors make cooperation highly desirable. It is apparent, that countries, which do not have modern, high-speed airplanes, up-to-date surveying techniques, navigation and airborne data registering equipment and processing facilities would lose pace in performing flights in the Open Skies Regime. To avoid this, establishing a centre is suggested, which could coordinate and organize Open Skies flights on a commercial basis, upon the orders from the participating countries. The application of unified surveying and sensing technology and techniques could also assure users to get access to high quality information. Joint flights, leasing of equipment, and reduction of cost by sharing information on a commercial basis are all important ways of making the regime more cost efficient. The treaty should provide a flexible framework allowing all possible ways of cooperation.

#### References

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