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East Europe Report

SCIENTIFIC AFFAIRS

(FOUO 2/82)

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CZECHOSLOVAKIA

SATELLITE, AERIAL SURVEYING OF CSSR DESCRIBED

Prague GEODEDICKY A KARTOGRAFICKY OBZOR in Czech No 1, 1982 pp 2-6

[Article by Eng Jiri Sima, CSc, Institute of Geodetics National Enterprise, Prague, Center for Remote Earth Surveying: "Space and Aerial Surveys of Czechoslovakia for National Economic Purposes"]

[Text] 1. Introduction

Space and aerial surveys carry out observation, measuring and recording of the energy and polarization characteristics of the radiation reflected or produced by objects and phenomena on the earth's surface and in layers immediately above and below the surface. These data are then processed by special techniques so that the results will provide information on the spatial position, types and condition of the ground objects and phenomena being monitored. Depending on the altitude and the type of platform carrying the recording apparatus, we speak of space or aerial surveys. Measurements and investigations conducted on the ground are an important supplement to both types of survey. The two types of remote surveying are virtually noninterchangeable. Survey data from space have a global or regional character, while data obtained from aerial surveys give a chosen degree of detail and make it possible to determine the types and conditions of even individual small objects. There is a considerable gap between the two categories of imaging, since for technical reasons spacecraft carrying sensing apparatus can operate only at altitudes above 200 km, while special aircraft can reach a maximum altitude of 20 km (more frequently only 10 km) and ordinary aircraft only 5-8 km. Space photographic surveys or other types of imaging have an initial scale of 1 : 1,000,000 or smaller, while aerial surveys are at a scale of 1 : 100,000 (or 1 : 50,000 when aerial cameras with a constant greater than 100 mm are used) or greater.

In addition to the scale and the degree of resolution associated with it, selection of a suitable spectral band is of primary importance for most applications of remote earth surveying in the national economy. The specific aims of different surveys require survey data not only in the visible part of the spectrum which has been in common use up to now, but also in the near, medium and far infrared and even in the millimeter and centimeter wave regions.

In a number of cases it is desirable to minimize the time between recording of the image data, special processing and the presentation of the required information; this is done by using real-time or quasi-real-time systems. The implementation of these complex activities as technical processes directly serving the needs of the national economy makes great demands on capacities, investment and expenditures.

The development of remote earth surveying in Czechoslovakia is only now beginning to be measured in years, and accordingly most of the activities involved still belong in the domain of basic and applied research. Nonetheless, we can already point to the first successes in obtaining space and aerial survey data for Czechoslovakia intended for specific tasks in the national economy. A participant in the success has been the Center for Remote Earth Surveying, founded in 1978 pursuant to CSSR Government Decree No 249/1977 as part of the Czech Geodetic and Cartographic Office; this organization coordinates or directly performs work associated with civilian applications of remote earth surveying.

2. Space Surveys of Czechoslovakia

The main source of data for space surveys of Czechoslovakia is multispectral photographs provided by Soviet automatic satellites or (more importantly) by piloted spacecraft and an orbital laboratory. These were provided in accordance with the Agreement on Provision and Use of Data From Space Surveys concluded in 1978. These materials have the following main advantages:

--they are metric (photogrammetric) photographs with known internal orientation and minimal distortion;

--they were taken in specially chosen parts of the visible and near infrared spectra;

--they provide a high degree of resolution of ground detail (20-40m);

--they are at a relatively large scale for space surveys (1 : 1,100,000 to 1 : 2,500,000).

These materials are being processed by the Center for Remote Earth Surveying, which is providing a variety of derivative presentations from them according to orders from authorized users, for example:

--photomaps of Czechoslovakia at a scale of 1 : 1,000,000 from space photographs taken in the 6-0-700 nm band (visible);

--photomaps of Czechoslovakia on a scale of 1 : 1,000,000 from space photographs taken in the 700-840 nm band (near infrared);

--similar photographs of the CSR, SSR and CSSR at a scale of 1 : 500,000;

--black-and-white prints and enlargements of complete photographs or sections at scales up to 1 : 200,000 from photographs taken in the 510-600, 600-700 and 700-840 nm bands;

--color syntheses of two to four partial black-and-white multispectral (zonal) photographs (positives and negatives) on a scale five times greater than that of the original photographs;

--recording of individual black-and-white photographs in digital form on magnetic tape with selected image element size (from 25 to 400 microns).

New forms of effective use of the space survey data continue to be found, primarily in geology, involving the authentication, more precise location or discovery of linear and circular structures in Czechoslovakia, and also in hydrology, involving entry and more precise mapping of newly-found water sources on survey hydrological maps, as well as for monitoring the environment (sources, intensity and direction of propagation of industrial emissions).

Some tasks on a regional or global scale in geology, hydrology and environmental protection can be successfully accomplished using easily accessible imaging data from the Meteor, TIROS and NOAA meteorological satellites.

3. Aerial Surveys of Czechoslovakia

In the narrow sense, aerial surveys of Czechoslovakia refer to imaging of a largely nonmetric character, generally with special films or special processes using either aircraft, helicopters or miniature aircraft. In terms of use of the data, aerial surveys can be classified as:

--multipurpose surveys, i.e., colored photography and multispectral (multizonal) photographs;

--special-purpose, i.e., spectrozonal photography and immediate photographic documentation.

For technical and economic reasons, colored aerial photographs are generally taken with MRB 9/23 and 15/23 metric cameras using Czechoslovak-produced 244-mm Fomachrom D-20 color reversing film. To obtain realistic hues, the maximum flying altitude is 2,000 m. These photographs are intended primarily for identifying boundary changes and soil use for the purpose of updating suburban land maps and the production of forestry maps. Secondary uses are for updating hydrologic maps and planning water conservancy improvements, for reclamation, and in regional planning. These photographs have a suitable metric character, since the changes found may be photogrammetrically evaluated for use in the relevant maps.

Multispectral (multizonal) aerial photographs have up to now been taken primarily by a system of six AFA-39M cameras at scales from 1 : 25,000 to 1 : 50,000 using Soviet-produced 80-mm black-and-white panchromatic and infrared film. The narrow-band interference filters used are identical to those of the MFK-6 multispectral camera (C. Zeiss, Jena). The individual black-and-white

zonal photographs are used for visual interpretation either singly (particularly photographs taken in the 640-680 and 790-890 nm bands) or in various combinations for production of color syntheses which allow optimal identification of the objects and phenomena of interest. Because of the considerable decrease in clarity toward the edge of the photograph (vignetting of the objective) it is difficult to carry out photometric normalization of these photographs and interpret them by computer. Nonetheless, the materials obtained with the AFA-39M system have played a major role in mastering the applications of multispectral photographs and meeting the initial requirements of various sectors of the national economy for remote territorial surveys of Czechoslovakia.

For high-quality, photogrammetrically normalizable multispectral photographs, a set of four Hasselblad 500EL photographic instruments with special accessories has been imported and adopted as a four-band multispectral camera with various automated functions typical of modern aerial metric cameras. The photographs are taken on 70-mm panchromatic and infrared film. Following extensive research and analysis of foreign publications (summarized in Table 1), four spectral zones suitable for most current and future applications of multispectral aerial photography in Czechoslovakia were chosen:

Band	Filter	Type
380-500 nm	Blue	Kodak Wratten 47B
470-620 nm	Green	Kodak Wratten 58
610-740 nm	Red	Kodak Wratten 29
740-900 nm	Infrared	Kodak Wratten 87

The color filters are made of gelatin and give homogeneous transparency. The 4X Hasselblad 500EL multispectral camera is provided with f = 800 mm/2.8 and f = 400 mm/4 objectives with minimum vignetting and distortion, whose characteristics are similar to those of the objectives of aerial metric cameras. The format is smaller than that of the cameras mentioned above (55 x 55 mm) and accordingly these cameras are suited for use primarily with smaller areas and in cases where subsequent analog or digital processing of the information on the objects and phenomena in question is required.

It remains to mention other possibilities for obtaining extremely high-quality multispectral aerial photographs in connection with the work of a flying laboratory invited from the Soviet Union which is equipped, among other things, with the MKF-6M six-band camera. The individual spectral-band photographs obtained with this camera have both extremely good photometric properties and photogrammetric characteristics; so that their geometric content may be precisely interpreted (using analog photogrammetric devices, differential rectification and the like). Special equipment including the MSP-4

multispectral projector also speeds up and simplifies the preparation of 56 x 81 mm color syntheses from these photographs.

Czechoslovak organizations have considerable interest in the results of multispectral aerial surveys, and requests currently exceed capacities, which are limited primarily by:

--available aircraft;

--suitable weather conditions for surveys;

--the capabilities of imported film.

Spectronzonal (colored infrared) aerial photographs are taken with the MRB 11.5/18 camera on Soviet-produced 190-mm SN-6 M negative film or with the Hasselblad 500EL photographic instrument using 70-mm Kodak Aerochrome infrared 2443 reversal film. The spectral sensitivity of both materials is so chosen that the resulting image distinguishes by color even small changes in the chlorophyll content of plants or of the total chlorophyll content typical of a given type of plant. Accordingly, spectrozonal photographs are particularly suitable for distinguishing different types of forest cover, determining the degree of harm it has suffered from industrial emissions or biological pests, or for identifying disease or pest infestations of agricultural crops.

These photographs are for special purposes and are most often taken in connection with the evaluation of the extent and results of natural calamities. These activities cannot be planned far in advance, and accordingly the photographs are taken from helicopters as the need arises and to an extent depending on the amount of film available.

Quick-response photographic documentation from aircraft or helicopters includes other types of special-purpose aerial surveys which may be one-time activities or regularly repeated (monitoring). The aerial photographs are taken with MRV 15/23 large-format measuring cameras and the like or a variety of other photographic devices using 70-mm, 60-mm and 35-mm black-and-white panchromatic, infrared, color reversal or color infrared film. Most of these activities require that the survey results be available in the shortest possible time, even at the expense of photometric normalization and geometric precision. Some examples are given below:

One-time activities

--documenting failures of process equipment (leakage of oil, gas and chemicals);

--documenting the extent of flooding and windstorm damage;

--advance surveys of archeological finds;

Monitoring

--data for management of large-scale agricultural production;

--transport surveys in cities;

--monitoring of ice formation on navigable rivers.

In contrast to the unfavorable situation in past years, the number of authorized organizations capable of carrying out fast-response photographic documentation from aircraft and helicopters is now increasing. A considerable proportion of these tasks may also be carried out in small areas by photography from remote-controlled model aircraft (miniature aircraft).

4. Directions of Further Development of Spectral Photography

Table 2, showing selected applications of remote surveys in the Czechoslovak national economy, graphically illustrates the requirement for further expansion of spectral photography. The performance of certain tasks requires the recording of electromagnetic radiation of a longer wavelength than that to which infrared photography is sensitive (i.e., λ = 0.9 microns). Analysis of experience abroad indicates that the microwave band from 2 to 5.6 microns could be used effectively for recording a temperature image of the soil surface, vegetation and water (thermovision), and that use could also be made of centimeter wave radiation emitted by a side-looking radar on the flying laboratory and recorded after reflection from surface objects. Both cases result in image recording produced by successive exposure of the image elements in lines (i.e., in a dynamic mode) and characteristically involve a certain radiometric and geometric distortion which must be compensated during further processing of the image data. The relevant sensing systems provide images of strips of territory in analog or digital form, with the width of the strips depending on the altitude and the viewing angle of the apparatus.

The Center for Remote Earth Surveying is pursuing both of these approaches intensively and is taking a variety of steps to test sensing systems and make them available.

In 1981 thermovision sensing of five test areas in Czechoslovakia was carried out using the AGA THP-1 system in the 2-5.6 micron region with a viewing angle of 80° and a resolution of about 0.2° C. Thermal images of strips of territory 400 to 900 m wide were made on ORWO NP-55 panchromatic film (motion picture film) at an original scale of 1 : 15,000 to 1 : 39.000 from altitudes of 220 to 555 m. The sensing was carried out at speeds of 80 to 200 km/hr at various times of the day and night (1600, 1800, 2200, 0000 and 0200 hours). The surface temperatures of soils and water and the temperature and humidity of the air were measured at selected ground stations at the moment when the helicopter flew over. These data allowed subsequent conversion of the radiation temperatures to the contact temperatures of the surfaces of the objects in question. In addition to a planar temperature image, temperature cross sections were also taken, which in particular allows more precise determination of the temperature differences between adjoining objects.

Preliminary evaluation of the results of the thermovision experiment indicates that the method can provide valuable survey data which indicates in both image and quantitative form the extent of thermal and biological pollution of streams and water bodies as well as subtle changes in soil moisture. Another promising area of thermovision research is the identification of locations and causes of heat energy loss (heat leakage for steam pipelines, panel-type dwellings and the like).

5. Conclusions

Space and aerial surveys of the territory of Czechoslovakia have been systematically conducted only for a few years, and most potential users of their results are still acquainting themselves with the characteristics of the survey material and the methods of using it for national economic purposes. The rather small extent of application of space surveys of Czechoslovakia is explained not only by limited past experience and a limited number of variety of space photographs, but also by the fact that the surface situation and natural resources are already highly explored. Most of the required applications of the remote surveys require a considerable degree of detail, and accordingly most organizations are concentrating their interest on aerial surveys. A respectable level has been achieved in this field in a short time, particularly in multispectral photography, which is now routinely performed. There are real possibilities for further developing the processes for quick-response photographic documentation from aircraft, helicopters and remote-controlled miniature aircraft. In addition, the conditions for further expansion of spectral photography into the microwave and centimeter wave ranges (thermovision and radargrammetry) have also been created.

Šima, J.: Kosmický a letecký ...

METEOROLOGICAL SATELLITES
h > 1000 km

SATELLITES FOR INVESTIGATION OF EARTH RESOURCES; h = 600-1000 km

MANNED SPACECRAFT AND ORBITAL LABORATORIES; h = 200-500 km

AIRBORNE LABORATORIES
h = 5-20 km

AIRCRAFT; h = 500-8,000 m

HELICOPTERS; h = 50-2,000 m

MINIATURE AIRCRAFT; h = 50-1,000 m

GROUND-BASED RESEARCH h <20 m

Table 1. Use of multispectral photography for the needs of the national economy (based on analysis of foreign data)

Field	Application	400	500	600	700	800	900 nm
Agriculture	Agricultural crop recognition		×		×		×
	Soil use				×		×
	Soil use				×	×	×
	Soil use		×			×	×
	Vegetation identification in waterlogged	soil	×	×			×
	Identification of erosion phenomena				×	×	
Forestry	Distinguishing coniferous from deciduous	trees	×		×	×	
	Vegetation density, meadows, water		×		×		×
	Damage to forest growth			×		×	×
Hydrology	Phytoplankton in water		×	×	×		
	Shallows to depth of 10 m		×	×	×		
	Properties of snow cover		×	×	×		
Geology	Age of rocks (in arid areas)		×		×		×
	Eruptions, sediments, fractures		×		×		×
	Lithosphere		×	×	×	×	×
Environment	Water pollution		×	×	×		
	Desertification				×	×	×
Most suitable spectral transmission maxima of color filters			440 530	620	700	750	850 nm
Multispectral photographic systems usable in CSSR	MKF 6 / AFA 39		A	B	C	D	E	F
	4 × Hasselblad 500 EL		M	Z	Č		IR	

Table 2. Selected applications of remote surveying in the Czechoslovak national economy

Application \ Remote Surveys	Data acquisition method								Processing method				
	spaceborne	aerial	black and white photography	color photography	black and white infrared photography	color infrared photography	thermal sensing	radar sensing	monospectral	multispectral	multitemporal (monitoring)	texture analysis	supporting ground data
Agriculture													
soil surveys		X		X					X		X	X	
management of plant production		X		X									X
regional statistics	X		X		X					X	X		X X
agricultural crop diseases		X				X				X	X	X	X X
waterlogging		X					X		X				X
soil erosion		X	X		X					X			
Forestry													
disaster surveys		X	X						X				
vegetation classification		X	X	X	X				X			X	X
regional statistics	X		X		X	X				X			
harm from industrial emissions	X	X				X				X	X		X
harm from biological pests		X				X				X	X		X
map updating		X	X	X	X				X	X			
Hydrology													
map updating	X	X		X	X				X				
stream and water body pollution		X				X	X		X	X	X		X
snow cover	X		X		X		X		X	X			X
subsurface water		X					X		X				X
Geology													
lineaments	X		X		X			X	X				
classification of surface layers	X	X	X	X	X			X	X	X		X	X
mineral resource investigation	X	X	X		X					X		X	X
map updating	X	X	X		X			X	X	X			
Environment													
atmospheric pollution	X		X	X	X				X	X			X
desertification	X	X			X	X				X			
leakage of thermal energy		X					X		X		X		X

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