POSSIBILITIES AND PROSPECTS OF DEVELOPMENT OF AEROSPACE MEASURING TEST SITE IN KALMYKIYA

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1. INTRODUCTION

The development of quantitative methods of interpretation, based on the application of geometrical and radiation specifications of the terrain objects determined by aerospace survey data, getting more and more importance in view of the problem of monitoring of regional and global changes of natural environment.

It is known that random errors of measurements by aerospace survey data are not great. But due to significant systematic errors the results of measurements by the data acquired by different survey instruments, and more over, by the instruments of different type and kind can significantly differ. That fact can make an obstacle for formation of banks of interpretative features and requires an implementation of great volume of ground field surveys since each particular survey data require own teaching sampling of objects.

The main method of elimination of systematic measurements errors is a calibaration of survey means in the flight conditions on special measuring test-sites. The general conception of measuring test-site, particular characteristics of aerospace test-site in KALMYKIYA and methodological aspects of its application are considered in the report.

2. GENERAL CONCEPTION OF THE TEST-SITE

2.1. Purpose of the test-site

2.1.1. Ensurance of a metrological uniformity of measurements of geometrical and radiation specifications of terrain objects by survey data acquired by air and space survey equipment of different types;

2.1.2. Evaluation of information properties, flight test and calibration of air and space survey means;

2.1.3. Elaboration of methods for determination of atmosphere influence on information and measuring properties of air and space survey data;

2.1.4. Formation of the bank of quantitative interpretative features for the main objects classes of geographic zone where the test-site is located.

2.2. Main requirements for the test-site

2.2.1. High probability of cloud-free (0-3 marks) weather.

2.2.2. Availability and compact arrangement of representative sampling the objects of main classes typical for the given geographical zone.

2.2.3. Equipping by the special standards (line and radial ground targets, control photometric and thermal fields, reflectors of radiation in radar band , control geodetic points,etc) with well known characteristics and by means for measuring the parameters characterizing the terrain objects state and aerospace survey conditions.

2.2.4. Minimum expenses for construction and exploitation of the test-site (problems of alienation of lands for construction of engineering facilities; availability of road network, means of communication and electric power supply; problems of service staff placing etc).

2.3. General features of the test-site functioning Independently from particular solved tasks, main principles of the test-site work are:

-integrated consideration of factors influencing on the results of aerospace measurements and survey;

- combination of application of artificial standards and natural elements of terrain for evaluation of information value and measuring capabilities of survey means.

The main type of the work to be performed on the test-site are under-satellite works. They contain in the following. During space survey days the staff explores and determines the characteristics of sampling the terrain objects, makes control spectrometric and radiation measurements of standards, measurements of indices of spectral brightness and indicatrices of dispersion of terrain objects, makes actinometric measurements and meteorological observations in different points of the test-site, records an illumination of the terrain, the Sun altitude and azimuth. The air survey from low, middle and high altitudes will be done simultaneously with the space survey in the same spectral bands. Methodical questions of the perfomance of these works are explained in (1).

The composition of the works perfomance and the content of different types of works can differ dependently of particular solved tasks .

3. THE TEST -SITE IN KALMYKIYA

3.1. General specifications

The test-site is situated in western part of the Kaspian depression, in the area of transgression from dry to arid climate. The area has more 250 sunny days per year, there is no significant anthropogenic pollution of atmosphere, fog and dust storms probability is small.

Within the test-site having the area of about 80x80 km there are all main kinds of objects typical for arid zone: natural grass vegetation, dry-farming arable lands, areas requiring irrigation, solonchaks , sands, eroded soils , water bodies ; there are also lands with low productivity which can be used for placing the engineering facilities; road network is enough developed; necessary laboratories and accomodation for service staff can be arranged in Elista.

There are on the test-site territory network of control geodetic points for geometrical calibration of space survey means and three control points (fig. 1).

The first control point is intended for geometrical calibration of air survey means; the second - for radiation calibration and evaluation of spatial resolution of air and space survey means operating in visible and thermal IR band, the third - for radiation calibration and evaluation of spatial resolution of radar survey means, and also for photometric calibration of air survey means operating in visible and near IR bands .

Besides solution of these tasks the following should be done during the survey days on all control points: actinometric measurements and meteorological observations ; check-out and determination of the characteristics of sampling the objects of main classes located in the area of the control point; measurements of brightness specifications of objects used as natural control photometric fields.

3.2. State and development plans

Nowadays the construction and equipping of the test-site is not completed . Nevertheless the test-site can be used for solving a number of practical tasks.

3.2.1. The network of geodetic control points intended for geometrical calibration of space means of survey and the field of geodetic control points on the first point serving for geometrical calibration of air-borne means of survey are completely ready.

The outline points of terrain reliably identified on space images (with the spatial resolution of 20 m and better) with timely stable position were used as the control points of geodetic network. The points are situated on the distance 8+- 2 km of one from another within the whole area of the test-site. They are fixed on the ground by special centres. There are totally 213 points with the co-ordinates determined in photogrammetric system of co-ordinates, with the accuracy not worse by X and Y axes than +-0,8m, by the altitude +- 0,5 m.

The field of geodetic control points has the size of 2000X2000 m and consists of the points situated as on a chess-board at the distance of 50,100 and 200 m each from another. The points are marked by a sign as the shape of"Maltese cross" with the ray size of 2X2 m (fig.2). The accuracy of determination of the points co-ordinates is +- 0,2 m.

3.2.2. Near the Elista city the site was selected for establishment of the second control point. Four control photometric fields (CPF) and two radial ground targets (RGT) of painted concrete (fig.3) will be constructed. The size of each CPF is 100X200 m, diameter of RGT is 100 m. Nominal values of brightness indices of CPF are : 0.06+-0.02; 0.2+-0.02; 0.3+-0.02 and 0.6+-0.05. The sectors of RGT must have the same values of the brightness indices and respectively one ground target will have the contrast of 0.2, the second - of 0.8.

CPF are designed for radiation calibration of aerospace survey means operating in visible and near IR spectral bands, and also considering the differencies in the temperature of fields with variuos reflecting characteristics , for calibration of survey means in thermal band of wave lenght. Besides it is planned to execute the testing experiment for determination of spatial resolution and temperature sensibility of air-borne means of survey in thermal band.

RGT must provide for the assessment of information value of aerospace systems having spatial resolution of 1 to 15 m. In addition to RGT , CPF should have line ground targets for determination of the resolution from 2 m to 15 cm.

3.2.3. The third control point will have a system of angular reflectors for calibration of radiation survey means. Nowadays there are the runways for light aircraft and the squares for portable photometric standards which serve for calibration of air survey means operating in visible and near IR spectral bands, and also the system of irrigated fields which can be used as natural control photometric fields for calibration of space survey means.

3.2.4. The test-site has spatial actinometers which can measure atmosphere transparency in the spectral bands, used in space survey; standard meteorological instruments; portable photometric standards and the unit of multispectral air survey cameras reliably standardized photometrically and operating in the zones of spectrum used in space survey; the laboratory permitting to perform primary processing of survey and measurements data .

3.3. The problems of test - site use

3.3.1. Proceeding from the points how the test-site is equipped now it can be used for the following main aims:

- geometrical calibration of air and space survey means;
- radiation calibration of aerospace survey means operating in visible and near IR bands by natural control photometric fields;
- formation of the data bank of brigtness and spatial-frequency objects interpretative features of main classes of arid zone and the elements of degradation of soil and vegetation

coverage.

3.3.2. The essence of geometric calibration of survey means consists in the following. The co-ordinates of geodetic control points should be measured on a space image.

X1 Y1, X2 Y2, ...,Xi Yi,..., Xn Yn (desirably n= 80-100)

An application of a part of control points (~ 0,1n) allows to determine the parameters of function which correlates the co-ordinates of control points in the system of terrain co-ordinates and the co-ordinates of their image in the picture system of co-ordinates (for photographic systems that will be the elements of exterior orientation of image). Using these parameters we will calculate the co-ordinates of control points

X1' Y1', X2' Y2',...,Xi' Yi',..., Xn' Yn'.

The differencies of the calculated values of co-ordinates and of real values from the catalogue of co-ordinates of control network shall be total error of the co-ordinates calculation

$\varepsilon_i^x = x_i' - x_{0i}, \quad \varepsilon_i^y = y_i' - y_{0i}$.

The total error in its turn is the sum of systematic (Δ) and random (δ) errors $\varepsilon_i = \Delta_i + \delta_i$.

For $n \to \infty$ the sum of random errors is coming to zero. Therefore, approximately it is possible to take a systematic error equal to mean arithmetic value of the values of total error

$$\frac{\sum_{i=1}^{n} \varepsilon_i}{n} \approx \Delta .$$

Respectively random error $\delta_i = \varepsilon_i - \Delta$

and $\frac{\sum_{i=1}^{n} \delta_i}{n} = 0$.

The systematic error can be applied for correction of calculated values of co-ordinates of terrain points $X_i = X_i' - \Delta X$, $Y_i = Y_i' - \Delta y$ and for making exact the parameters of survey system, introducing into the function of link betweem the co-ordinates of the points of terrain and their image (for photographic systems that will be the elements of interior orientation).

The accuracy of the measured co-ordinates (Xi', Yi') is characterized by the value $\delta_\varepsilon = \pm\sqrt{\sum_{i=1}^{n} \varepsilon_i^2 / n}$ and of the more exact (Xi, Yi) -

$$\delta_\delta = \pm\sqrt{\sum_{i=1}^{n} \delta_i^2 / n}$$

3.3.3. Radiation measurements by aerospace data are based on the correlation between the quantity of radiant energy (F) falling on the surface of radiation receptor and energetic brightness (B) of the correspondent object of terrain. The arguments of the function which characterize this connection are survey instruments parameters (C1, C2,..., Ck), survey conditions specifications ($\psi, \varphi, \ldots$) and atmospheric parameters. Hereby the atmosphere is characterized by two values - "multiplication" (index of transparency - T) and "additive" (brightness, index of atmospheric brightness -γ_a). Respectively the function will consist of two parts, main ("multiplication") which include (besides one) all the parameters of the survey system, and "additive" which characterizes the atmospheric brightness and the radiation dispersed inside the survey camera (Ck)

$$B = f\,[c_1, c_2, \ldots, c_{k-1};\ \psi, \varphi, \ldots;\ T, \varphi) + (\gamma_a + c_k)] \quad (1)$$

The consequence of combined influence by errors in formula (I) arguments values constant for the given survey system is the systematic error in determining brightness characteristics of terrain objects. The influence of this error may be significantly reduced if "multiplication" part of formula (I) will be added by correction as the multiplier Δ . So the task of radiation calibration can be formulated as determination of the correction Δ . However this is impossible to do without knowing the atmosphere parameters T and τ_a. Therefore considering that the arguments Δ and T make part of formula (I) as the relation Δ/T, radiation calibration can be done in the following way:

- by an application of the images from two CPF with well known brightness values we will receive and solve two equations with two unknown values $X = \Delta/T$ and $Y = \tau_a$;

- by an application of the results of actinometric measuremets made during the space survey we will calculate the value T and will find the correction $\Delta = XT$.

For realization of radiation calibration there will be required CPFs like those planned on the second control point of the test-site. Approximately this task can be solve by natural square objects, optical specifications of which will be determined during space survey by reliably calibrated airborne facilities operating at the low altitudes when we can accept $T=1$, $\tau_a = 0$. The accuracy of such way of calibration are seriously influenced by non - orthotropic surface of natural objects and generalization of images. Nevertheless if the compensation of that factors is good, the calibration by natural objects is useful.

3.3.4. The realization of radiation calibration can raise significantly the accuracy of radiation measurements, compatability of the results of measurements made from different types of survey instruments. That allows to store statistic initial data required for forming the banks of the interpretative features by regular inspection of the sampling the features under the study and by determination of their brightness characteristics on the survey images.

4. CONCLUSION

4.1. The aerospace measuring test-site is the important means to provide for ensuring the metrologic uniformity of geometric and radiation measurements made by different on-board survey instruments and measurements.

4.2. The aerospace measuring test-site to be created in KALMYKIYA can now on a contractual basis to:

- perform geometric calibration of space and air-borne survey video means with the ground resolution of 20 m and better;

- perform radiation calibration of the space survey means operating in visible and near IR spectral bands by natural objects;

-output data about state and necessary specifications of the assigned objects corresponding to the time of the their space survey;

- output the values of indices of zonal brightness of assigned objects corresponding to the time of their space survey;

- output data about spectral transparency of atmosphere during space survey.

4.3. The realization of the reported plans of KALMYKYIA test-site development will open broad possibilities of calibration and different investigations of aerospace survey means, operating in visible, thermal and radiation spectral bands.

Considering the importance of the test-site creation for effective solution of global and regional ecological problems , it is expedient to conclude these works by joint participation of interested users probably under the UN aegis.

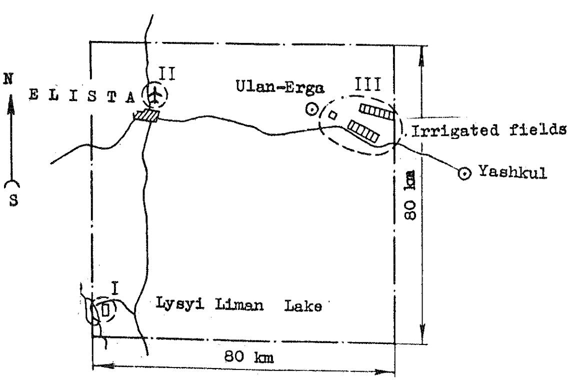

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Fig.1.General scheme of the test-site : I,II,III - control points

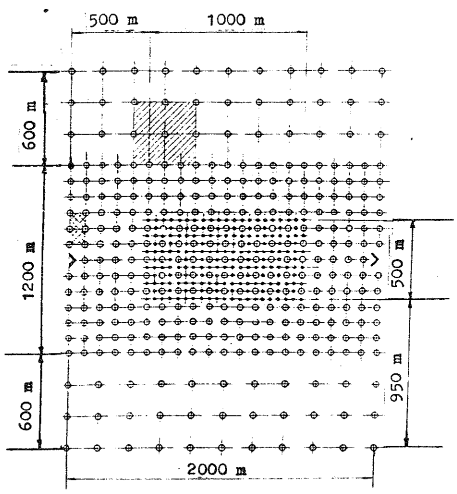

Fig.2. Field of control points

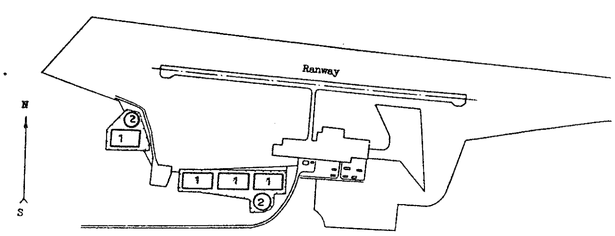

Fig.3. Second control point: 1-basic photometric fields,2-radial ground targets.