ENGINED DELTA-GLIDER (MICRO-LIGHT AIRCRAFT) IN TECHNOLOGY OF TOPOGRAPHIC PLANS AND MAPS TIMELY REVISION.

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ABSTRACT:

Here results of reseaches and experiments carried out at TsNIIGAiK in 1992-1994 with participation of field expedition for timely revision of plans and maps of scales 1:500-1:10 000 then using an Engined delta-glider (Motodeltaplan-MDP) are presented. Two technology variants were tested: one-using photographic materials obtained from MDP aerial survey with the futher airvisual observation from the MDP and the other one -by using in flight and on-ground interpretation data with no additional aerial surveys.

1.INTRODUCTION.

TsNIIGAiK has prepared technology of timely revision of large-scale (1:500 - 1:10 000) topographic plans and maps using engined delta-glider (micro-light aircraft), in Russian: MOTODELTAPLAN -MDP.

Choice of MDP for these works was based on achieving of effectivity because of lower (for the order) cost of exploitation, comparing it with traditional carriers such as An-30, Mi-4; possibility of approaching of a basings place of air-survey party to work-object; simplicity of exploitation and technical serving, absence of hard demands of choice of take off and landing field - its size and coverage; low speed of flying (60 km/h), letting look at changes of areas more thoroughly, big viewing, possibility of virage flying round the objects.

Two variants of technology were used by materials of new air survey by MDP with folow airvisual inspections on it and with materials of interpretation flight and landings without doing new airsurvey (laing some airsurvey of strips in special necessity).

Experimental laboratory works consisted of foundation of a programe and a working project of experimental works, preparation of working map manuscript of revision,definition of degree of modernity of a plan and map and a control of their accuracy; definition of air images conteining of photokeys of update, keeping duty map with an information of videofilm and other cartographic originals; laboratory preparation of air images and fotogrammetric bridging of net; making of originals of changes with MDP images on AP "Stereoanagraph-2"; getting of up-date originals.

Experimental field works were done in a region of a small town and connected collection of materials of the cartographic meaning in various organizations; spade-work of parts of area for survey from MDP; airsurvey; training and reconnassance flights on MDP in altitude 100-250m and survey of an videofilm, recognizing and interpretation flights on an altitude of 150m for discovery of changes and conteining for plans 1:500 and 1:2000 and a map of scale 1:10 000; interpretation flights for revision of plans of scales 1:500 and 1:2000 with landings for correcting of map 1:10 000, control field observation. A programe of experimental works defined sequence, volumes and time of realization of spade-work and afterflying field works.

2. EXPERIMENTAL WORK.

2.1 Terrain areas observed.

For experiments three parts were chosen. First one was correspondid to a list of map of scale1:10 000. Hilled (excess over midd flatness ±54m) settlement with separate forest massives and country-sides. Square is 16sq.km. Degree of modernity of map is (are) 64%. The second one is equal to plan 1:2000. Square is 1.0sq.km. On a plan a settlement of town kind (buildings from 2 till 9 floors) with developed communication net. Excesses over medium flatness are ± 22m. Degree of modernity of plan is 46%. The third one is equal to three plans with a scale 1:500 of common square 0.3sq.km. It situated on area of

the second part. Excesses over middle flatness are ±10m. Maps and plans were found in1978. For every part on a transparent base blue, black and double -side black-blue copies of originals of changes, conserved contours and combined were made. In process of correcting it was discovered that map 1:10 000 and plan 1:2 000 comply with demands of precision made by normative documents. For a map middle excesses contained corsespondingly 035mm and 0.37 m on corrected 16 plane points and 27 height points; for a map correspondingly on 12 and 27 points - 0.22 mm and 0.14m . Accuracy of plans 1:500 of 1984 year survey did not comply with demanas of normative documents, that is why the were not liable to revision.

If during period of works it was impossible to change a part of area they used points of a 1;500 plan of tacheometric survey of 1993 as check ones.

2.2 Preparatory work.

Before flying on MDP, in various regional and town organizations materials were gathered; with their help they defined degree of modernity of maps and plans. Air images of previous years (1991),general plan of town of scale 1:10000, statistic reference books of censuses of the population, materials of autoroads, nature hydrography, ingeneer buildigs,etc. were used.

By these materials photokeys of in terpretation on "old" air images and fragments of map originals with due regard for some special things for various stages of work were contained During spade-work preliminary photokeys on plan airimages of 1991 year of scale 1:18000 (for map of 1:10000) and helicopter images of 1992 year of a scale 1:4000 (for plan it is 1:2000). Number of objects, which lists were given in description to photokey were marked by arrows and numbers. Besides, a method of iterpretation (by field method with air images, with department cartgoraphic materials) was shown. Some columns served for marks, got from reconnaissance flight, videofilm, and field inspection. Objects that need airvisual or field inspection (when landing MDP) were marked with "?".

During period of field preliminary works base of fly-survey group and field photolaboratory, area of work was studied and the main runway of 150x20m was chosen, land marks were adjusted. To choose a runway it was necessery to take into account direction of winds. Pilot had documents giving him the right to pilote MDP with a pas sanger; it was got from local organizations of Federal microlight avia tion. A pilot must have practical experience of working with equipment; the second member of a group must be a topographer or cartographer with experience of interpretating of images.

2.3 Reconnaissance flights. Videofilm making.

Before survey and interpretation works training reconnaissance flights on MDP at altitudes 100,150,200m were realized to study a region of works, correct communication and equipment.
During the flying, an information about the changes of the area was recorded under the numbers and was marked on a paper copy of map, fragments of original or on air-photo and also characteristics of objects and elements of an area, that were impossibe to recognize in flight, werw also recorded.
In areas where elements of the area during flying were not recognized, landings were done. New and changed elements were marked by measuring by polar method. As a result of recognizing flights a scheme of interpretation flights and landings was written, excluding photokey.

In a process of survey video-film special attention was paid to a day-time(morning hours)because the main signs of recognazing of objects are color and britghness. Voices connection with objects and area elements,names and descriptions were done under their numbers.First line of a flight and geographic names were marked.Ai rvideofilm was studied by looking through on video and joining of information with the elements of a map and airimages.In videofilm changes of roads contours and boards of nature, appearing of new gardens,buildings and desappearing of old ones are seen clearly.By the information got from videofilm the photokeys,where objects and elements of area were marked by red,green,brown and black colours,were prepared by new method;they were interpreted accordingly by the lab method,from MDP, by video-film,department materials,in field inspection. For a map of scale 1:10 000 four photokeys for the main local areas were created (see T.able 1)

Table 1

Pfoto-key	Percent correllation of objects interpretation			
	by lab method with		when flying on MDP	on the land
	air-imag	other depart-ment material		
1	46.7	13.4	20.0	20.1
2	39.1	5.5	48.1	7.5
3	60.0	-	22.7	27.3
4	48.1	-	43.4	8.7
Medium	46.0	4.5	33.5	16.0

It was counted by data of photokey that 79,5% of changes were interpreted by "old" airimages and airvisually from MDP, in a laboratory by other department materials and in a field-20,5%.
To study changes on the second and third parts photokeys were contained on helicopter images during recognizing flights.But in view of the fact that on these parts airsurvey from MDP was prepared,a percent correlation from interpretation of objects on images from MDP was count by various methods after training flights (table 2).

Table 2

Scale of plan	Percent correllation of objects interpretation		
	by lab method	when flying on MDP	on the ground
1: 500	46.7	13.4	20.0
1:2000	39.1	5.5	48.1

It was found that a part of field works was equal only to 1/5,and 75-80% were interpreted in laboratory and by airvisual observation

2.4. Airsurvey.

Airsurvey was done in August 1993 mainly on morning hours when air turbulance was not very high.Differently from the first part (second type of the technology),where it was not necessery to do airsurvey,in the second and third parts(first type of technology) survey was done.Here they tried to choose thoroughly altitude and direction of flight,stability of situation of MDP(transfering when change strips not much than 30,time of excluding from heel not longer than 3 sec.) A pilot had to observe condition of air:wind speed was not much than 5 m/sec;an absence of solid and cumulus cloud;an altitude of the Sun was not less than 15 above the horizon in surveying by black-white film.

Before surveying a camera was set into a special installation(bracket) providing its fixation, angle stabilization in limits of ±7°,vibroprotection in limits of its own frequency and turn of drift angle in the interval of ±25° Airsurvey was done by AFA-TE-100(fc=98,46mm,18x18cm) in scales of 1:6000 and 1:3000 on black-white film.Overlaps of images were as follows:a forward one -80-90% and a lateral one is 40%.Chemical photo processing of materials in lab conditions and evaluating of their quality was done by traditional way.

Interpretation flights were realized in accordance with the project and scheme of field inspection(airvisual and land). The crew had flight map,black-white photocopy of the corrected land mars-orientirs (by lab way)with a scale 1:10 000 folt up by bucklet and set of lab interpretated air images increased till a scale 1:2 000.
2.5 Air-photo interpretation. Interpretation fligts, airvisual and field observation.

Interpretation of airimages got from MDP was prepared by lab method simultaneous preparing for interpretation in flight.By indian ink in present secret signs results of interpretation was designed,parts of area and objects needed flight by MDP were marked by arrows and numbers.

Finally,images were designed after airvisual interpretation.Drawing was coloured;in addition for difficult parts lists of interpretation were written.Every object was presented with the same number that on airimage and a kind of its interpretation was indicated.The same numbers were typed in- , to audiophone.At the same time a scheme of field inspection with selected parts of objects unindicated on airimages,but situated on department documents was made.This scheme was used in containing of project of field inspection where points of the main geodetic network and survey substantiation, objects, elements and parts for correction,verification or resurvey,strips of airvisual inspection and places of landing for field inspection, a situation of land stations intended for resurvey of objects were presented.

For field observation minimum numbers of strips and landings were planned.In a project of airvisual observation on a issue paper copy the directions and numbers of strips and land marks at the beginning and the end of the strips with the distances not much than 3-4km were marked.

Several kinds of work were done for every point of landing.Before field experimental works interpretation, a working project with schemes of airvisual strips and landings for the ground experiments,"plastic" with schemes of field experimental works,copies of originals of revision maps corrected in laboratory was formed.Compliet set of airimages with results of labinter-pretation;photokeys of inter-pretation,copies of summaries by limits of trape-zium were done.

Interpretation flight for plans 1:2000 and 1:500 was realized at the altitude not higher than 150 m. Speed of a flight over difficult objects was lowed up to 60km/h Special attention an interpreter paid to objects planned by observation.New unprojected objects also were fixed. At the same time a topographist dictated explanations of it.

Viewing of difficult objects (e.g.local areas)were done by the flying over perimeter and along the main streets.To recognize them better some circle flights were done.During observation of roads they flew

with a distance of 200 m from a road to see all the details (e.g.bridges, tubes, kilometre posts etc.).These types were interpreted just after flight.By the results in a working copybook and on images some marks were written.This information was used for correction of map manuscripts.

Interpretation flight with the second type of the technology for correcting a map of scale 1:10 000 had a number of special things,got from an absence of materials of new airsurvey from MDP.Observation for keeping duty map manuscript by correcting some details in a copy during flight and landings was realized.Besides an interpretator had results of videofilm and map manuscript corrected by materials of cartographic meaning.Altitude of the flight was not higher 100m with min speed of 60 km /h.There were much more landings and virages(by 2 times) comparing with the first type of the technology.In interpretation works map manuscript was compared with condition of area some required detaile and characteristics were done.

Landings of MDP were realized in areas of objects with difficult situation for interpretation with small elements that were not recognized in flight. The data obtained was processed immediately after observations, while the terrain details are fresh in the memory of an image interpreter. Each time MDP flights were followed by field data processing. Field observations of all the areas flew over took place to check air visual interpretation data that resulted in the recognition of about 20% of objects, thus proving the interpretation results by photokeys for populated sites of the second and the third areas. (See Table 2). Field surveying was followed by in-door revision of field maps and by their preparation for copying and printing.

2.6 Timely revision of plans and maps and results evalution.

The 1:500 scaled plans were fully prepared for revision (control points taken from the plans of 1:500 tacheometric survey, 1993, were repinned). Each stereo-pair was supplied by, at least, four control points, by "nests" of contour points of the old plan or by photogrammetric bridging points (3-4) positioned at the corners of the area surveyed. Marking device MP-1 was used for point marking. Control points and photogrammetric bridging points taken from 1:4000 helicopter air survey documents,1992, were transfered to air photographs obtained from new air surveying. As for contour points they were transfered by repinning from 1:2000 plans made on the basis of these documents.

Elements of innner and reciprocal orientation were determined from the models designed on Stereoanagraph-2, and then tilt angles of MDP air photographs were defined by those elements. Determination by 11 stereopairs of 1:6000 scale resulted in $\Delta\alpha_{max}$=2°.6, $\Delta\varpi_{max}$=7°.4, $\Delta\chi_{max}$=7°.0,(witct $\Delta\alpha_{min}$=0°.1,$\Delta\varpi_{min}$=0°.0, $\Delta\chi_{min}$=0°.1),and by 9 stereo-pairs of 1:3000 scale respectively:1.°5, 7.°3, 4.°3 (0.°1, 0.°3, 0.°4).From observation results you can see that there are rather significant differences of tilt angles and turns of air photos presented in some cases, that is why an analytical device was used for image processing. Spatial network bridgings were carried out by an analytical method with using SK 18x18 stereocomparator and "Onega-2"automated recording device. The bridging results used for revision of 1:2000 scaled plans showed that residual errors do not exceed 0,15mm with an admissible value being 0,25 mm. As for bridging based on 1:3000 aerial photographs intended for revision of plans of 1:500 scale, it failed to give positive results (errors reached 0,4 mm), therefore air-photos of 1:6 000 scale were used for revision on the basis of 1:500 tacheometric survey data.

Map revision methods vary depending on customer's demands, so the kinds of revision also may be different: a partial revision where high accuracy of some map elements is required; a simplified revision where accuracy of the whole map or of some map elements is not so high; and a full revision where it is necessary to revise the whole map content with a required accuracy. Based on the results obtained it was decided to make timely revision of plans at scales of 1:500, 1:10 000, and 1:2 000 by three methods respectively.

The choice of a method applied to map revision on AFP depended on the amount of corrections to be made, relief of the terrain, and tilt angles of air-photos. All the working documents i.e data referred to the flight strip and needed for the map board orientation, a catalogue of coordinates, and stereopairs to be processed have been prepared for the revision. The catalogue of coordinates for the second area contained 89 control points, for a processed stereo-pair of 1:6 000 scale almost fully covering the plan of 1:2000 scale it contained 15 control points. R.m.s. error (further "error") of reciprocal orientation did not exceed 5 mkm, errors of exterior orientation computed by 7 points were dx=0,08 m, dy=0,10 m, dz=0,15 m. Accuracy estimation of geometrical model designing on the basis of 14 points resulted in the following values: dx=0,17m,dy=0,18m, dz=0,25 m. Errors of the map board orientation were dx=0,12 mm, dy=0,05 mm, ds=0,13 mm. For the repeated orientation of the map board five or six identical points per each stereo-pair were additionally included into the catalogue. After the evaluation of geometric constructions completed a digital manuscript of changes was formed together with simultaneous

graphicali presentation on screen, and then -on plotter. For accuracy estimation horizontal and vertical positions of the identical points in the map manuscript revised on the basis of survey data, and those in the map manuscript compiled from tacheometer survey of 1:500 scale, 1993, were compared. (Table 3).

Table 3

Scale map	Numbers of points having discrepances						Disc-rep.
manus skript	0.3	0.4	0.5	0.8	1.0	1.6	max
	in plan						
1:500	11	2		1	1	1	1.6mm
1:2000	11			3	1	2	1.3mm
	in height						
1:2000	31	5	2	9	1		0.9mm

X,Y errors were 0,4 and 0,5 mm for the plans of scales 1:500 and 1:2 000 respectively, and the error in relief was 0,3 m. The latter result means that it is possible to detect and make corrections in the relief having a contour interval equal to 1 m or mo- re. Blue, black and double-side copies were used for the revision procedure. Air-photo interpretation should be carried out simultaneously with compilations of the manuscript of changes, the manuscript of left con tours, or together with corrections of the revised map manuscript. New and corrected contours were applied to the blue copy, and the former ones were removed from the black copy. Drawing of the revised map manuscript was performed in accordance with the symbols adopted. New elements were agreed with those that were left. By means of simultaneous copying of "the map manuscript of changes" and "the map manuscript of the left contours" made on a transparent base, a revised composite drawing was received. It was checked basing both on 1:500 tacheometric survey data, and on field interpretation of air-photos of 1:2000 and 1:10000 scales. Comparison results have shown that interpretation of the air-photos obtained from MDP survey is quite the same in its fullness as that while we employ other carriers. Percentage of in-door and on-board air visual interpretations amounted to 80-85% in comparison with the field interpretation. To meet customer's demands the map manuscript is copied in a required number, or "the manuscript of changes" is prepared, and then in-printed into a certan part of the map issue, or multi-colour reproduction is provided.

3.CONCLUSION.

Instructing technical document has been compiled on the basis of the MDP air survey results. It included: a description of MDP design, objectives and a branch of MDP applications, main specifications, technical requirements to air survey equipment and to an air vehicle employed as a tool for expeditious map revisions; the consecutive order of work stages, and some peculiarities of preparatory work and air surveying process itself; instructions and procedures of reconnaissance flights and landings for obtaining data about terrain changes in the field; description of procedures for expeditious revision of topographic plans and maps at scales ranged from 1:500 to 1:10 000 with using MDP. There are some recommendations of the Instructing technical document we are presenting here. They are as follows: The first technological variant i.e. when a new aerial survey takes place, is suitable in cases where significant terrain changes are revealed, and the map is up-to-date by less than 80%. Map revision on the basis of MDP air visual observations and field measurements during MDP landings (when there is not any new air surveys) is needed when changes of the terrain elements are less than 20% (the second variant). Before designing the project it is necessary to study customer's requirements with respect to an accuracy of map elements being revised, final view of a cartographic product, work dates, the available information on the area to be surveyed. If a user is the Federal Service of Geodesy and Cartography all the obiects of the I-category of importance are to be corrected. As far as topographic objects of the 2-nd and 3-d categories of importance are concerned their changes can be partially interpreted according to a user's order. The MDP performance requirements are as follows : maximum comfort should be provided for an operator's and topographer's jobs during the flight; control and operation of the air survey equipment should not effect on the pilot's body position while air surveying; a good view for a topographer should be provided, as well as steady fixing of a tape recorder and a camera. It is recommended to use AFA-TE as a mapping aircamera (as no lighter camera is available yet) with an image size of 18x18 cm, focal lengths of 70, 100, 140 or 200 mm, relative lens aperture not less than 1/17, and a central-type shutter with exposures of 1/80 -1/240 c or 1/40 - 1/120 c (depending on the illumination of the terrain area to be surveyed). AFA turns should be within limits of $\pm$ 20° . Recommended scales of taking photographs with respect to AFA focal lengths are presented iin Table 4.

Air survey should be completed at least 2 months before the revision work starts. Optimum speed of MDP flight for air surveys of 1:12 000 and 10 000 scales is 70 km/h, and 60 km/h - for those of 1:6 000, 1:4500, 1:3000 scales. The data obtained during the flight is compiled in the form of booklets (with a 20x20 cm sheet size). Before starting MDP flights the terrain areas planned to be surveyed should bestudied and zones requiring special

Table 4

Air camera focal length mm	**Flight scale for revision of plans (maps) of scales**				
	1 : 500	**1 1000**	**1: 2000**	**1 : 5000**	**1: 10 000**
70	-	-	-	1:12 000	1:14 000
100	1:2500	1:4500	1:6000	1:10 000	1:12 000
140	1:2500	1:4500	1:6000	1:10 000	1:11 000
200	1:2500	1:4000	1:5000	1:10 000	1:10 000

regulations of flying over detected; air survey flights and all the procedures necessary with respect to time and dates of flights, radio communication and acquisition of meteo information should be agreed with the local control bodies. During reconnaissance flights a video film or a number of photographs taken by a miniature camera for peculiar terrain features are to be produced. Those flight strips considered to be the most complicated are planned as combined ones i.e. they should be accomplishrd as air visual surveying flights, and the results should be checked against those of field interpretation.

It is advantageous to use MDP for expeditious plan and map revision in the cases where other air carriers are not economically efficient to be employed due to different reasons such, for example, as dates of map revision fixed by a user (from three months to one year), sizes of an terrain area to be revised, the amount of changes and a variant of the work. Timely revision with using MDP can be practised for urban small territories, town surburb areas of intensive summer cottage constructions, villages, developing industrial areneeded.