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Presented Paper

PHOTOGRAMMETRY IN ENGINEERING SURVEYS
FOR PROJECTING OF NEW AND RECONSTRUCTION
OF EXISTENT RAILBOARDS

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ABSTRACT: This report deals with railroad survey methods with the use of aerophotography and photogoniometry, which are realized in the USSR, and covers the problems of systems for automatic road tracing by using of the digital terrain models.

INTRODUCTION

In the USSR, construction of new railroads of great extent is being realized concurrently with intensive reconstruction of existent lines. There are, as a rule, two stages in the design of new objects: technical project and working drawings. For solving cardinal problems, a pre-design stage is introduced: the technical and economical substantiation of construction (TES). Aeromethods are at the basis of engineering survey for many objects, the concept implying a complex of applied sciences: aerophotography, aerohydrometry, aerogeology and others.

Photogrammetry is the main constituent part of aeromethods. There are mainly two directions in using the aeromethods: surveys for new railroads and surveys for reconstruction of existent lines.

AEROMETHODS, USED IN SURVEYS FOR NEW RAILROADS

Geological engineering surveys	Drawing up route survey topographical plans
Study of physical and geographical phenomena, typical for specific regions	Survey of river bed cross-sections
Aerohydrometry	Acquisition of data for preparing the digital model of terrain

Efficiency of aeromethods depends on the geographical zone of railroad to be designed and on factors, influencing formation of natural landscapes. Tundra, forest-tundra, forest-steppe, steppe, half-desert and desert are the best zones for data acquisition by aeromethods to trace railroads.

Considering that the relief view in forest zones is inaccessible for direct survey, it is a good practice, for higher accuracy of photogrammetrical measurements, to carry out the aerial surveying in the short period between melting of snow and blossoming of leaves. The best results of such aerial surveying are obtained in deciduous forests or in coniferous forests with larch predominance.

The accuracy of aerotopographical surveys can be improved by the use of laser aeroprofilographs. Aerial surveying and photogrammetry find use at all design

stages as furnishing objective and accurate data, required for railroad tracing. The survey technology depends on quite a number of specific engineering problems and local conditions and may have various practical implementation. At the stage of TES, it is necessary to determine the economical expediency of construction and select the main railroad direction, for this purpose, all possible variants should be traced.

SURVEYING PROCEDURE FOR TES

- (a) Tracing of variants on topographical maps to scales 1:100 000 or 1:25 000.
- (b) Selection of key and standard layout sections for field tracing, fixing of reference points and geological engineering decoding of aerophotographs.
- (c) Aerial route photosurveying by variants to scales 1: 25 000 - 1:15 000.
- (d) Aerohydrometry on the large river crossings.
- (e) Drawing up route topographical plans to scales 1:10 000 - 1:5 000 for standard sections, by using of aerial survey data, mopping, processing of aero-hydrometry, making photodiagrams.
- (f) Handing of technical documents and data, obtained by aeromethods over to designers.

SURVEYS FOR TECHNICAL PROJECT

The survey technology depends on landscape peculiarities within the zone of the railroad to be designed and predetermined schedule of project works. The survey data should be sufficient for projecting the plan and profile of railroad, design of all buildings and structures, their location, and for estimation of the cost of construction.

The main photogrammetrical task, at this stage, is drawing up route topographical plans along the whole layout to scale 1:2000 and, in some instances, 1:5 000. Ratio of aerophotograph and plan scales is 1:5 or 1:6.

Topographical plans are drawn up with the help of such devices as STEREOPROJECTOR SPR-3 (made in USSR). Plan-height reference marks, required for stereomodel external

orientation, are determined in nature and fixed to trunk levelling line, which is approximated to the possible railroad position and is based on the State triangulation network.

It should be emphasized that aerial route surveying along the projected railroad lines is the basis of photogrammetrical measurements and mapping made for railroad engineering surveys. Arrangement of reference points is determined by linear position of photogrammetrical rows.

Plan reference points are given along the route on the trunk levelling line and height ones are given symmetrically on photo ends to ensure geometrical conditions for levelling the stereomodel. A group of height reference marks, as regards their diametrical position with respect to the aerial survey route and the trunk levelling line, is termed "crossline".

Allowable distance between height crosslines, as a function of scales for topographical plans to be prepared, is:

(in photographic bases)

1:1000	- 4
1:2000	- 5
1:5000	- 6
1:10000	- 7

Condensing of the base geodetic network is performed by aerotriangulation methods and for that purpose it is well to use both analogue devices type (STEREOMETROGRAPH) and high-precision stereocomparators, for instance, STEKOMETER (made in DDR by the "Karl Zeiss" firm).

The final document of railroad surveys is the longitudinal profile of the railroad to be designed. At present, tracing by topographical plans gives way to tracing by means of computer on a digital model.

Modern photogrammetrical instruments, equipped with automatic devices for recording the results of measurements on the magnetic or punched tape, allow to solve various engineering problems, relating to accounting for the topographical information.

The "photogrammetrical instrument - computer" system allowed to construct the digital model of terrain, which became the basis for automated systems used for tracing of railroads. In practice, a structural - digital method of building the relief model found on application as it allows for the geomorphological peculiarities of earth surface sections to be modelled and ensures their quantitative reconstruction with predetermined accuracy.

The distinguishing feature of the method is that the initial information is given as arrays of points on the traces of relief section by horizontal or inclined plans, on watersheds, riverbeds and specific orographic points. The model in this case represents a system of polyhedrons. Information density depends on relief dissection and predetermined accuracy of model interpolation. A specially worked out algorithm allows to find all the relief break points practically with the same accuracy as by building on horizontals of topoplan. The structural-digital diagram for construction of the relief digital model allows to considerably reduce the initial data volume, the accuracy remaining the same as in other methods. Automatic tracing was carried out according to the "man-computer" diagram.

Angle vertex coordinates and values of curve radii are set by a tracing-engineer. Being inserted in computer memory, the digital model of terrain is used for projecting the optimum longitudinal profile line by predetermined line direction and the relevant roadbed cross profiles with the use of cost data. The automatic drawing of profiles is ensured by the plotter, combined with computer.

One and the same digital model may be used for designing and comparing several variants of the line layout, within a comparatively short period of time. The final choice of optimum variant is the designer's.

Development, mastering and implementation of automated project systems will define future trends in the railroad survey and design. Layout of the railroad to be designed on location of future bridges across large rivers. The hydrometric works are carried out to determine the crossing points. Geodetic measurements, combined with hydrometry in nature may be successfully replaced by laboratory photogrammetrical measurements on aerophotographs.

Aerohydrometry consists mainly in successive, many times repeated aerial survey of changeable ice conditions and different water horizons. The main purposes of photogrammetry are: to determine surface current velocities, to definite trajectories of flow surface streams, to obtain marks of river overflow levels and record general ice condition variations in time.

Surface velocities are determined by means of shift measurements for ice or artificial indicators (on the stereomodel). Velocity is considered as a function of a floating object linear translation in time between adjacent pairs of plates. The object translation under the influence of current conforms to the difference of longitudinal parallaxes, which are perceived during stereoscopic examination as convexity or concavity of water surface with

floating indicators. The more the excess of such conventional "water relief", the higher the current velocity. Aerohydrometry requires no field works, Aerophotograph scale is determined with sufficient accuracy by means of radioaltimeter. The aerosurvey route should be plotted along the river bed. The altitude for making photographs is selected as to see both river banks on the whole row of photographs.

AERIAL SURVEYING OF RAILROAD STATIONS AND DISTANCES BETWEEN STATION STOPS

Stereophotogrammetrical survey of railroad Stations became the principal method of engineering surveys in development of designs for reconstruction and modification. Aerophotogrammetry reduces to minimum the quantity of field topographical and geodetic measuring works on station sites. The plans of stations and distances between station points are drawn up to scales 1:2000 and 1:1000 by stereophotogrammetrical methods. The railway station plan represents a track development drawing, combined with topographical mapping. The peculiarity of this plan is the abundance of digital information such as: distances between centres of tracks, coordinates of switch centres, marks of railheads, curve elements, useful and full track lengths, clearances, marks on cross profiles of roadbed, coordinates of angles of buildings, heights for hanging of wire and others.

Much of digital data is obtained through coordination of required elements on stereomodel by means of high accuracy devices. Average error in coordinating of clear contour points on aerial photographs to scale 1:4000 is ± 0.11 m. Average error in definition of distances between centres of tracks is ± 0.04 m. For design purposes, the distances between station points are given by route photoplans to scale 1:2000 on a territory having the width of 300-400 m. Route photoplans are used for land, choice of sites for different buildings, coordination of land tenure, design of communication lines, power supply and others.

Mechanization and automation of photogrammetrical measurements on the basis of computers is the principal aim of the technical progress in engineering surveys on existent railroads.