PHOTOGRAMMETRY IN CHINA

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PAST

THE Central Bureau of Land Survey under the Chinese General Staff in Nanking organized the first training class in photogrammetry in 1930. This Bureau and the subordinated provincial branch offices selected the trainees from their mapping officers and organized an aerial photogrammetric party the following year. The projects undertaken at that time included assignments both for the military as well as for other purposes such as railway planning, hydraulic plants, and particularly cadastral surveys. The application of aerial photogrammetry in the following ten years was manifold. Even with the progress made in these few years, the development of photogrammetry is still in an experimental stage.

The aerophotogrammetric methods adopted at that time can be divided into two kinds, namely: rectification and stereoplotting. Rectification was based upon four control points for each picture, located by ground surveying methods. After rectifying and compiling on a grid sheet, reproduction was made on blue prints which were to be used as a basic material in delineating the details. Take the cadastral survey as an example. The aerial photographs were taken at a scale of 1:10,000; they were rectified and mosaics compiled to the scale of 1:2,500 and the reproduced to the final map scale of 1:1,000. In the stereoplotting, the stereoplanigraph and the aeroprojector multiplex were exclusively used. The former was used more for the plotting of control while the latter was used both for the bridging of short distances and for detail sketching. In the recent practice for the mapping of the 1:50,000 series, pictures were taken with the 10 cm. focal length wide angle Zeiss Topogon lens at a scale of 1:30,000 to 1:35,000. The plotting scale under the multiplex plotter was 1:10,000 which was then reduced to a scale of 1:40,000 for inking and delineating for the final map scale of 1:50,000.

The historical development of photogrammetry in China can be divided into two periods; the first covered the years 1931–1935; the second, the years 1936 until the present. During the first period, introduction, experimentation, and acceptance followed each other. After experimenting with this method, the map users found the technique of photogrammetry a highly satisfactory process which superseded the former process of plane tabling to a great extent.

The Survey Bureau began operations with one plane in 1931 and, by 1935, was using seven. The personnel assigned to this work numbered 44 in 1931, 182 in 1933, and 432 in 1935. The surveying cameras were the normal angle ones with the focal distances of 13.5 and 21 cm. Cadastral surveying parties were organized in two districts, in addition, two parties were formed for aerophotogrammetric surveys of the Yang-tze River and the Railways, respectively.

* Maj. Gen. Wang, Fourth Department, Board of Military Operations, Nanking, China, has been in the United States for several months, reviewing American equipment and methods. Gen. Wang will welcome suggestions or remarks, by photogrammetrists, on methods and plans outlined herein. The opinions expressed in this article are the personal ones of the author.

The works carried out during the period 1931–1935 can be tabulated as follows:

Kind	Military			Cadastral		Railway		Hydraulic		
Scale	1:10,000	1:25,000	1:50,000	1:1,000	1:2,000	1:5,000	1:10,000 mosaics	1:10,000 maps	1:10,000 mosaics	1:20,000 mosaics
No. of Sheets	494	18	42	46,121	1,550	182	600 km*	19	79 & 600 km*	197

* Linear surveys of varying width.

It is worth noting that the maps of 1:50,000 scale produced in this period were located in places of military operation where, at that time, ordinary ground survey methods could accomplish nothing.

The second period in the development of photogrammetry in China extends from the year 1936 until now. Again we divide this phase of the work into two parts, the dividing line being July, 1937 when invading troops of Japan swept into China. As the first period ended in 1935 with the acceptance of this new science, photogrammetry, as a useful tool, the second period began with plans for the unification of mapping works for both military and cadastral purposes. Formal discussions between the General Staff and the Ministries of Interior and of Finance were under way to achieve this coordination. The Central Land Survey Bureau augmented the number of aeroplanes and equipment; wide angle surveying cameras were exclusively used. Just as this work was really getting under way and well organized, Japan marched against China.

Surveying activities were, then, shifted gradually into the western interior of China where the topography is very rough, means of communication meager, and weather conditions not usually favourable. Moreover, the constant occurrence of air raid alarms, the economic consideration of the scarcity of gasoline, and the shortage of photographic materials all made the circumstances for mapping photographic flights more difficult from year to year. In these recent years, photogrammetric surveying in China was practically suspended and its place was taken by the ordinary plane tabling methods. The work carried out during this period can be summarized as follows:

Kind	Military				Cadastral		Railway	Hydraulic
Scale	1:10,000	1:25,000		1:50,000	1:1,000	1:5,000	1:5,000	1:25,000
		maps	mosaics					
No. of Sheets	157	110	68	186	74,301	153	120	20

Problem in the Future

The aerophotogrammetric works in China of the past have been generally satisfactory to the map users. Naturally, in a very strict sense, they were not all up to ideal standards. Examples, like that of the excessive enlargement made in the cadastral survey as described above, certainly astonishes a photogrammetrist but not always a map user. Unfavorable criticism has flourished. Professor Schermerhorn of Holland commented after his visit in China that the

methods of rectification used in the cadastral survey ought to be changed altogether and better means found for showing results. We ourselves have been trying to find better ways of doing the work. During those war years, we were practically isolated from the rest of the world and could not keep informed as to the recent instrumental developments in foreign countries. Every now and then occasional news came through, but the reports were far from being complete and, sometimes, were even distorted. The U. S. Coast and Geodetic Survey nine lens camera and the U. S. Army three lens camera particularly impressed the Chinese surveyors at that time. Some of the surveyors thought that the use of the very effective multiple lens camera would render obsolete the single lens camera. So far this has not been the case.

Now the difference in the choice of mapping methods lies in the choice of various combinations of three factors, namely: accuracy, economy, and speed. If one lays too much emphasis on one factor, he must sacrifice one or both of the other factors. As for accuracy, it means in one sense that which is prescribed by a rigid specification and, in the other sense, that which is obtainable under the governing circumstances. Wartime difficulties make the latter rule obligatory. A peacetime program aims for the former. In this latter case, the degree of accuracy is usually understood to be represented by the scale of the map. What is economy in one country may not be economy in another country, and this varying factor sometimes affects the choice of method. For example, in America the cost of photography is usually a minor part of the cost of mapping; in China, such might not be the case. In America the use of a plotting scale of 1:10,000 in multiplex for a final map scale of 1:50,000 is not considered seriously extravagant; it is even sometimes considered necessary. In China we have been seriously hampered by our inability to bring the direct plotting scale smaller.

Today, there is a tremendous mapping problem facing China. We aim to make a complete series of maps of the scale 1:50,000. If such an undertaking proves too slow, we shall have to content ourselves with maps of smaller scales for less densely populated areas. Such a procedure is worth considering only if we really have surveying methods which will take into consideration such factors as speed, economy, and accuracy and which can be applied advantageously to the different scales. This approach excludes the expedient use of the methods which originally, inherently, and naturally lead to the map making of scales much larger than necessary and then reduction to the required scales. In planning for a peacetime mapping program, why should one try to produce maps, say, of 1:200,000 in certain areas instead of say, 1:50,000, if he, by the lack of a proper method of doing, has to make the 1:50,000 preliminary base maps first and then reduce them to the final scale of 1:200,000. It seems that the economic use of photogrammetry for very small scale mapping works is limited by its capacity for identification of the details on the small scale photographs. Even though comparatively uneconomical in this case, photogrammetry is still the only method to use. The question is whether and to what extent it is advisable to allot in a standard series of a certain map scale another series of smaller scale maps in certain localities in order to save time and money.

An aeronautical series of maps of the scale of one to one million, compiled by the modern trimetrogon method, has been made of China. This series will be very helpful in the navigation of the flights for the larger scale mapping purposes. Evidently, the trimetragon method, once it has certain refinements, can be suitably adapted to mapping scales much larger than the one to one million. Plotting of the trimetrogon photographs with the help of the oblique multi-

plex projectors might be worth trying in the making of the Chinese 1:100,000 and 1:300,000 series. As for the standard series of 1:50,000, it seems that the conventional multiplex method will still be retained. The alternatives might be the use of the Wild autograph A6 or the K-E-K Instrument. The experiments with these instruments haven't yet been made. The use of the K-E-K Plotter gives theoretically an approximate solution. To substitute the theoretically more sound multiplex method with the K-E-K Plotter is only justifiable when the latter proves to be definitely more economical. In the comparison of the first cost of the instruments, of course, one K-E-K Plotter set should be compared with only a two projector portion of a, say, eight projector Multiplex set. I am now of the opinion that if the Shoran Method can be adopted in the triangulation of the second order, and we let the stereoplanigraph or Wild autograph A5 do the third order work while the multiplex plotter does the still lower order control and finally the detail plotting, these methods, would formulate an expedient procedure.

As a wider angular field of the photographic camera is always a desirable quality and this quality is usually faced with insurmountable difficulties in the optical design of a single lens, the map makers resort to the use of the multiple lens. Development in this direction should prove to be very promising. The difficulty lies now not in the construction of the camera itself but in the design of the proper plotting method. It seems that in this case the only method will be the rectifying and the plotting by the principle of the reflecting stereoscope, as followed generally by the U. S. Coast and Geodetic Survey, the Aero Service Corporation, and formerly the Munich Photogrammetry, Germany. This method needs many control points and is too involved in laboratory procedure for the mapping of comparatively small scales. The utilization of the oblique multiplex projector for the plotting of the trimetrogon photography might be a partial solution. If we want to develop the method to its full capacity coupled projectors duplicating the relative coupling of the trimetrogon cameras should be provided in order to acquire better bridging of the control points and the topographical details. Of course, this is only an idea or rather a theory or supposition of the direction for a line of improvement. Innumerable difficulties might lie ahead, but the ideas and plans are challenging.

Photogrammetry from a More Theoretical Point of View

When I first came to the United States in October, 1945, I was impressed by a statement made by Professor Schermerhorn of Holland concerning the two schools in the development of photogrammetry. According to him, one school of development represents America and England where photogrammetry is thought to be the best method for the unmapped countries. Ways and means are sought to obtain mass production by comparatively simple apparatus and methods. The other school is the European or continental development where photogrammetry is applied to mapping works of precision. Competition in accuracy with the ground methods is attempted and complicated optical and mechanical solutions based upon rigorous theories are exclusively developed. It seems that this statement still generally holds true.

The European countries attack the plotting problem mostly by trying to reestablish the pencil of rays of the original photograph during the plotting process. The instruments like stereoplanigraph, multiplex, aerocartograph in Germany, different models of Wild autograph in Switzerland, half a dozen Nistri and Santoni instruments in Italy and the stereorestituteur in France all represent the same principle—in all these plotting instruments, the inner orienta-

tions of the surveying cameras are retained. The American development, however, points in a different direction. With the exception of the widely used multiplex, no attempt has been made to set the pictures at the position simulating that during the original exposures. Instruments like the stereocomparagraph, the Brock stereometer, and the recently developed K-E-K plotter are based upon the plotting principle of the reflecting stereoscope which separates the projection center from its relative position with the picture plane. This might simplify the instruments but deviates at the same time from the more rigorous solution.

I really believe there is a demand for the double picture automatic plotting machine, a representative model of which is the stereoplanigraph, particularly when triangulation should be carried out photogrammetrically. Photogrammetric triangulation, according to our opinion in China, should not be dispensed with in order to have the most economical use of Photogrammetry. The reasons for not having them made in America are probably:

(1) The machines are usually so expensive that one can hardly be furnished with enough sets.
(2) The liability of relatively large errors introduced by angular displacements of optics due to lost motion and deflection of supporting members.

These difficulties have to be solved by ingenious designs and high standard of precision production. If such machines are made available, they should be used for the primary purpose of carrying out the photogrammetric triangulation.

An alternative method of overcoming the above mentioned difficulty is to resort to the analytical method instead of the optical and mechanical process. By the analytical method, only very simple instruments are usually adopted, and this method has the further advantage of employing many computors working on the problem at the same time. But, to make the analytical method practical, we must try to simplify the necessary computation forms and formulae. Scientists in China are now making a great effort to achieve this simplification.

Now the principal problem in the analytical method is the relative orientation between the successive photographs. Simplification in the computation can be achieved by a proper choice of the different kinds of systems adopted in the representation of:

(1) The elements of the camera orientation.
(2) The orientation criterion.
(3) The position of the picture image points.

As for the elements of outer orientation, there is the difference in the choice of the principal axis of rotation, i.e., the axis of rotation which will remain stationary in space, like the y-axis (axis parallel to the ground surface and perpendicular to the direction of the air base) used in multiplex or the z-axis (axis perpendicular to the ground surface and the direction of the air base) adopted by the theoretical deductions by Professor Church. Professor Church has, however, introduced another method of representing the outer orientations by using the direction cosines of the photographic space coordinates. As for the measurement of the image points on the picture plane, there is again a difference between the use of linear coordinates right on the picture plane or the angular ones with the center of objective as the center of rotation. And, moreover, as for the orientations criterion of the spatial intersection of the respective rays, either the so-called linear vertical parallax (y-parallax) or the angular parallax between the respective epipolar planes can be used. So there is plenty of room for research

work in this field. From a comparative investigation made by the author,* it seems that the combination with the use of angular parallax for the criterion of the reciprocal orientation, the angular measurement in the picture image points and the adoption of the x-axis (axis in the direction of the air base) as the principal axis of rotation for the outer orientation will furnish the most advantageous data for analytical computation.

* Special Publication of the China Institute of Geography, "A Comparative Study of the Differential Formulae Used in the Analytical Methods of Computation in Aerial Triangulation," by Chih-Cho Wang, written in Chinese.

PHOTOGRAMMETRIC QUIZ ANSWERS

1. (b)
2. (a)
3. (c)
4. (d)
5. (c)
6. (b)
7. (c), (a)
8. (d)
9. (e)
10. (1, c)
    (2, d)
    (3, b)
    (4, b)