Aircraft

Ordinary military planes equipped with the usual navigating instruments are used for the photography, which is done by military pilots.

Organization and Operation

The larger photographic projects are planned and executed by the Cadastral Department.

Control points are marked prior to the photography. These marks consist of 5×5 meter (16×16 feet) crosses painted with whitewash or built with brush and moss on sand areas. Natural objects such as intersections of canals and roads, and buildings are also located for picture control.

Weather conditions are generally unfavorable for photographing because of low clouds and haze. The best months are April and May, shortly before and after midday.

Photographs are taken at a scale of approximately 1:7,000 and enlarged to 1:5,000 for graphic plotting of planimetric maps and for mosaics.

Contours are not plotted from photographs because of lack of special equipment.

Norway

Adolph Hoel, Correspondent of Committee No. 2

THE NORWEGIAN SCIENTIFIC EXPLORATION OF SVALBARD AND ADJACENT ARCTIC REGIONS

The research work in Svalbard (Spitzbergen and nearby islands) was continued in 1936 with a large expedition, which included parties of air photographers, topographers, hydrographers, geologists, botanists, and others. Since 1925 no similar expedition had been sent out to this island group. The main task this time was air photography. The Norwegian Marine Aviation in Horton furnished a plane of the type M F 11 and the necessary personnel.

A Zeiss type R.M.K.-P 21 air camera, negative size 18×18 cm. (7×7 inches) was purchased in co-operation with the Norwegian Geographical Survey.

Svalbard has an area of 62,000 square kilometers (24,000 square miles). Of this, 20,000 square kilometers (7,700 square miles) have been photographed by terrestrial methods. For the remaining part, it was found preferable to use oblique air photography.

The weather conditions are not very favorable, but if the routes suitable for being photographed at certain hours are properly co-ordinated, one can photograph almost at all times of the day and night. The good days were taken advantage of effectively without the annoyance of long shadows which one encounters in an area of peaks such as at 78°30′ latitude. All routes to be photographed were arranged beforehand on a map of scale 1:500,000. The camera was mounted with a slope of 22° from the horizontal.

The crew of the plane consisted of the chief of party, radio operator and photographer. The latter, who is one of the topographers of our Institution, worked the plan out and supervised the work in the field. For an emergency landing, a rubber boat, a tent, pillows, cooking utensils and provisions for ten days, mainly pemmican, were carried in the plane. For the first part of the summer the airbase with radio station was at Dicksønfjord. Later, during the

photographing of Barentsøya, Edgeøya, the vessel of the expedition, "Polarbjørn," served as base for the flights and was anchored at Zieglerøya.

The photographic flights were made during the period of July 9 to August 18. In 86 hours 3,300 photographs were taken, which covered Barentsøya, Edgeøya and nearly all of West-Spitzbergen, an area of 40,000 square kilometers (15,000 square miles). The altitudes flown were 3,000 and 3,500 meters (10,000 and 12,000 feet) and the air-base lengths were 1,800 meters (5,900 feet). Agfa aeropan film was used, which gave extremely good results with clear details to the very edge of the photographs. A more thorough report about this work was published in *Norsk Geografisk Tidsskrift*, Vol. VI, Magazine 3, Oslo, 1936 and in *Norges Svalbard og Ishavs-Undersøkelser Meddelelse, No. 34*, by Bernhard Luncke. Furthermore, in *Skrifter om Svalbard og Ishavet, No. 73:* Adolph Hoel's report on the activities of *Norges Svalbad og Ishavs-Undersøkelser* 1927–1936, Oslo, 1937.

In 1934 the Geographic Society of Norway and our Institution purchased a Zeiss stereoplanigraph, model c/5. This instrument is being used for the construction of 1:50,000 scale maps from air photographs. Triangulation, and terrestrial photography are being carried out over a large area for control and to supplement the air photographs.

The ground surveying work was executed in 1936 by two topographic parties whose main task consisted of running triangulation from Krossfjord to the astronomic point of Biskayerhuken in the northwest corner of Spitzbergen. Thirty-seven triangulation stations were observed and from 28 of these, 206 terrestrial photographs were taken. Twenty-three stone observation stations were built. In Virgohamna, 88 hours of tidal observations were made. A third topographer followed with a vessel for reconnoitering in the vicinity of East Spitzbergen and took 47 photographs from 32 photogrammetrical stations at sea.

REPORT ON THE PHOTOGRAMMETRIC WORK OF THE NORWEGIAN GEOGRAPHICAL SURVEY[1]

K. S. Klingenberg and E. Bjorstad

Terrestrial Photogrammetry

Since the last report, new field equipment has been purchased from the firm of Zeiss, Jena. This equipment consists of a photo-camera, a repeating theodolite, and accessories. The camera has three objectives of equal focal length which permit a large vertical field. The desired horizontal orientation is given by swinging the camera around on a graduated horizontal circle.

Only the horizontal camera axis type of equipment has been used so far.

Scope of Work

As a continuation of the report of 1934, the following review of the work performed by terrestrial photogrammetric methods during the report period is presented. This review shows working time, cost, and other data pertaining to the survey.

The development of the methods in Norway since 1937 has now increased

[1] The first part of the following interesting discussion, forwarded by the Norwegian correspondent, Mr. Hoel, might have been properly included in the report of Committee No. 1 (Terrestrial Photogrammetry). However, it was received too late for forwarding to the chairman of Committee No. 1 and it has, therefore, been included herein.

the number of triangulation stations to such an extent that for a scale of 1:50,000, there are from 6 to 10 stations available over a 100 square kilometer (40 square mile) area. This development has made it possible to obtain a better and more economical adjustment of the photographs over open country and altogether satisfies the photogrammetric interests in the preliminary planning as well as in the execution of the work.

During the period of 1934–1937, 7,800 square kilometers (3,000 square miles) were photographed for the photogrammetric construction of maps on a 1:50,000 scale.

Terrestrial photogrammetry is now the chief survey method used by the Land Survey. By this method, approximately 60% of the newly acquired areas are being recorded yearly, at a cost per square mile which has become more and more favorable during recent years.

As the methods used in Norway are still in the experimental stage, a short review is given of their development.

The report of the activities of the Norwegian Geographical Survey in 1927 contains a short statement in regard to the application of photogrammetry in our Land Survey. (Partly described in *Archives of the International Society of Photogrammetry, Vol. III, 1930.*) One purpose of this report was to show the character of our technique and the economic practicability of this method for our conditions. Terrestrial photogrammetry had been in use by the topographic section of the Land Survey for seven years. In this short period of time the full efficiency of this method, either technically or economically, could hardly be determined, particularly in a country of ever-changing topography like Norway.

Norway was one of the first countries in Europe to decide on the systematic use of terrestrial stereophotogrammetry in topographic land survey work. At that time no complete previous knowledge could be directly applied to our conditions. Everything had to be learned by experience. This made comparison with an old and long established method, the plane-table, difficult under these circumstances.

Altogether in 1927 there were original photogrammetric maps covering a total area of 4,000 square kilometers (1,500 square miles), for which full use of stereotopography had been made. These maps were prepared in various parts of the country, and over territory where the topography was quite different, but nevertheless they had one characteristic throughout, which must be looked upon as favorable for the technique of photogrammetry.

As a means of comparison we selected sections where the terrain, weather, working conditions, and all other known factors which play a part in cost, were alike. The results for the scale of 1:50,000 are combined in the following table:

Location	Area covered by Photogrammetric Method (sq. km.)	Cost in kronen per square kilometer	
		Plane-table Method	Photogrammetric Method
Hemsedal	440 (170 sq. mi.)	24.50 ($16.80/sq. mi.)	34.00 ($23.50/sq. mi.)
Hardangervidda	780 (300 sq. mi.)	29.70 ($20.70/sq. mi.)	29.00 ($20.20/sq. mi.)
Valdres-Gudbrandsdal	570 (220 sq. mi.)	33.40 ($23.30/sq. mi.)	23.00 ($16.00/sq. mi.)
Ryfylke	440 (170 sq. mi.)	38.36 ($25.90/sq. mi.)	48.30 ($32.40/sq. mi.)
Troms	1120 (430 sq. mi.)	26.03 ($18.00/sq. mi.)	30.67 ($21.20/sq. mi.)

As can readily be seen, the results obtained at that time showed no advantage for the photogrammetric method from the standpoint of economy. Nevertheless, full justification of the method, regardless of the figures, lies in

consideration of the advantage which the latter method offers in the automatic addition of the map detail. However, the work of the past ten years shows new and noteworthy results, and during this period terrestrial stereophotogrammetry has proved more and more satisfactory with respect to cost.

Since 1927, terrestrial photogrammetric maps over an area of 16,000 square kilometers (6,000 square miles) have been constructed, chiefly on a scale of 1:50,000. The areas surveyed have been mostly in the broadly formed and mountainous regions of the central and northern parts of the country.

During the same period the plane-table method was applied in the areas of southern Norway because of its suitability to these broken and wooded regions.

Therefore a direct comparison in efficiency and economy of the results between photogrammetry and plane-table cannot be obtained. The development of terrestrial photogrammetry is therefore expressed as to cost in the following table which shows a comparison between the older and the newer photogrammetric surveys.

From the following table one can gain a fair knowledge of surveys made in recent years. The table shows the results of the main areas surveyed photogrammetrically (at a scale of 1:50,000) during that period, covering a combined area of 9,500 square kilometers (3,700 square miles).

Place	*Year*	*Area sq. km.*	*Cost in kronen per sq. km.*
Troms 0 7	1929–32	1395 (500 sq. mi.)	19.51 ($13.50/sq. mi.)
Jotunheimen	1931–35	1970 (720 sq. mi.)	12.27 ($ 8.20/sq. mi.)
Troms 0 6	1932–37	1570 (570 sq. mi.)	9.98 ($ 6.70/sq. mi.)
Dovrefjell	1932–35	1530 (560 sq. mi.)	8.55 ($ 5.70/sq. mi.)
Yoss-Sogn	1932–35	1760 (640 sq. mi.)	10.95 ($ 7.20/sq. mi.)
Indre-Sogn	1932–37	1286 (470 sq. mi.)	8.39 ($ 5.50/sq. mi.)

Whereas in 1927 the cost per square mile was approximately $22.00, this amount has been reduced to about $7.00 during the years of 1933–1937. Even though the figures are not directly comparable because prices and expenses have decreased in the later years and the topography is not always the same, nevertheless the two tables give doubtless proof of the development of this method in efficiency and economy.

Results of the Topographic Survey

Year	*Area Surveyed (sq. km.)*	*Year*	*Area Surveyed (sq. km.)*
1926	3560 (1380 sq. mi.)	1932	3290 (1270 sq. mi.)
1927	4120 (1600 sq. mi.)	1933	3770 (1450 sq. mi.)
1928	3730 (1440 sq. mi.)	1934	3970 (1530 sq. mi.)
1929	3960 (1530 sq. mi.)	1935	2720 (1050 sq. mi.)
1930	4790 (1850 sq. mi.)	1936	3640 (1400 sq. mi.)
1931	3620 (1400 sq. mi.)	1937	4490 (1740 sq. mi.)

This unusually successful development by the Land Survey was obtained through judicious and rational application of survey methods, but mainly because of the ever increasing efficiency in terrestrial photogrammetry.

Below we have compiled a table which shows the relation between the use of the plane-table and of photogrammetry during the past seven years, generally on a 1:50,000 scale. The table shows the areas surveyed and the percentage of the total surveyed area by each method on the same scale.

Of the amount spent on field work during the same period, approximately 60% was used for the plane-table surveys and about 40% for photogrammetric surveys.

Year	Plane-table (sq. km.)	Photogrammetric (sq. km.)	Percent of Total Area	
			Plane-table	Photogram-metric
1931	752 (240 sq. mi.)	1179 (450 sq. mi.)	39.0	61.0
1932	919 (350 sq. mi.)	1869 (720 sq. mi.)	33.0	67.0
1933	1358 (520 sq. mi.)	2349 (910 sq. mi.)	36.6	63.4
1934	1307 (500 sq. mi.)	2545 (980 sq. mi.)	34.9	65.1
1935	1058 (410 sq. mi.)	1500 (580 sq. mi.)	44.1	55.9
1936	1666 (640 sq. mi.)	1330 (510 sq. mi.)	55.5	44.5
1937	1418 (550 sq. mi.)	1920 (740 sq. mi.)	42.5	57.5
Average	1210 (470 sq. mi.)	1810 (700 sq. mi.)	40.0	60.0

The figures are noteworthy in that it is interesting to observe that the percentage of money spent on the field work in each method is a reciprocal of the areas covered. This, however, cannot be looked upon as a definite saving, since a considerable portion of the area covered by the photogrammetric method requires additional office work before it can be completed.

The table shows, nevertheless, that photogrammetry gives unusually effective results for the amount spent on its field work providing one has available well-trained personnel and suitable instruments to derive full use of the photographs.

Summary

Official cartography in Norway has willingly adopted terrestrial stereophotogrammetry and has been successful in increasing the rapidity and lowering the cost of this process of constructing maps.

AIR PHOTOGRAPHIC SURVEY

Instruments

1 Automatic Serial Surveying Camera, 12×12 cm. (5×5 inches) Zeiss-Aerotopograph)
1 Automatic Precise Series Air Camera R.M.K.-P 21, 18×18 cm. (7×7 inches) (Zeiss-Aerotopograph)
1 A. T. G. Rectifier
1 Zeiss-Bauersfeld Stereoplanigraph, C 4
1 Mirror Stereoscope

The Precise Series Air Camera R.M.K.-P 21 and the planigraph are jointly owned by the Land Survey and the Norwegian Scientific Exploration of Svalbard and Adjacent Arctic Regions.

Scope of Work

A statement was made in the report of 1934 regarding the first experiments using rectifying methods. This experimental work is now completed.

No other work of any importance has been planned with the rectifying of single photos.

The first important air-photogrammetric work ever performed with our stereoplanigraph is now undergoing plotting. The object is to construct a map on a scale of 1:25,000 over an area of 650 square kilometers (250 square miles) in northern Norway. This region is an irregular, wooded and mountainous area with numerous lakes and swamps and with elevations ranging between zero and 500 meters (1,600 feet).

Photography

Air photos were taken at an approximate scale of 1:20,000. Only vertical photos were made. The camera used was a Precision Series Air Camera R.M.K.-P 21, flown at an altitude of 4,200 meters (14,000 feet). The flight lines had been plotted on a map of scale 1:100,000. Because of the irregularity of the area to be surveyed, a reasonable and economical plan of flight seemed very important, and the utmost care was taken in laying out the flight lines.

Due to unfavorable weather conditions and the distant location of the area, the expenses were rather high.

The picture flights were performed by the private aviation company, Wideroe A/S, Oslo, who also took care of the developing of the films and the cutting up into single photos.

Triangulation Control and Auxiliary Points

Before the picture flight, a triangulation net of the third order had already been established. Directly before the flight all points necessary for identification were marked. This was done in the following manner: On bare rocky ground they were painted with whitewash, on lighter ground with black paint. In wooded areas, flags were attached to the tops of trees. The size of these signals was 2×2 meters (7×7 feet). All points were identified without difficulty.

The measurement of the necessary auxiliary points for the orientation of the photographs in the plotting machine was accomplished after the flight.

As auxiliary points we selected picture points in the terrain which could easily be identified. These points were houses, road intersections, bridges, points along the shore line, etc. The positions were fixed in the most simple manner, either by cuts or by the polygonal system. The required accuracy was obtained by the sharpness of the symbols.

The total number of triangulation stations and auxiliary points was 150. Furthermore, the elevations of 27 lakes were determined.

The work of plotting with the stereoplanigraph machine is already under way. Our personnel had previously received the necessary training at Zeiss-Aerotopograph in Jena. Before measuring the picture pairs, all points were identified and marked on the prints.

The number of fixed ground points was not sufficient for the orientation of the pictures in the plotting machine. The ground points were therefore supplemented by points located by picture triangulation.

The open country was shown with 10 meter (33 feet) contour lines, and the settlements were indicated by symbols.

The plotting of the picture pairs has become a rapid and systematic procedure. In 900 hours, an area of 450 square kilometers (170 square miles) was covered. The plotting was carried out without gaps and although the area is heavily wooded, the contours were added without difficulty.

The original drawings will be taken to the field for comparison this summer and information will be added wherever necessary; inquiries regarding names will be made at the same time.

No definite statement can be made at this time as to the economical advantages of this method. However, it is very doubtful that the construction of maps by the air photographic survey method will be found more costly than by older methods (tilting alidade and plane-table).

Additional air-photo compilation has been planned, the photographic flights for which have already been completed. Last summer a total area of 550 square miles was flown for air-photo surveys. The maps to be made from these surveys will be published on a scale of 1:25,000.

TABLE 1

Location	Scale	Area in km.²	Photography and Triangulation				Office Work Cost in Norwegian Kronen				Total Cost Norwegian Kronen	Cost Per 100 km.²	Working Hours in the Field Per 100 km.²	Triangulation & Auxiliary Points Per 100 km.²	Number of Stereographs Per 100 km.²	Plotting Gaps %
			1st Year		2nd Year											
			Working Hours	Norwegian Kronen	Working Hours	Norwegian Kronen	Layout	Construction	Finishing Map	Total						
Troms O 5 und O 6	1/50000	1570 (600 sq. mi.)	411	3084 ($825)	1455	7554 ($2025)	228 ($60)	1559 ($420)	3237 ($870)	5024 ($1350)	15662 ($4200)	998 ($268)	119	8	10	25.4
Dovre 37 C	—	675 (260 sq. mi.)	148	1634 ($445)	438	1929 ($525)	205 ($55)	554 ($145)	1448 ($380)	2157 ($580)	5770 ($1550)	855 ($230)	92	8.7	16	7.8
Lom-Skjåk E 29	—	750 (290 sq. mi.)	165	1512 ($405)	673	2486 ($665)	126 ($35)	1040 ($280)	1643 ($435)	2809 ($750)	6807 ($1820)	908 ($244)	115	8	10	9.0
Øst-Jotunheimen E 30	—	270 (105 sq. mi.)	100	1159 ($315)	182	1126 ($300)	136 ($35)	387 ($105)	506 ($135)	1029 ($275)	3314 ($890)	1227 ($330)	104	12.6	20	20.4
Vest-Jotunheimen D 30	—	770 (300 sq. mi.)	332	1913 ($510)	1021	5013 ($1340)	660 ($180)	1908 ($510)	1710 ($460)	4278 ($1150)	11204 ($3000)	1455 ($390)	176	23.5	18	11
Filefjell-Årdal Lærdal etc. D 31	—	1286 (500 sq. mi.)	464	2869 ($775)	1369	3670 ($985)	498 ($135)	1098 ($295)	2666 ($710)	4262 ($1140)	10801 ($2900)	839 ($226)	109	12.8	16	18.7
Voss-Sogn C 32	—	1761 (680 sq. mi.)	825	4660 ($1250)	2156	7076 ($1900)	802 ($215)	3381 ($905)	3369 ($900)	7552 ($2020)	19288 ($5170)	1095 ($295)	169	16.6	11	9.7

Thus, in Norway, air photographic surveying has kept pace with the older methods and its use will be continued by the government surveys in the future.

At present, picture cartography is limited mainly to a scale of 1:25,000. Its scope will be enlarged next year to a scale of 1:50,000.

In this connection, it should be mentioned that the air photographic survey of Jostedalsbre has already been begun by Norway in co-operation with Germany, on a scale of 1:50,000. It will include approximately 3,500 square kilometers (1,400 square miles), the greater part of which is covered with snow and ice.

Refer to Table 1 for cost data.

Switzerland

N. Frischknecht, Correspondent of Committee No. 2

Air Cameras and Accessories

Single Cameras for General Use

General purpose single cameras in Switzerland are being used mainly for military purposes. These are of Zeiss and Wild construction with 250 mm. (9.8 inch) focal length and 13×18 cm. (5.1×7.1 inch) plates. The Wild camera is also made for the use of film, and has a Wild Objective, Type "C," with f/5 aperture, a sector shutter for 1/150 second, with iris diaphragm and internal yellow filter. The time of exposures with the Zeiss camera is from 1/90 to 1/360 second with focal plane shutter.

Single Cameras for Stereophotogrammetry

For stereophotogrammetric purposes, the Government-Survey of Switzerland[1] uses only the precision air camera of the firm of Heinrich Wild, Geodetic Instruments, Heerbrugg. This camera has a focal length of 165 mm. (6.5 inches) with negative size 13×13 cm. (5×5 inches) and aperture ratio of 1/5, resulting in an aperture of 33 mm. (1.3 inches). With the iris diaphragm, the aperture ratio may be changed from f/5 to f/8. The yellow filter can be mounted in front of the objective. The camera is equipped with a Lamellen Instant Shutter which permits an exposure of 1/150 second.

This Wild constructed center shutter has proved to be perfectly satisfactory for use in altitudes of 6,000 meters (20,000 feet) or more above sea level. For air photography in the Swiss Alps this is quite essential, as photography is done at elevations of from 5,000 to 6,000 meters (16,000 to 20,000 feet) above sea level.

For taking photographs with the camera held free hand, there is attached to the camera housing a folding sighting device. A circular level with an adjustable scale permits the adjustment of the camera to various inclinations.

For vertical photographs there is a suspension gear by means of which the camera may be moved into and held in the required position. The suspension gear is arranged for mounting on the plane with rubber cushions. This suspension gear is also equipped with adjustable sights. The immense broken terrain of the Swiss Alps demands properly adjusted sights for successful photography.

The magazine contains ten plates, each individually cased. The plates are pressed into position by spring action. Various safety devices make wrong manipulation impossible.

[1] Meaning all official branches of the government, also county or city surveys.