MILITARY USES OF AERIAL PHOTOGRAPHS*

Captain R. R. Arnold, C.E.

THE army uses aerial photographs for two general purposes. One of these purposes is the preparation of the maps which are used by army staffs to plan their operations and by the combat troops to find their way from place to place on the ground or to compute field artillery and infantry firing data. Aerial photographs are also used for intelligence purposes. Pictures taken from the air over enemy lines are studied for signs of activity to aid us in making our plans and to disclose those of the enemy. By taking similar pictures of friendly territory, breaches of camouflage discipline are detected and the extent that our own plans are revealed to the enemy can be deduced. This latter activity is referred to as counter-intelligence.

Photographs are used in peacetime by topographic battalions in making maps for war use as has been described in a paper presented by Colonel Herrington, Commanding Officer of the 30th Engineers Topographic Battalion.

Lack of maps needed for war in areas of the United States which the army may be called upon to defend, has tremendously influenced the mapping plans of the Army of the United States and has made its map plans differ from those of any other country in the world. Other countries are either already suitably mapped or now lack the facilities for preparing to do rapid mapping in war.

Nowadays, the essence of war is speed. We have organized fast moving and hard-hitting mechanized units which can travel long distances at speeds undreamed of not many years ago. These units are what military men call "extremely sensitive to terrain," a technical term meaning in ordinary verbiage simply that they can be delayed or stopped by many kinds of natural or artificial obstacles, and need good maps to find their way around them. The necessity for speed and hostile reaction limit the amount of ground reconnaissance which can be performed. Our lack of suitable maps and the fast movement of modern armies years ago made it imperative that the Corps of Engineers, responsible for furnishing maps in war, have organizations which could map much faster than would be possible by ground means. The very nature of aerial photography and photogrammetry offered us the only practicable solution for mapping our own and enemy territory with the necessary speed. Hence, the Air Corps and the Corps of Engineers of the United States Army have pioneered the use of aerial photography and mapping by photogrammetry in this country.

Since the outbreak of the European war, a tremendous rearmament program has been undertaken by this nation. Soon we will be prepared to defend our country against any invader. This defense cannot be performed without suitable maps since maps are as much weapons as guns or tanks. Within the limits of available funds, and with the cooperation of other governmental and private agencies, important areas are being mapped as rapidly as possible. However, because of the tremendous area of our country and likely theaters of operation, it is obvious that some maps will have to be prepared after war has started. Depending upon the type of war, the strength of the enemy and other factors which cannot be determined in advance, the army requires maps of varying scales and accuracies. In order to form some standard, the ultimate requirement for maps in war has been called the "battle map," a 1/20,000 topographical map having 50-foot contours, prepared photogrammetrically by the topographic battalion.

The battle map was evolved primarily to fulfill the needs of the field artillery.

* Presented at Annual Meeting, Washington, D. C., January 24, 1941.

The map shows all important topography, works of man of potential military value, such as buildings, fences, and roads, and other terrain features usually appearing on a map of this type. Battle maps produced in the United States are plotted on the polyconic projection and the military grid is placed on them. The sheets are limited in size by available field offset presses to 22″ by 29″. This covers about 10,000 by 15,000 yards at the usual reproduction scale. The maps are reproduced in two colors, black, and green for the woods. More colors may be used, if time permits. At least one clearly identifiable point should be located in each 1,000 yard grid square to furnish sufficient control for resection. The result is a map sufficiently large for convenient plotting by the field artillery.

As you know, it takes a considerable period of time to prepare a map such as the battle map, even using the best photogrammetric methods and sacrificing as much accuracy as possible for speed. Tests conducted during recent years by the army have shown that the topographic units of each field army can prepare about 100 square miles of 1/20,000 battle map per day, with the first issue about two weeks after the aerial photographs have been taken. Although this is very fast by ordinary standards, it still will take too long to prepare maps of an area for an army's operations which might cover as much as 300 square miles per day. In unmapped territory it is difficult to foresee in what areas maps will be needed. In case the war is similar to that fought in Poland or France, battle maps may not be needed, since operations may be largely confined to quick movements by mechanized forces, largely on the highways.

Frequently, then, battle maps will not be available because of failure to foresee the area of operations sufficiently in advance, because they are not needed or because movements are so rapid that the mapping troops cannot keep up with the combat troops. In these cases, the troops can get along with a less accurate map of smaller scale. The engineer topographic units will issue the troops aerial photographs in some form to fulfill this need.

At present, the army is equipped with single lens 7×9 and tandem 9 lens cameras to take pictures which are readily converted into rough planimetric maps by the engineers. The single lens pictures are made into mosaics, controlled or uncontrolled depending on time and ground control available. The mosaics are reproduced in quantity by high speed contact printing machines or on offset lithographic presses and issued to the troops as quickly as 24 hours after the air corps has taken the photographs. Mosaics and reproductions of the 9 lens 32″×32″ tandem T-3A composite photographs are usually issued at scales of 1/20,000 or 1/40,000, depending on the purpose for which they are to be used and the general nature of the military operation—whether it is a "blitzkrieg" or a defense.

Specifications have not been set up for standard mosaics. However, the needs of the artillery and the practical limitations of time and equipment define rather specifically the type of mosaic which will be prepared in war. Usually, time limitations and lack of ground control will preclude the preparation of an extremely accurate product. The prints will normally not be ratioed. If time permits, the mosaic will have a military grid placed on it. However, in most cases, an arbitrary atlas grid 1.8″ square will be used, with abscissas and ordinates designated by letters and numbers. Depending on whether the mosaic is laid and reproduction is performed by army or corps topographic units, the mosaics will be 22″ by 29″ or 19″ by 20″ in size. Marginal data will include designation of approximate magnetic north, a graphic scale, a reference to adjoining sheets, and the names of the agencies involved in photography, production and reproduction.

The map prepared from the tandem T-3A composite photographs will have

approximately the same characteristics as the mosaic. Since the pictures are laid by template, more accurate results may be expected than in the case of the mosaic unless much ground control is available and ratioing is done.

Both the single lens 7″ by 9″ and the tandem composite pictures have their objections. The former is so small that it takes a long time to prepare a mosaic from it. In addition, the plane taking the pictures must make flights so close together that only a small area can be covered in one ascent and the enemy is likely to detect the photographic plane and shoot it down. The T-3A tandem camera requires a special airplane to carry it. Wing prints must be rectified and pictures mounted by templates, resulting in lack of definition toward the edges, mismatching of tone and loss of time. These and other objections to these two types of cameras for mapping photography have led the army to develop wide-angle single lens cameras. Many wide-angle lens have been ordered and wide-angle cameras and multiplex equipment will shortly be available. The army has great hopes for the wide-angle picture—both as raw material for the battle map and the mosaic, and as a hasty map.

Tentatively, it has been decided that the map prepared from the wide-angle photograph will be issued on a sheet 19″ by 20″. As in the case of the mosaic, the photograph will have on it a 1.8″ atlas grid with grid squares designated by letters and numbers. The scale will be 1/20,000. An attempt is being made to develop a printer which can make projection prints at high speed and in quantity at the desired scale.

The aerial photographs for the preparation of the battle maps and the mosaics will be taken by special air corps airplanes, flying at altitudes as high as 35,000 feet, to avoid enemy interference and secure great coverage. The maps will be prepared, the mosaics laid and the reproduction performed by engineer topographic battalions or corps topographic companies.

The topographic battalion is an organization of about 1,000 men equipped and organized to perform field surveying, photogrammetry and reproduction by contact printing or lithography. Since this unit has been described in Colonel Herrington's paper, I shall not discuss it further.

The corps topographic company is a small edition of the battalion. It is a new organization, developed less than a year ago and comprises about 125 men. One company is assigned to each army corps. The company is organized and equipped to run ground control of not greater than third order accuracy and usually fourth order, for the artillery to make and reproduce aerial photographic mosaics of limited size and to reproduce line maps in one color. Its principal item of photogrammetric equipment is the stereocomparagraph. The reproduction unit of the corps topographical company has recently been developed and is now being procured in quantity. It consists of two multiliths capable of handling sheets up to 19″ by 20″ and a 24″ by 24″ precision copying camera, each mounted in a $2\frac{1}{2}$ ton semi-trailer, drawn by a $1\frac{1}{2}$ ton 4×4 tractor truck. Additional trucks carry supplies and 5 KVA sets for power and light. A special laboratory truck for carrying chemicals and to permit standardizing solutions, and a high speed contact printing trailer are under development for possible inclusion in the train.

In addition to the battle maps, mosaics and other products of aerial photography, the army will, of course, use rough, small scale maps such as road maps and the standard 1/500,000 strategic map. The latter is being prepared for the entire United States by the WPA under the supervision of the Chief of Engineers. Many forms of aerial photographs which have not been mentioned will also be used. The field artillery plans to make quick reconnaissance strip mosaics.

Single obliques will be found extremely useful by both the army and marine corps in planning landing operations. They are also useful for studying detail behind enemy lines and can often be taken under conditions which would prohibit vertical photography.

Aerial photographs are widely used in peace and war for general intelligence purposes, as well as for the preparation of maps. To intelligently prepare their own plans, military commanders must know as much as possible of the enemy's activities. These activities can be recorded by the eye of an aerial observer or of a camera. Of the two, the latter furnishes a permanent record and is far less fallible. Photographs taken over enemy terrain are used to locate enemy machine guns, batteries, trenches, convoys and troop movements. Photographs are also taken of important objectives for our bombers and are carefully studied to break down enemy camouflage and guide our planes to their objectives. Aerial photographs are used extensively in the development of our own camouflage methods and for detecting errors made in concealing our own military equipment or movements which might be of value if located by the enemy's aerial photographers.

Photographs for intelligence purposes are taken by observation squadrons of the air corps, who also develop the film and make the prints.

At the present time, the air corps is employing cameras of the K-3B type which take a 7-inch by 9-inch or 9-inch by 9-inch picture on a roll of film $9\frac{1}{2}$ inches wide by 75 feet long. The camera is equipped with three cones making available focal lengths of $8\frac{1}{4}$, 12 and 24 inches. Another standard camera is the K-7C which takes a picture 9 inches by 18 inches in size and has a focal length of 24 inches. The air corps is equipped with special intelligence photographic equipment enabling them to take photographs at night from altitudes as high as 7000 feet. A new 4 by 5 camera is being developed which will be put in practically all airplanes and should make available a larger quantity of photographs useful for intelligence studies. The air corps is also developing equipment for preparing quick prints. Prints have actually been dropped from the air and used by troops on maneuvers a few minutes after they are taken.

Three principal kinds of film are used for intelligence work. The principal type, of course, is super double-X or triple S panchromatic aerial film having a Weston factor of about 100. This film is usually used with a minus blue filter to correct for haze. Infra red film, because of its ability to cut haze and to distinguish between natural foliage and certain types of pigments used in camouflage, is used for intelligence purposes, especially for the detection of camouflaged enemy installations. Color film has been used, but only on an experimental basis. Because all the haze is recorded on color film, and because of its slow speed, narrow latitude and the difficulty of processing it, its use has so far been limited except in connection with experimental camouflage work.

The usual technique of taking intelligence photographs is for the plane flying over enemy terrain to search the area until the observer finds evidence of enemy activity such as tracks made by tanks moving into an assembly area, or smoke from bivouacs otherwise hidden in the woods. This area is then photographed on a reconnaissance strip, pictures overlapping 50 to 60% in direction of the line of flight so that stereoscopic studies can be made.

Prints furnished by the air corps observation squadron may be used by intelligence sections, by camouflage units, by the artillery in connection with the battle map and occasionally will be used by some unit of the combat troops as a map.

As an illustration of a typical use for intelligence photographs, let us suppose

that an airplane on a reconnaissance mission over enemy territory notices some fresh tracks leading into but not emerging from a clump of woods. The pilot flies over the woods and the aerial photographer takes a stereoscopic pair of vertical pictures of the suspicious area. The negatives are taken to the airfield where they are promptly developed, probably in one of the air corps' new field photographic laboratories. The negatives are examined wet, and quick prints are made and delivered to the intelligence section of the unit to which the observation squadron belongs. The prints are studied, interpreted and if a target is detected a suitable field artillery battery will be sent a print with the target designated on it with an order to destroy the target by fire. The field artillery commander will resect the position of the target on his battle map, calculate his firing data and commence firing. His fire will be adjusted by air or ground observation or he may simply use the map data and cover a sufficiently large area by fire to take care of map errors.

All units of the army down to the company have intelligence sections whose general function is to keep the commanding officer of the unit informed as to enemy activities. However, in units below the division the sections are small. Units the size of the division and larger have substantial intelligence sections organized to study and interpret aerial photographs for enemy activities, and to aid the commander in making his plans and selecting targets for the artillery or objectives for the tanks. Prints received from the air corps are studied by experts using stereoscopes, drafting equipment and other aids in reading photographs. New photographs received are compared very carefully with those taken previously to detect the most minute changes in the terrain. The cutting of several trees may well mean that a field of fire for field artillery pieces has been cleared.

The function of the intelligence section is of extreme importance and its members must not only be expert in the reading of aerial photographs, but must also be familiar with the appearance of various kinds of military equipment from the air and with military tactics. By collecting information from many pictures and studying and interpreting it correctly the enemy's plans or dispositions can frequently be deduced. It is unfortunate that in peacetime we have perhaps not laid sufficient emphasis on the training of personnel for intelligence sections.

The enemy also uses photographs for intelligence. His planes fly over our installations and continuously photograph them, and he has experts looking for the location of our troops, guns and tank parks. We, therefore, must hide our own equipment, continuously test the efficacy of our camouflage by aerial photographs and correct errors in concealment. These functions are performed by engineer camouflage battalions, assigned one to each field army and one to G.H.Q.

The camouflage battalion contains about 400 men and officers. In addition to equipment for applying paint and aiding the troops in concealing themselves, it has a liberal supply of stereoscopes and various kinds of drafting equipment to study aerial photographs taken by the air corps of our own installations. Photographs of batteries, air fields, camps, machine gun nests and other important objects are studied by experts, errors in camouflage are detected and corrected and then the objects are re-photographed to check the corrections. This process goes on endlessly during war.

Aerial photographic prints are also used by commanders to designate artillery targets and by artillery commanders to locate their batteries and targets accurately on their maps by resection.

This paper presents briefly the major uses of aerial photography. There are

many other less important uses in time of war and peace which have not been discussed. It must be obvious to members of the Society that in time of war the army will require a tremendous number of personnel who are experts in mapping, photogrammetry, the laying of mosaics, and in the interpretation and use of aerial photographs. I believe that the American Society of Photogrammetry is potentially a source of such experts and believe that there should be close cooperation between the Society and the War Department in helping to solve the problems involved in aerial mapping and photography.

It should not be hard for me to convince this Society that the army must use aerial photographs instead of maps for its military operations. Only by this means can we eliminate the time consuming delays of transferring terrain information from photographs to topographic or planimetric maps.

The difficulties of so using photographs should likewise be apparent to this audience—the lack of elevations, errors of scale, small area coverage, distortions due to lens errors and difficulty of faithful and rapid reproduction. The problem of combining photographs into accurate mosaics quickly and with a minimum of ground control, is just one of the knotty problems gentlemen such as yourselves may help us solve. Every step in the direction of increased speed of delivery of a useful map to the combat arms will constitute an effective contribution to the national defense.

NOTICE TO READERS

TECHNICAL MANUAL TM 5-230 TOPOGRAPHIC DRAFTING, prepared under direction of the Chief of Engineers, U.S. Army, and for sale by the Superintendent of Documents, Washington, D. C. at a price of $1.00, embraces in a single text the entire range of subjects relating to topographical drafting and the use of aerial photographs. As of possible interest to the readers of PHOTOGRAMMETRIC ENGINEERING the sections comprising this valuable manual of instruction are listed herein:

Section
I. General.
II. Description of Equipment.
III. Instructions in use and care of equipment.
IV. Basic drafting instructions.
V. Aerial photographs.
VI. Detail from aerial photographs.
VII. Use of simple stereoscopes.
VIII. Hasty Maps from aerial photographs.
IX. Information on maps and mapping.
X. Profiles and cross sections.
XI. Map projections and coordinates.
XII. Office computations and adjustments
XIII. Plotting methods.
XIV. Characteristics of aerial photographs.
XV. Preparing photographs for mapping.
XVI. Photographic control and adjustment methods.
XVII. Photogrammetry and photo-mechanical mapping methods.
XVIII. Planimetric detail and contours from photographs.
XIX. Provisional and battle maps from photographs.
XX. Compiling and finishing maps.
XXI. Restitution.
XXII. Mosaics.
XXIII. Reductions and enlargements.
XXIV. Outline of complete instruction course.