Elastic requirements for useful photos, but stringent specifications for the best.

INTELLIGENCE PHOTOGRAPHY

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In the days and months after the Nazi blitzkrieg suddenly overran France, British topographic intelligence, ill prepared to support the evacuation at Dunkirk and subsequent raids on the French coast, resorted to photo intelligence from post cards, travel folders and brochures, and tourist snapshots collected by public appeal.[1] That they were driven to this kind of improvisation illustrates the wisdom of building up in advance an intelligence photo collection even on objects and areas where no intelligence need is foreseen. It also shows that casual photos taken without any regard to the requirements of a photo interpreter can be useful. Nevertheless their usefulness is increased and the interpreter's work eased in proportion as his requirements—most of them stemming from his need to take measurements—are fulfilled.

There are times when a single photograph is *the* documentary evidence upon which a critical decision must be based. The specially skilled personnel of a photographic intelligence center may spend days and sometimes weeks exploring with their computers and precision measuring devices a single 35 mm. negative, extracting information that could not be imagined to reside in it. It may yield only one required fact, but sometimes that tiny piece of acetate and silver becomes the key to a cabinet full of hitherto inaccessible secrets. In the story of the Yo-Yo missile guidance system told in a recent issue of the *Studies*,[2] photographs of a grass-covered bunker ending in two large triangular discs provided the critical information that led to a break-through.

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[1] See James Leasor's *The Clock with Four Hands*, reviewed in *Studies* IV 1, p. 99.

[2] V 1, p. 11 ff.

The history of these Yo-Yo prints also illustrates the tribulations imposed on the photogrammetrist trying to get his measurements when the necessary technical data does not accompany the film. The make of camera that took them was not reported, nor the focal length of the lens, nor any estimate of camera-to-target distance. Even the size of the negatives was uncertain, there being no black border to show that they had not been cropped. Nevertheless a crude indicator for scale was found—a number of cows shown beyond the bunker in one of the pictures. These were identified as of the Angus breed, the average hip-to-ground height of Angus cattle was obtained from the Department of Agriculture, and the task of triangulation could begin. The resulting measurements of the visible parts of what turned out to be a new kind of radar system were later verified by repeated photographic coverage as being within 10% of the actual dimensions.

Measurements

When the focal length of the lens and the camera-to-target distance are known, the scale of the image on the negative is immediately available as their quotient. Measurements of the target's image, usually made in hundredths or thousandths of a foot, can be converted by this scale into the target's true dimensions:

$$\text{image dimension} \times \frac{\text{distance}}{\text{focal length}} = \text{true dimension}$$

The scale will be accurate, of course, only for objects in a plane at exactly this distance from the plane of the camera lens; the computation of the size of objects shown nearer to the camera or farther away is more complex.

If the focal length is not reported, but an object of known size—preferably something better standardized than cows—is shown, the scale will be the quotient of a measured dimension of that object's image by its true dimension; and the size of other objects in the same range plane can then be found with the formula:

$$\text{unknown image dimension} \times \frac{\text{known true dimension}}{\text{known image dimension}} = \text{unknown true dimension}$$

For the most accurate measurement of fine detail, however, the photogrammetrist uses angular measurements and trigonometric computations, based on the angular field of view of the lens and the size of negative used in the camera. The standard 50 mm. lens for a 35 mm. camera, for example, takes in a horizontal angle of 38.2° and a vertical angle of 26°, while a 400 mm. telephoto lens takes in only 5½° by 3½°. At a given range the lateral distance from the center point of the field of view to one of its extremes will be the product of the range distance by the tangent of half the maximum angle in question.

Fortunately, measurements are not always needed, even of military equipment in denied areas. Specialists on the type of equipment in question can often identify a known model by its distant, poorly defined silhouette, and the knowledge that such a piece of equipment was seen in that location is what is important. New models or modifications of old ones are a different matter; their capabilities have to be determined by the measurement of critical parts. And here especially the refinements that make the difference between a tourist snapshot and the most informative photograph, while small, are important. They are of two kinds, qualities inherent in the negative itself and a sufficiency of accompanying data about it.

Photographic Requirements

The first requirement is the highest resolution—sharpness of image—of which camera and film are capable. It can be achieved by focusing the lens properly, by holding the camera steady, and by using a relatively high shutter speed ($1/_{100}$th second or faster) to minimize camera and subject movement. The film, when there is a choice, should also be selected with a view to resolution; and here, unless light is good and motion minimal, it is necessary to compromise between fast film and the slower fine grain. Panatomic-X (ASA 25) or its equivalent is an excellent choice when light conditions are good and the finest detail is necessary. For poor light or when a very fast shutter is required, films such as Tri-X Pan (ASA 200) should be used. As a compromise, Plus-X Pan (ASA 80) is the best all-purpose film. Color film is desirable only when color is an important feature of the subject; that now on the mar-

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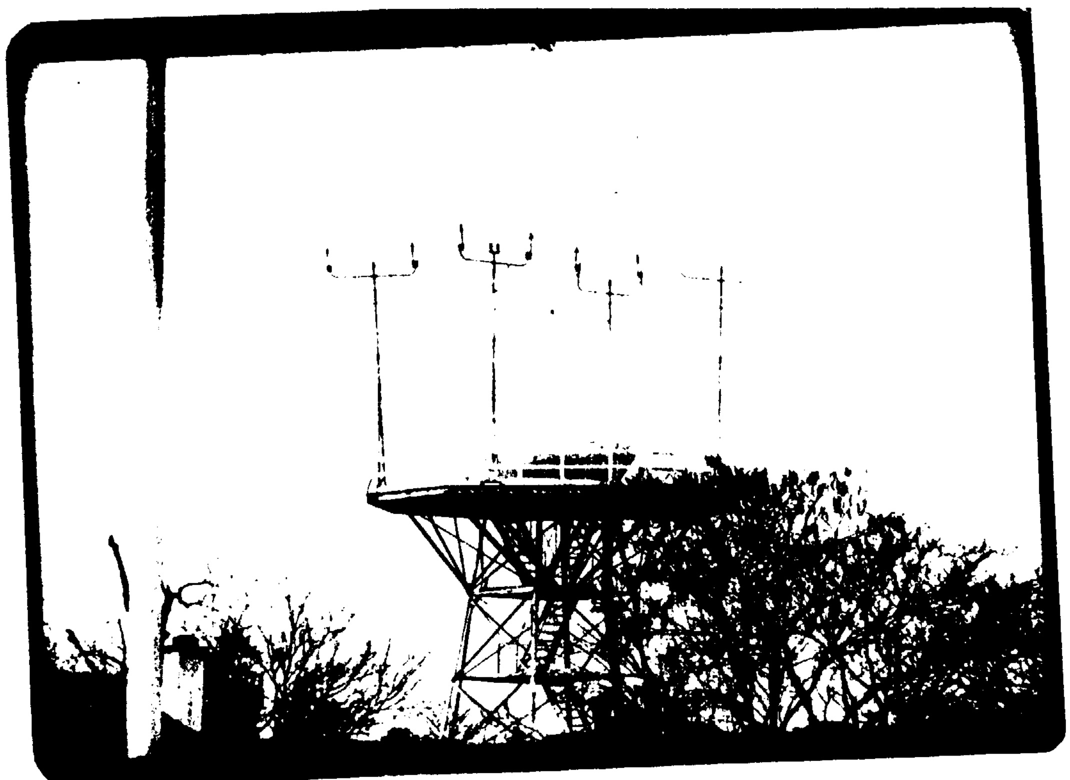

Print from 35 mm. negative taken with a Lietz 400 mm. telephoto lens at a distance of 700 feet. Note the required black border.

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ket gives rather poor resolution as the color fringes blur into one another. With improvements, film of the type of Eastman's Kodacolor may in the future be the answer to this problem.

The second requirement is that photographs not be cropped. If a print is submitted it should be made from the full negative. The analyst's ability to take fine measurements from a photograph is keyed, as pointed out above, to knowledge of the angular field of view of the camera lens and the size of the negative used. If a print has been cropped or masked, the angular relationship is left without its frame of reference. But if prints are made with a little of the negative's clear margin showing on all four sides, the resulting black border assures the interpreter that he is working with the full frame.

Third, if a print is submitted, the contrast should be neither light nor heavy, but medium. The details important to photoanalysis are frequently in shadow areas, which would be blackened by heavy contrast. But whenever possible, the original negatives, not prints, should be submitted. The best of prints will contain only about 35 of the 200 to 300 different tonal shades of gray that the negative may have, and each tone may represent additional information. The photogrammetrist, to be sure, will not use the original negative for fear of damaging it, but he will make a positive transparency that has all the qualities of the negative by contact printing on a piece of film designed for this purpose.

Accompanying Data

The analyst can sometimes improvise, as we have seen, but he will be able to get the most out of each photograph if it is accompanied by the following information:

Where the picture was taken—geographic location, province, city, town, and as nearly as possible the exact position. On a train the notation might be, "Ten rail clicks south of milepost 147 on x-y rail line," or on the highway, "300 yards SSE of intersection of highways N30 and N12." Further, the compass direction in which the camera was pointed; the more accurate the azimuth reading the more valuable the photo will be.

Date and time. Precision as to the time of day within five minutes will give the analyst a secondary method of making height determination by reference to astronomic data on sun position computed for the area in question.

Make and model of camera; different models may have different frame sizes, the Robot "Star," for example, producing a 1″ by 1″ negative and the Robot "36" a 1″ by 1⅜″. Paramount is the importance of recording the focal length of the lens, which is always engraved on the front of the lens rim.

Camera-to-subject distance, with method of measuring it—paced, map reference, eye estimate, etc.

Any unusual conditions at the scene—sounds, smells, colors, smoke, anything that might help to identify an unknown activity.

For all these purposes some system of numbering the exposures to key them to the data is necessary. Film for 35 mm. cameras is convenient in this respect because each frame is numbered during manufacture.

Special Techniques

Every lens has a distortion pattern of its own, displacing the photographic image from its true position. When the camera and lens to be used on a photographic mission are available to the photo analyst, he has them calibrated on an optical bench, recording the distortion pattern of the lens and the precise alignment between lens and plane of film. This calibration in advance is not often possible, but the photographer can easily provide calibration data himself. He stands, with his camera, between two parallel lines, such as the curbs of a street, or even better a straight stretch of railroad tracks, and makes one exposure looking down these lines with camera held level in normal position. Then he turns the camera 90° about its lens axis so that the horizontal dimension of the frame is vertical and makes a second exposure of the same view from the same position. If these two negatives are submitted along with the photos taken by the camera, the optical technician can plot the pattern of distortion and compute its effect on measurements in the latter.

A real photographic study of a subject requires views from various positions, even if they can be taken from only one direction—distant views to show the entire area and the position of the subject in its environs; medium ones for definition of the relationships of components of the subject to each other; close-ups for details of structure, size, and functioning of individual components. These three kinds of view can be taken either by moving progressively closer to the target or by successive use of wide-angle, normal, and telephoto lenses. There is no such thing as too many photographs of a subject, particularly of telephoto views, in which atmospheric interference and the foreshortening of the field present additional problems to the photo interpreter.

When a subject is too broad or tall to get into a single frame, it can be covered by a series of exposures—a procedure called panorama or partial cyclorama. The photographer takes a position at an identified point and starts with a picture of one of the extremes. Then from the same position he takes a second shot with a 30% to 40% overlap of the first, and so continues until he has covered the area. If possible, this procedure should be duplicated from a second or even third position, recording the relationship of each camera position to the others.

Of all the techniques used in ground photos, stereophotography probably has the greatest versatility and value. The simulated third dimension can be of great help in distinguishing between components of a subject or several similar objects in proximity to one another. Although 35 mm. stereo cameras are available on the market, they are of little use at distances beyond 50 or 60 feet. Stereophotographs at greater distances are best made with an ordinary camera, taking pictures of the same object from two or more slightly separated stations with the optical axis of the lens parallel in all shots. As a rule of thumb, the distance between camera stations should be one foot for each 100 feet of range. This distance, called the stereo base, should be reported. Stereophotographs can be made from a moving vehicle by holding the camera in fixed position and making successive exposures as rapidly as possible. The interval between exposures and the speed of the vehicle, if they can be estimated, will provide a stereo base.

These refinements of technique, together with accurate and complete data accompanying submitted films, enhance the intelligence value of reports based upon photography. But the elaboration of sophisticated requirements should not be allowed to obscure the most important requirement: *Take pictures.*