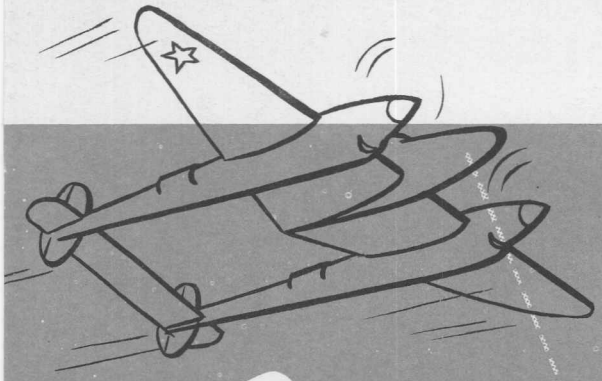
P + I Unit Camouflage Branch



CAMOUFLAGE

AND THE AERIAL CAMERA

ARMY AIR FORCES CAMOUFLAGE REPORT NO. 201

CAMOUFLAGE

AND THE AERIAL CAMERA

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SCOPE - The photographs obtained by the aerial camera are of different types and must meet certain requirements to enable thorough and accurate photo interpretation. This report is intended to furnish the "Camouflage Officer" information on these requirements and the factors governing them, which are applicable to photographs obtained for camouflage study and construction.

INTRODUCTION

A. TYPES OF AERIAL PHOTOGRAPHS.

Aerial photographs are of two types, namely: (1) vertical; and (2) oblique.

1. *Vertical.* The aerial camera is fixed in a vertical mounting, with the lens pointing directly downwards through a hole in the fuselage. The vertical photograph thus presents a view of the area covered as seen from a point immediately above that area. In general, the vertical photograph is more valuable for intelligence purposes than the oblique, for the following reasons:

a. Vertical photographs are easier to take.

b. The area covered is presented in the form of a map, and its identification from the map therefore presents little difficulty, since there is a close correspondence in the appearance of linear features such as roads, railways and rivers.

c. An approximate scale for the area covered can be determined. All features in the photograph are shown in the same scale. Consequently measurements, both linear and angular, can be taken.

d. A run of overlapping vertical photographs can be joined together as "strips" or "mosaics", thus permitting the photography of an area larger than that covered by a single photograph.

e. There is no dead ground in a vertical photograph.

2. *Obliques.* The camera is fixed (or hand-held) so that it points towards the ground at an angle to the horizon, this angle normally being from 15° to 40°. The oblique photograph thus presents a perspective view of the area covered. Such photographs possess none of the advantages referred to above. In the oblique, scale varies from the foreground (where it is larger) to the background (where it is smaller) it is therefore impossible to determine a representative fraction or scale for the photograph as a whole. Bearings and angles are distorted and become subject to the laws of perspective. It is more difficult to compare the area covered with the corresponding area on the map. In hilly country objects may be hidden in dead ground. On the other hand, such photographs possess the following advantages:

ACKNOWLEDGEMENT

This report is composed of extracts and briefs from:

1. *Notes of the Camouflage Training and Development Center, R.E.,ME.* M.A., Cairo, Egypt April, 1942 (English)
2. *Air Forces General Information Bulletin No. 6,* Nov. 1942, *Photographic Requirements for Photo Intelligence Strategic Reports.*
3. Technical Manual 30-21

a. They present a familiar view of the landscape, and identification of objects is therefore simplified.

b. At a given altitude and with the same lens, an oblique photograph will always cover a wider area on the ground than a vertical.

B. FUNCTION OF THE AERIAL PHOTOGRAPH.

1. Modern developments in photographic apparatus and technique have placed in the hands of the enemy a source of intelligence of paramount value. While photographic aerial reconnaissance can never replace visual aerial reconnaissance - each type having its own sphere of utility (the former being mainly strategical, the latter mainly tactical), it must be remembered that the photograph is able to yield information whose detailed accuracy will more than compensate for the delay involved in photographic processing and interpretation.

2. Data furnished by the camera is both more detailed and more reliable than that recorded by the eye, for the following reasons:

a. Using modern apparatus, the photograph contains much detail invisible to the eye working at the same altitude or distance. Such apparatus includes: (a) long-focal-length lenses which, together with subsequent enlargement, enormously increase the size of the image; (b) color-filters, which in conjunction with suitable photographic emulsions, have haze-penetrating and tone-differentiating properties; (c) stereoscopic technique, which enables the photograph to be seen, and measured, in relief.

b. The photograph provides a permanent, accurate and detailed record, available for study at length and at leisure by trained experts in possession of numerous other sources of information (including earlier and later photographs) relating to the area covered.

THE SCALE OF AERIAL PHOTOGRAPHS

A. SELECTION OF THE PROPER SCALE.

1. The intelligence purposes for which a photograph is most suited depends upon its scale:

a. *Large Scale.* (1/5,000 to 1/10,000)

Such photographs cover a relatively small area, but give great detail. They are consequently of value in deciding between real and dummy positions, in identifying camouflage work, and locating small features such as minefields, traps, and details of the defenses.

b. *Medium Scale.* (1/10,000 to 1/15,000)

These show detail sufficient for ordinary intelligence and counter-battery purposes. Battery positions and details of trenches and other field works may be seen.

c. *Small Scale.* 1/15,000 to 1/20,000)

This type, while covering a large area, shows comparatively little detail, and is essentially of strategical value, providing information of camps, depots, airfields, road and railway activity or construction,

and large concentrations of vehicles or troops.

2. To arrive at something more definite regarding the type and scale of photography required, a study has been made to determine the limiting factors governing identification of objects. It has been found that objects whose longer dimension appears on a photograph as .025 inch or larger, have definite size and shape and therefore can be readily identified. Objects whose longer dimension appears on a photograph as .01 inch or less have no definite size or shape, and are practically unidentifiable. Objects whose longer dimension appears on a photograph between .01 inch and .025 inch are usually identifiable, but do not appear to have definite size or shape.

a. This means that when objects appear on a photograph smaller in size than .01 inch, it is unlikely that they can be identified; when they appear between .01 inch and .025 inch, it is possible to identify them, especially when they have a relation to allied strategical objects also appearing on the photograph; and when they appear larger than .025 inch, it is practically certain they can be identified, even when isolated from other strategic objects.

b. The two values - .01 of an inch and .025 of an inch - may be used as roughly defining the practical limits of photography to be used for intelligence purposes.

c. Since the various objects which are to be identified vary in size, *we must be governed by the smallest object which we wish to identify accurately.*

d. The following formula may be applied to determine the minimum scale at which the photographs may be taken to assure identification.

$$(\text{length of Object in feet}) \times \frac{12 \text{ (to change to in.)}}{0.01 \text{ (of an in.)}} \quad \text{Scale}$$

e. The fraction $\frac{(12)}{0.01}$ is a constant (1200) and therefore is the multiplying factor to determine the smallest "Representative Fraction" of photograph from which satisfactory interpretation is possible. R. F. equals 1200 times the length of the object in feet.

f. The following table is presented as a guide giving the optimum scale of photography and the maximum scale beyond which satisfactory identification is impossible..

OBJECT	OPTIMUM SCALE	SCALE BEYOND WHICH SATISFACTORY IDENTIFICATION IS IMPOSSIBLE.
Airdromes (Including facilities)	1:15000	1:30000
Decoy Airdromes	1:10000	1:40000
Small Aircraft (Less than 40')	1:10000	1:20000
Large Aircraft	1:15000	1:30000
Seaplane Bases	1:12000	1:30000

OBJECT	OPTIMUM SCALE	SCALE BEYOND WHICH SATISFACTORY IDENTIFICATION IS IMPOSSIBLE
Harbors and Ports	1:12000	1:30000
Antiaircraft (Including light AA)	1:8000	1:20000
Coast Defense Guns	1!15000	1:30000
Barbed Wire	1:6000	1:12000
Trenches	1:14000	1:25000
Military Camps	1:15000	1:40000
Ammunition Dumps	1:10000	1:20000
Industry	1:8000	1:20000
Marshalling Yards	1:14000	1:30000
Radio Towers	1:8000	1:18000
Highways	1:15000	1:40000

B. CALCULATION OF SCALE.

The scale or Representative Fraction (R.F.) of a vertical photograph can be calculated by reference either (a) to the focal length of the lens, and its height above the ground; or (b) to the distance between two points on the photograph and the same two points on the map.

1. *Calculation of scale from focal length and height.*

R.F. of photograph $\frac{\text{focal length}}{\text{height}}$

Example: Focal length = 8 ins.
Height = 8,000 ft.
R.F. of photograph = $\frac{8}{8{,}000 \times 12} = \frac{1}{12{,}000}$

2. *Calculation of scale from map and photograph.*

R.F. of photograph $\frac{D}{d} \times$ R.F. of Map.

Example: D (distance between two points on photograph) = 4 ins.
d (distance between same two points on map) = 2 ins.
R.F. of map (one-inch) = 1/63360
R.F. of photograph = $\frac{4}{2} \times \frac{1}{63360} = \frac{1}{31680}$

C. FACTORS UPON WHICH SCALE DEPENDS.

The scale of an aerial photograph depends upon two factors, namely: (1) the focal length of the lens; (2) the height of the camera above the ground.

1. *Relation of Scale to Focal Length.*

The scale varies directly with the focal length of the lense, e.g. the longer the focal length, the greater the scale.

Example:- 5" lens at 8,000' : R.F. of photograph $\frac{1}{19{,}200}$

8" lens at 8,000' : R.F. of photograph $\frac{1}{12,000}$

20" lens at 8,000' : R.F. of photograph $\frac{1}{4,800}$

2. *Relation of Scale to Height.*

The scale varies inversely with the height, e.g. the greater the height the smaller the scale.

Example: 8" lens at 4,000' : R.F. of photograph $\frac{1}{6,000}$

8" lens at 8,000' : R.F. of photograph $\frac{1}{12,000}$

8" lens at 12,000' : R.F. of photograph $\frac{1}{18,000}$

THE SCALE OF AERIAL PHOTOGRAPHS

Representative Fraction	Inches to the mile	Yards to the inch
$\frac{1}{2,000}$	31.6	55
$\frac{1}{4,000}$	5.8	111
$\frac{1}{6,000}$	10.5	166
$\frac{1}{8,000}$	7.9	222
$\frac{1}{10,000}$	6.3	277
$\frac{1}{12,000}$	5.3	333
$\frac{1}{14,000}$	4.5	389
$\frac{1}{16,000}$	4.0	444
$\frac{1}{18,000}$	3.5	500
$\frac{1}{20,000}$	3.2	555

Representative Fractions between 1/2,000 and 1/20,000 are tabulated above for convenient reference in the more familiar terms of inches to the mile and yards to the inch.

REQUESTS FOR AERIAL PHOTOGRAPHS

A. HOW TO REQUEST AERIAL PHOTOGRAPHS.

1. Requests for aerial photographs will be made through normal channels to the commander of a unit to which observation aviation is attached or assigned. They may be made in writing or orally, but in any case must contain the following essential information:

(a) Map area or point to be photographed.
(b) Approximate hour of exposure.
(c) For oblique photograph, direction from which to be taken and elevation.
(d) For vertical photographs, the scale expressed as R.F.
(e) Purpose for which photograph is intended.
(f) Number of prints desired add time and place of delivery.

2. Titling of negative will be done by the Air Corps before delivery and will contain:

(a) A north arrow in lower left hand corner of vertical.
(b) Name of locality or nearest locality.
(c) Approximate coordinate of the center of the photograph.
(d) Scale of photograph expressed as R.F. in vertical and height above ground and focal length of camera in oblique.
(e) Hour.
(f) Date - day in figures, month in letters and years in figures.
(g) Designation of Squadron.
(h) Serial number of negative.

3. A printed form follows showing a convenient and clear way of ordering aerial photographs. It is not an official standard, and is printed to serve as a guide. For further information see FM 30-21.

WAR DEPARTMENT
HQ. 23RD AVN. ENGR. B N.
226 'F' STREET, KOREA, AFRICA

SAMPLE

Refer to File No. 2672-B

Nov. 11 1948

SUBJECT: Aerial Photography for Camouflage Observation.

TO : Commanding Officer, HQ. HQ. SQ 206th FIGHTER WING Abilene Field, Korea, Africa

1. Authority Telephone conversation between Maj. C. E. Smith 23 Avn. Engr. Bn & Lt. R. B. Brown, 206th Fighter Wing

2. Aerial photographs as described in table below of areas indicated on inclosed maps of Korea, Africa are required.

3. The 23rd Avn. Engr. B.W. HQ. Co. KOREA, AFRICA requests the outlined mission to be performed on Nov. 12 1948, or the first suitable day thereafter and delivered to Lt. John Doe and if possible before 10 A.M. 11/13 1948.

Signed John Doe 1st LT. C.E
23rd Avn. Engr. B N.

PHOTO NO.	1	2	3	4	5	6	7	8	9	10	11
AREAS (Marked on Map)	A	A	A								
*FOCAL LENGTH	12"	12"	12"								
*PHOTO SIZE	7x9	7x9	7x9								
FILM Type & Filter	PAN MB	PAN MB	PAN MB								
VERTICALS ELEVATION	10,000	15,000									
OBLIQUE Direction & *Elev.			NW 1000'								
STEREO-PAIRS Elevation											
*NO. OF PRINTS	2	2	2								
*TIME TO BE TAKEN	10AM	10AM	10AM								

*Will be determined by existing materials and conditions.

INTERPRETATION OF AERIAL PHOTOGRAPHS

1. It is of the utmost importance that a camouflage officer should have a clear grasp of the characteristics upon which the recognition of objects in an aerial photograph depends. Once these matters are thoroughly understood, he can take the necessary steps to combat and nullify the clues to recognition and thus render identification of an object difficult or impossible from all but the closest range.

2. The features in a photograph which render possible photographic interpretation are as follows:

(a) Size, shape, and stereoscopic appearance.
(b) Shadow cast by an object.
(c) Tone.
(d) Other features associated with the object.
(e) Its aspect on previous photographs.

A. SIZE, SHAPE, AND STEREOSCOPIC APPEARANCE.

1. In a vertical photograph, horizontal dimensions are seen in plan, giving length, breadth, and the contained surface of an object.

2. Height may be determined by stereoscopic methods.

3. It should be borne in mind that the shape, in plan, may be nearly similar for very different objects.

B. SHADOW.

1. Shadows frequently form a most important clue to identification in an aerial photograph. They are, moreover, difficult to camouflage. Shadows are of value to the photographic interpreter for the following reasons:-

(a) They may reveal the presence or establish the identity of objects otherwise rendered unrecognizable by camouflage.

(b) They frequently reveal an object's elevational outline, thus confirming an identification based on other clues in the photograph.

(c) From a shadow, it may be possible to calculate the height of the object which casts it. This is done by comparing the length of the shadow with that cast by an object of known height in the same photograph.

(d) Shadows may establish the presence or identity of objects otherwise invisible because of their small size in the vertical photographs, e.g. factory chimneys, radio aerials, and telegraph poles.

(e) Photographs taken early (after sunrise) or later (before sunset) are of especial value for photographic interpretation, since the low angle of incident sunlight produces long shadows. Such photographs reveal irregularities of surface, and low modelling, in accentuated relief, and thus indicate existing features not otherwise visible.

C. PHOTOGRAPHIC TONE.

1. Photographic tone may be defined as the appearance of an object in the scale from black, through intergrading shades of grey, to white. Photographic images toward the black end of this scale are spoken of as dark in tone; those towards the white end as light.

2. All objects, whatever the actual color or nature of their surface, are represented in a photograph as patches of tone, ranging from black (the darkest possible tone), through various shades of grey (half tones), to white (the lightest possible tone).

3. Apart from shadow, size and shape, the most important clue to the identification of an object in an aerial photograph is its tone. A knowledge of the various factors upon which photographic tone depends is therefore as indispensable to the camouflage officer as it is to the reader of aerial photographs.

4. The subject of photographic tone is somewhat complex. It is one for which easy generalisations and rules-of-thumb cannot be laid down, since even a single object, whether a garnished net, a sheet of water, or a tarmac road, may *each* be rendered in an air photograph as any tone from black to white, according to the conditions under which the negative has been exposed.

5. The subject therefore demands some knowledge of the elementary principles of optics and photography. Photographic tone depends upon a number of factors, of which the following are the most important:-

(a) The nature of the surface of the object, e.g. whether it is smooth or rough.

(b) The position of the object relative to the camera and source or incident light, e.g. whether the camera lies in, or out, of the path of reflected light rays.

(c) The texture of its surface, e.g. the amount of contained shadow.

(d) The color of the light reflected from its surface, e.g. its property of absorbing light of certain wave lengths.

(e) The properties of the photographic emulsion, e.g. its sensitivity to light or different wave lengths.

6. *THE EFFECT OF SURFACE ON TONE.*

In considering the effect of the nature of the surface of an object on photographic tone, several interrelated factors must be taken into account, namely: (a) The nature of the surface; (b) The position of the camera relative to the object; (c) The position of the camera relative to the source of incident light.

a. *The Nature of the Surface.*

(1) When light falls upon the surface of an opaque body, part of it is reflected and part scattered from the surface. The proportion of reflected to scattered light depends upon the nature of the surface: (1) from perfectly smooth surfaces incident light is mainly reflected; (2) from rough surfaces, the greater proportion of incident light is scattered.

(2) Since photographic tone depends upon the quantity of light acting upon the photographic emulsion, it follows: (1) that if the camera lens is in the path of light reflected from a smooth surface, the image of that surface will appear light in tone, since all the rays are reflected in the same direction--towards the camera-lens; (2) if an object of similar size and shape has a rough surface, this will appear dark in tone, since light-rays are scattered from it in all directions, and only a small proportion of them pass into the lens.

b. *The Position of the Object Relative to the Camera.*

(1) Parallel light-rays are reflected from a smooth surface in one direction only: it therefore follows that if the camera lens lies out of their path, the surface will appear as a dark tone in the photograph.

(2) Under these conditions, the photographic image of a rough surface will appear lighter in tone than a perfectly smooth surface of similar color, since from the former some scattered light reaches the camera, while from the latter no reflected light can do so.

c. *The Position of the Camera Relative to the Source of Light.*

(1) It will be seen from the above that the photographic tone of a smooth surface will depend largely upon the position of the camera relative to the direction of incident light. If the camera lies in the path of reflection, the object will appear light in the photograph: if, on the other hand, the camera lies out of the path of reflected rays, the same object will appear dark in the photograph.

(2) Rough surfaces scatter light in every direction; the tone of the photographic image will therefore be less influenced by the position of the camera relative to the direction of incident light, since from any direction a proportion of scattered rays will reach the camera.

7. *THE EFFECT OF TEXTURE ON TONE.*

a. Texture may be defined as the quantity of shadow contained in the surface of an object. Perfectly smooth surfaces are without texture because they contain no shadow. The more irregular or broken a surface becomes, the more shadow it will contain, and consequently the deeper will be its texture.

b. The texture of a surface has a pronounced effect upon its tone in a photograph. Other things being equal, textureless surfaces appear light in tone, textured surfaces dark in tone. This deepening of tone with increase of texture is due to the increasing proportion of shadow to high-light present in a given area of the surface photographed

c. It therefore follows that different objects of the same color may be rendered very differently in a photographic print, owing to the greater absorption of light by highly textured surfaces. For instance, a field of long grass will appear darker in a photograph than a field of short grass, since the former has a greater shadow content than the latter. For a similar reason, a field of thick grass will photograph darker in tone than one in which the grass is thin. Similarly, a pine tree is found to have an extremely dark, and a sycamore tree a very light, photographic tone, since the former has numerous vertical leaves enclosing much shadow, while the latter has broad horizontal leaves, scattering much light.

8. *THE EFFECT OF COLOR ON TONE.*

a. Since light of every wave length is reflected from a perfectly smooth surface, the color of such a surface has no influence upon the tone of the photographic image.

b. When light is incident upon a rough surface, on the other hand, light of some wave-lengths is absorbed, and the residue, which is scattered, is therefore not white, but colored.

c. Consequently the color of a rough surface will influence the tone of its image in a photograph: (i) If the scattered light is of a color to which the photographic emulsion is sensitive, the image will be relatively light in tone. (ii) If the color has little or no effect on the emulsion, the image will be relatively dark in tone.

9. *THE EFFECT OF THE PHOTOGRAPHIC EMULSION ON TONE.*

a. The emulsion on a photographic negative is not necessarily sensitive to the same range of the spectrum as the human eye. Photographic tone-values do not therefore necessarily correspond to visual tone-values.

b. The earliest photographic plates, while sensitive to (invisible) ultra-violet light, were not influenced by light at the red end of the visible spectrum. With such materials, violet and blue objects appeared unnaturally light, and red objects black, in the photographic print.

c. Modern panchromatic emulsions are sensitive to the whole range of the visible spectrum. When used in conjunction with a yellow color-filter (which cuts out the excess of ultra-violet, violet and blue

light to which they are over-sensitive), the rendering of photographic tone-values approximates to that of the eye for all colors of the spectrum, including red.

d. Infra-red negatives, besides being influenced by rays of the visible spectrum, are sensitive to (invisible) infra-red light-rays. In such negatives the tone of the photographic image may differ widely from that of the visual, or from the normal (panchromatic) image. Thus in the infra-red photograph foliage looks snow-white, because it reflects much infra-red light, while water looks jet black, because it absorbs all infra-red light.

D. ASSOCIATED FEATURES.

The associated features of an object may be defined as all those visible clues which are incidental to its operational role. More care is usually given to the concealment of a military objective than to the associated features: it is no exaggeration to say that fully 50% of aerial photograph interpretation is the making of reasonable deductions from aggregations of small features, none of which, examined separately, would give significant information.

The principal associated features of military objectives are:

1. *Tracks.* Tracks are of enormous value in aerial photograph interpretation and can betray surprisingly intimate details. For example a track running close to a communication trench will show that it is a route used by ration parties at night, while tracks along both edges suggest that the trench itself is in bad condition. Convergences of tracks will point to advanced CP's (especially when another associated feature - spoil - indicates a system of dug-outs), to gaps in belts of wire or minefields and to bridges, culverts and fords. A twisted track, the sharp turns of which have no obvious geographical explanation may betray the presence of a minefield. Tracks made by ammunition and ration trucks will show that a battery position is occupied: and their absence and improbable form will give an unnatural appearance to a badly made decoy position. A narrow, gently-curved track inside a sharply angled road junction will show where a light railway has been laid down alongside the carriage way of the straight stretches of road. A light railway running into a wood suggests the presence of a dump or heavy gun position.

2. *Spoil.* The amount of spoil thrown up will indicate the depth of trenches and weapon pits, and extra large patches of spoil in the middle of trench systems show the sites of dug-outs. A newly made pill-box is always a conspicuous object but it is usually the area of spoil and waste aggregate around it which is most easily spotted. The V or W shaped lines of spoil around slit trenches are often the only indication to the aerial observer that a house is in military occupation.

3. *Signs of Domestic Activity.* Signs of domestic activity include

smoke from cooking fires, bivouacs, washing hung out to dry, latrine screens and ablution benches. Their number tends to vary with the number of troops in an area, and their absence gives that air of "lifelessness" which so often renders a dummy position valueless. In snowy weather, melting of the snow on the roofs of occupied buildings or over inhabited dug-outs may give a clue to the extent to which positions are occupied.

4. *Changes in Plant Growth.* A newly laid belt of wire is often difficult to see, except for the tracks made by the wiring party. In a short time the grass below the wire grows long, partly because it cannot be grazed and partly because of the increase of moisture by condensation on the wire. The course of the belt of wire is then marked out by a dark-toned band running across country.

E. PHOTOGRAPHIC COMPARISONS.

1. Comparative photographs are of three kinds:

a. Photographs of one objective taken within a short space of time but from various angles, in order to overcome variations in appearance due to lighting conditions.

b. Photographs of one objective taken at different times in order to discover changes in the enemy's dispositions.

c. Photographs taken before and after a bombardment in order to give information on the success of the attack.

2. A series of photographs of one objective taken at different times is of the greatest value in intelligence work. Such a series is usually construed in combination with information obtained from other sources and can give much information about the enemy's intentions.

a. Future offensive operations are indicated by -

An sudden increase in the number of battery positions.
An increase in number of advanced landing grounds.
An increase in number and size of ammunition and supply dumps.
An increase in roads, light railways and the amount of rolling stock in stations.
The construction of assembly and "jumping off" trenches.
An increase in the number of field hospitals.

b. Defensive preparations are indicated by -

An increase in the thickness of wire, and the laying down of new belts.
An increase in the number of batteries.
An increase in the size of ammunition dumps.
A general strengthening of trench systems.

c. A future withdrawal is indicated by -

Decrease in the number and size of dumps of all kinds.
Preparations for demolitions.
Repairs and additions to wire.
Removal of light runways.