

Aerial Photography Basics

Hadley, Massachusetts

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AERIAL PHOTOGRAPHY INTERPRETATION

Aerial Photography Interpretation may be defined as the Art and Science of studying and identifying objects or conditions formed as images on the emulsion surface of film and evaluating their significance.

The Interpretation of Aerial Photography is based on features or conditions on the ground being recorded clearly on film or digital sensors.

It is reflected light energy that detected by the sensor or recorded on the film.

The clear recording of ground features and conditions is dependent on several factors:

Resolution: Capability of the film and/or lens to image (capture) spatial detail. Usually measured in line pairs per millimeter, or dots per inch in digital images.

Factors that Influence Resolution:

Height of Aircraft or Sensor: the higher a plane flies the less ground resolution there will be, using the same camera.

Lens speed: the light gathering power of a lens.

Film speed:

fast film; coarse grained, requires minimal lighting conditions, less resolution

slow film; fine grained, requires strong lighting conditions, higher resolution.

Film exposure: defined as the quantity of light allowed to reach the film surface. Exposure is regulated by shutter speed and aperture opening.

Filter Factor: Lens filters adsorb light so exposure time must be multiplied by the filter factor. Fortunately filters needed to filter out atmospheric haze have a filter factor of one, thus no increase in exposure time required.

Processing and duplication: influences the final resolution, duplication reduces resolution by 10-25% for each generation. PI's like to work with copies only one generation removed from the original film.

Aerial Photography Film Types

Black and white:

- * High resolution.
- * Tonal representation close to that of scene brightness
- * Least expensive.
- * Same range of sensitivity as the human eye.
- * Single emulsion layer of silver halide.
- * Use yellow filter (minus blue).
- * Traditional mapping film.
- * In use since the 1930's.
- * Because of its high resolution used for reconnaissance.

True Color:

- * Natural color rendition aides in interpretation.
- * More expensive than B&W.
- * More critical exposure requirements than B&W.
- * Good for water penetration and discrimination of underwater features.
- * Three emulsion layers; blue, green, yellow.
- * Reversal film; positive to positive (no negative).

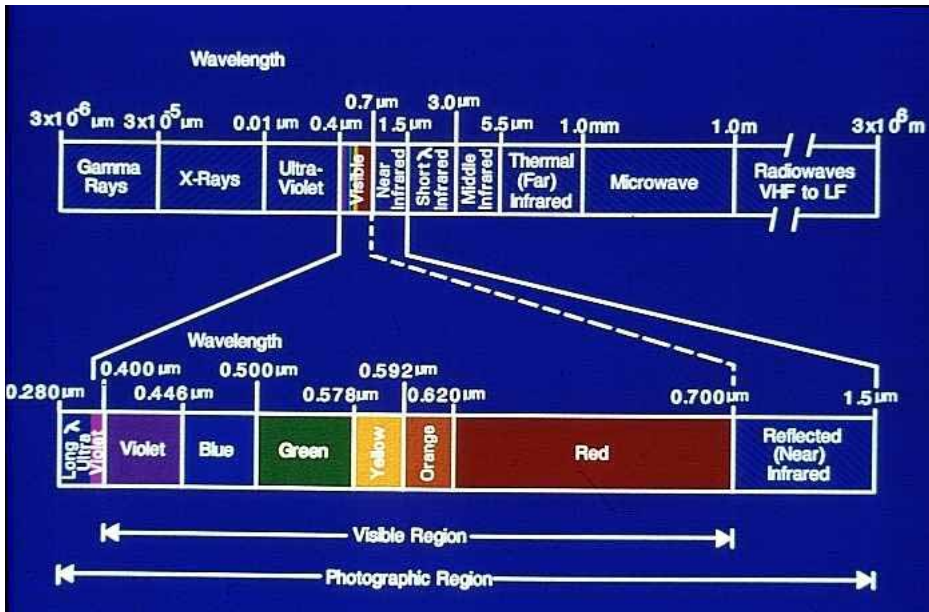
Color infrared:

- * A variation of standard color film
- * Sensitive to near infrared reflected light, not heat.
- * Superior for mapping the land-water interface.
- * Superior for wetlands mapping (leaf-off).
- * Wider spectral sensitivity than the human eye.
- * Use yellow filter (minus blue) CIR is sensitive to haze.
- * First developed for camouflage detection.
- * When properly exposed and processed living vegetation appears as shades of magenta (red).

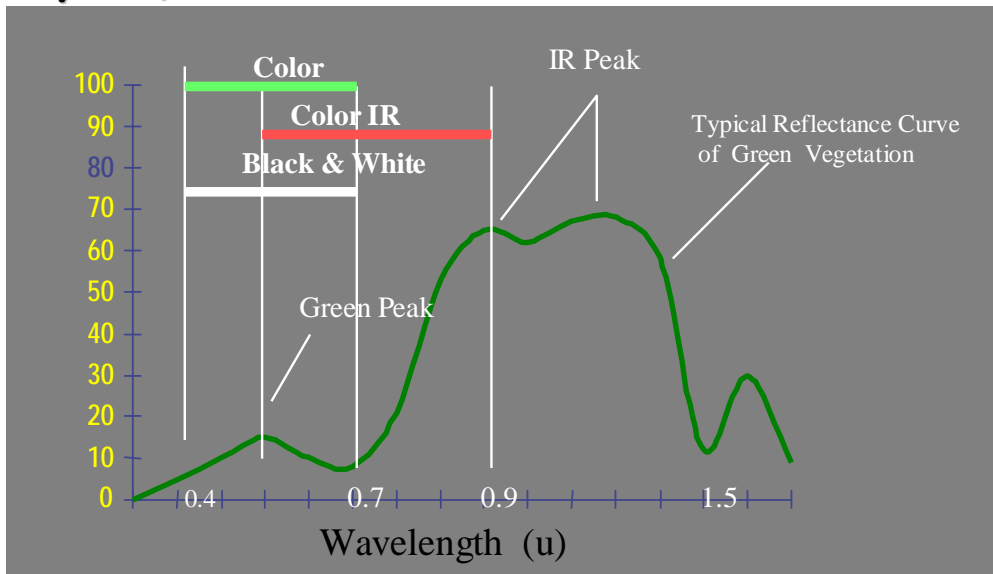
Summary:

- * Each film type has its strengths and weakness.
- * It is best to obtain a variety of film types, scales and dates covering a variety of seasons when interpreting aerial photography.

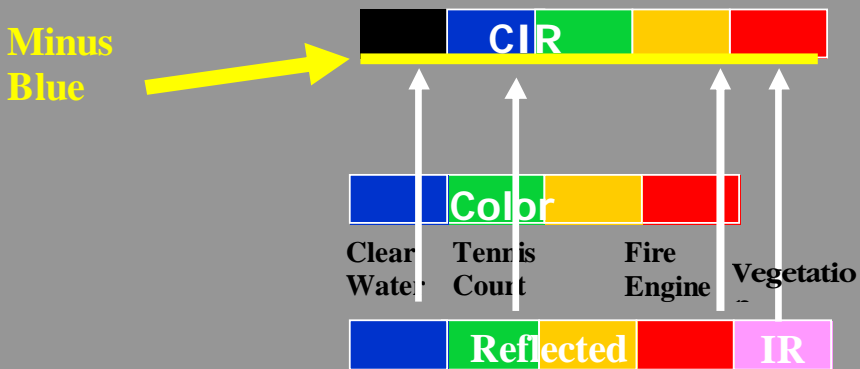
The Electrometric Spectrum



Film Sensitivities to Wavelengths of Light and a Typical Reflectance Curve for Green Vegetation (% reflectance is the y axis)



Simplified Color Shift



How Colors Appear on Processed CIR Film

Some True Colors as Represented on CIR Aerial Photography

Colors	Features
Black=Black	Healthy Green Vegetation=Red
White=White	Defoliated Trees=Blue/green/silver
IR=Red	Sand Soils=White
Red=Orange/yellow	Clayey Soil=yellow/green
Brown=Blue/green	Clear Water=Black
Yellow=Whitish	Turbid Water=Light to Dark Blue
Green=Purple/blue	

Aerial Photography Camera Systems

- * Passive device: passively records what comes to it, does not emit its own energy.
- * Captures reflected visible and near infrared light only.
- * Common Formats:
 - 9"X9" mapping camera
 - 70mm
 - Optical Bar
- * Shutters:
 - Leaf style (mapping camera)
 - Large Instantaneous Field of View (IFOV)

 - Moving slit (recon. cameras)
 - Small IFOV, high resolution.
- * Focal lengths:
 - 50mm to several feet
 - 6" standard for mapping cameras (8" next most common)
 - Optical bar has a 24" focal length.



Aerial Photography Products

* Contact Prints (1 to 1): made by placing the film diapositive (or negative) in contact with the sensitized photographic paper when the exposure is made. No enlargement factor introduced. 10"x 10" paper used for 9"x 9" standard product. Glossy or matte finishes available.

* Enlargements: made in a dark room with an enlarging device that exposes sensitized paper from varying distances creating various enlargement factors. Up to 4'x 4' enlargements are standard. Entire frame or partial frames can be enlarged. Referred to by factor of enlargement such as 2X, 10X ect.

* Diapositives: positive images on a clear stable base such as glass or plastic film. Used for photogrammetric purposes (making maps).

* Mosaics: A large composite photographic product (paper) created by cutting and feathering overlapping aerial photographs, matching the edges and attaching them together.

Controlled mosaics are made from rectified aerial photos which are scaled and oriented to horizontal ground control.

Uncontrolled mosaics are made by simply matching the details on the prints with no ground control.

* Rectified Prints: a print in which tip and tilt of the aircraft has been removed. Usually made with an enlarger that has been adjusted to compensate for the tip and tilt that occurred at the time of exposure in the aircraft.

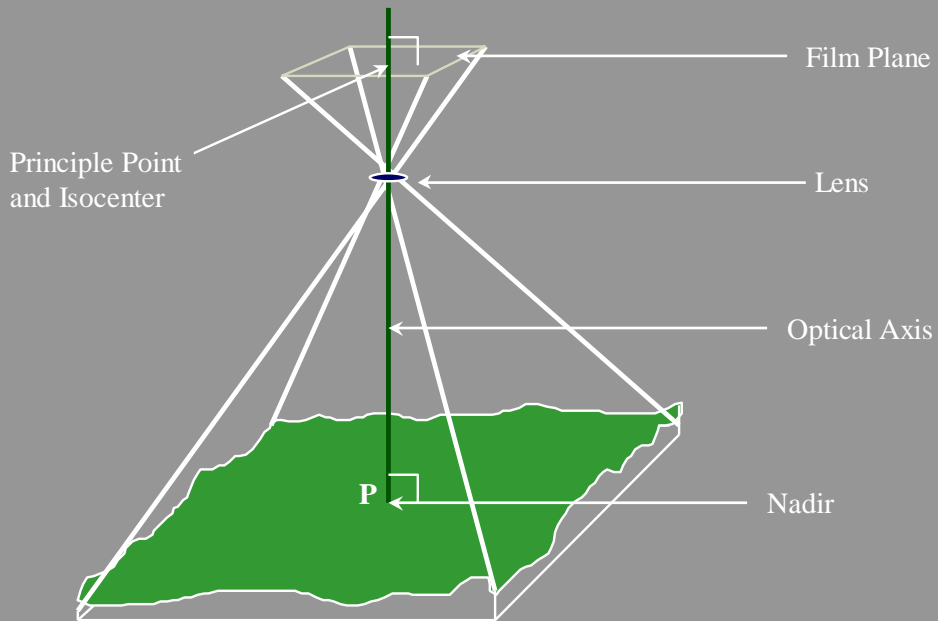
* Orthophotography: photographic reproductions that have had tip, tilt and relief displacements removed. Orthophotography combines the planimetric precision of a map with the detail available in an aerial photograph. Accurate measurements of distance, area and directions can be made, however should not be used for detailed photo interpretation due to a loss in resolution.

* Stereo Pairs: a pair of consecutive aerial photographs which generally have 60% forward overlap.

* Vertical aerial photograph: a vertical aerial photograph contains less than 3% tip or tilt. The objective of most aerial photography missions is to obtain vertical imagery for accuracy in map making and photo interpretation.

* Oblique photography: photography taken an extreme angle, generally much greater than 3%. Low obliques do not expose the horizon, high obliques taken at such an extreme angle that the horizon is exposed.

GEOMETRY OF A VERTICAL PHOTOGRAPH



AERIAL PHOTO GEOMETRY Some Fundamentals

AERIAL PHOTOS ARE **SCALED DOWN MODELS** OF THE EARTH'S SURFACE.

ALL AERIAL PHOTOGRAPHS HAVE A SCALE FIXED AT EXPOSURE

SCALE CAN BE DETERMINED FROM FORMULA OR FROM COMPARISON TO MAPS OF KNOWN SCALE

MEASUREMENTS CAN BE MADE ON SCALED IMAGES THAT REPRESENT GROUND DISTANCE, AREAS OR ANGLES

LINEAR DISTANCES (NEED TO KNOW SCALE)

ANGULAR DISTANCES (NEED TO KNOW NORTH)

DEFINITIONS

ISOCENTER: TRUE CENTER OF A LENS FOCUS

NADIR: THE POINT ON THE GROUND DIRECTLY BELOW THE AXIS OF THE LENS

PRINCIPAL POINT: THE EXACT CENTER OF THE FRAME

CONJUGATE PRINCIPAL POINT: THE LOCATION OF N ADJACENT FRAMES PRINCIPLE POINT

VERTICAL AERIAL PHOTOGRAPH: AN AERIAL PHOTOGRAPH IS CONSIDERED VERTICAL ONLY IF THE ISOCENTER, NADIR AND THE PRINCIPAL POINT ARE IN PERFECT ALIGNMENT

ORTHOPHOTO: A DIGITAL IMAGE DERIVED FROM AERIAL PHOTOGRAPHY WHERE ALL DISTORTIONS AND DISPLACEMENTS HAVE BEEN REMOVED PHOTOGRAMMETRICALLY

VERTICALEXAGGERATION:
VERTICAL SCALE IS LARGER THAN HORIZONTAL SCALE

ALL AERIAL PHOTO'S CONTAIN DISTORTION AND DISPLACEMENTS

LENS DISORTION MINOR
RADIAL DISPLACEMENT DUE TO RELIEF (ELEVATION) CAN BE SIGNFICANT AND ENABLES STEREO VIEWING
REMOVAL OF ALL RELIEF DISPLACEMENT = ORTHO PHOTO OR DOQQ

DISTORTIONS

OPTICAL (RADIAL LENS)
ATMOSPHERIC REFRACTION
EARTH CURVATURE
SHRINK/SWELL OF FILMS AND PAPER

MOST OF THESE MINOR AND CORRECTABLE

DISPLACEMENTS

TIP AND TILT: CONTROLLED BY GOOD FLIGHT PATTERN AND RECTIFIED BY LAB (NAPP PRODUCTS) MUST BE LESS THAN 3% TO BE CONSIDERED VERTICAL AERIAL PHOTOGRAPHY

RELIEF DISPLACEMENT: IS DUE TO ELVEVATION OR HIEGHT IS CAUSED BY THE PERSPECTIVE GEOMETRY OF THE CAMERA AND TERRAIN AT VARYING ELEVATIONS

RELIEF DISPLACEMENT IS THE MOST SIGNIFICANT OF ALL DISPLACEMENTS IS PRESENT IN ALL AERIAL PHOTOGRAPHY THAT COVERS TERRAIN OF VARIABLE ELEVATION

SUMMARY

OPTICAL AND OTHER DISTORTIONS ELIMINATED BY GOOD LENSES OR CAN BE CORRECTED IN LAB

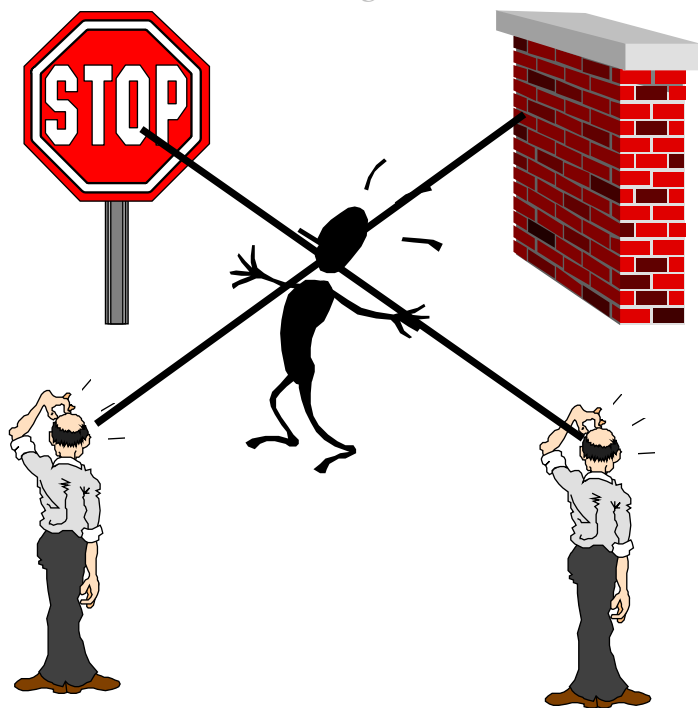
TIP AND TILT CAN BE CONTROLLED BY GOOD FLIGHT PATTERN AND CAN BE CORRECTED IN LAB

RELIEF DISTORTION IS SIGNIFICANT BUT ENABLES STEREO VIEWING AND CAN BE MEASURED AND CORRECTED

THE REMOVAL OF ALL DISTORTIONS AND DISPLACEMENTS CREATES AN ORTHO IMAGE OR MAP

Parallax

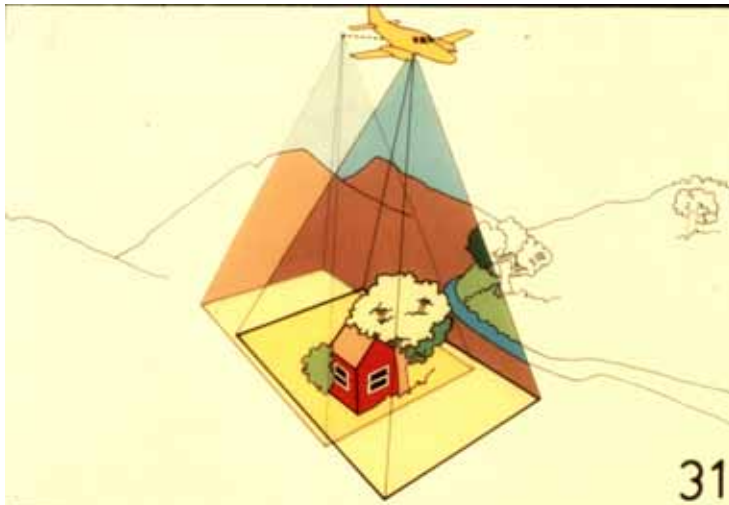
- Parallax is the apparent change in the position of an object with respect to another when viewed from different angles.



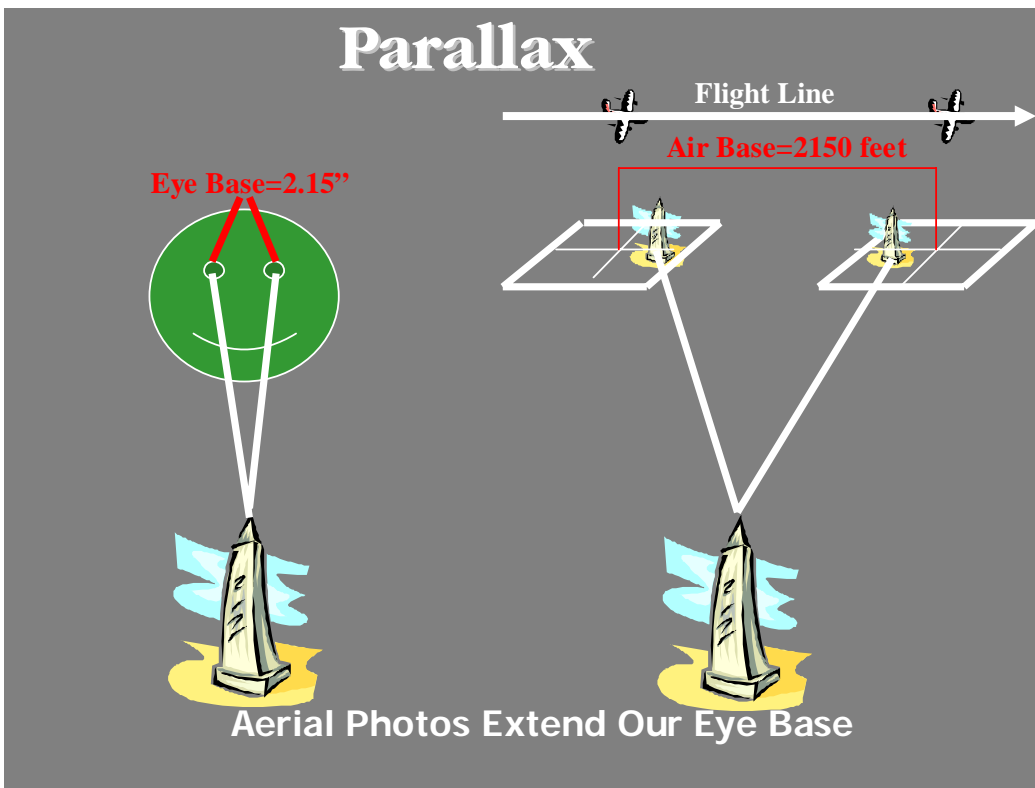
Parallax is the main reason we see

in 3D

Aerial photography is generally obtained in an overlapping format known as stereo aerial photography



Consecutive Aerial Photo View the Same Landscape from Widely Separated Points of View Creating Parallax



Parallax is the Source of Stereo Viewing in Aerial Photography

Stereo Viewing and Stereo Photography

Almost everyone possesses and automatically employs stereoscopic vision.

The effects of an exaggerated three-dimensional picture can be very startling and successful businesses have utilized this effect (parlor scopes, 3-D Movies).

The stereoscopic effect results from the parallax inherent in stereo aerial photography.

Parallax is the apparent shift in position of an object when viewed from two different positions.

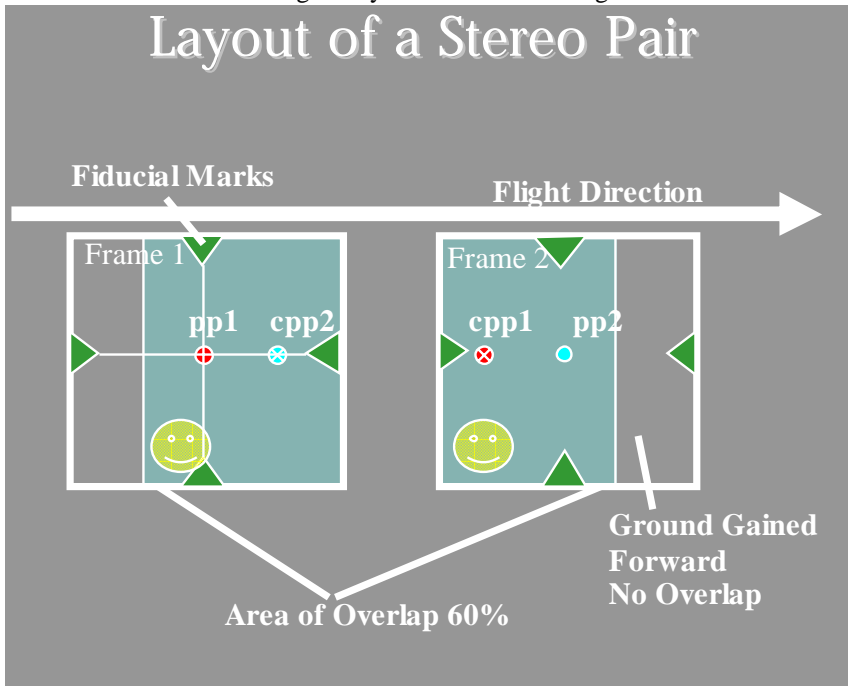
The two positions that create the parallax effect in a stereo pair are the two consecutive aerial photographs taken from 1000's of feet apart.

This separation in effect stretches the spacing of the human eye (each photo is viewed with one eye) so that greatly exaggerated (up to 10x) 3-D images are the result.

Stereo aerial photography is flown in parallel flight lines with 60% forward overlap and 20-30% sidelap.

The overlap is needed for stereo viewing and to tie all the photographs together for map making purposes.

Deviations off the flight line known as drift and skewing the airplane while in flight due to strong winds known as crab can negatively effect stereo viewing.



Stereo Pairs are Laid Side by Side in the Direction of the Flight Line for Stereo Viewing

Basic Elements of Photo Interpretation

1. Principles of Object recognition (adapted from Avery, 1977):

An aerial photo interpreter must exercise mental acuity and visual perception to consciously or unconsciously evaluate multiple factors visible on an aerial photograph. The following are the major characteristics to key in on when interpreting aerial photography:

Shape: A basic and useful characteristic, examples are, a highway "cloverleaf" intersection, a base ball "diamond" or a traffic "circle". Shape also refers linear vrs non linear characteristics.

Size: both absolute and relative to other features. For example an interstate highway as compared to a rural road. Also a football fields absolute size as measured from aerial photography will distinguish it from a soccer field.

Photographic tone or color: objects can be recognized by their actual color on color photography or by their tone on black and white photography. For example, a lush green field would appear dark green on a color photograph and as dark grey on a black and white photograph.

Pattern: the systematic or random distribution of objects on a photograph provides a useful characteristic for identification. Consider the systematic spatial pattern of an orchard as compared to the random pattern of shrubs invading an old field area.

Shadow: the shadow cast by objects depicted on aerial photography may provide more information than the object itself. For example, a tall smoke stack pictured near the center of an aerial photograph may be difficult to distinguish from the surrounding background, yet its shadow may extend some distance away revealing its shape and height.

Texture: photographic texture refers to the visual roughness or smoothness of a feature. Consider the texture of a mowed grass lawn with that of multi-layered mature forest canopy. Photographic graphic texture is highly dependent on scale.

Association: Association refers to the location of objects or features in relationship to other objects or feature. For example large parking lots will be found in association with large stadiums and floating docks will be associated with water bodies. Knowledge of common associations will aid in object identification.

2. Signature: a signature is the combination of the characteristics of a physical feature or phenomenon that allow for its identification on aerial photography. For example, from the list of characteristics above, the signature of a recreational baseball diamond is a combination of shape (two concentric wedges forming a larger wedge), size (90 feet along the sides of the inner wedge, +/- 300 feet from apex to outer edge of wedge), texture (smooth), pattern (large open outer wedge with patterned inner wedge consisting of center light toned circle surrounded by four discrete points forming the edge the inner wedge), association (small rectangular structures and banks of seating usually along outside edges of inner wedge).

A category is said to have a signature only if the characteristic pattern is highly representative of all units in that category.

3. Aerial photography key: Aerial photography keys are diagnostic tools that enable an interpreter to rapidly identify objects or conditions on aerial photography. Aerial photo keys utilize guidelines or comparative analysis to make an identification. Keys may be grouped into two general classes: selective keys and elimination keys.

Selective keys are made of typical illustrations, grouped into like categories, of which the interpreter selects the one that most closely resembles the feature or condition to be identified. An example of these is a key that shows various industries from the air, the photo interpreter then selects the one that most closely resembles the industry to be identified.

Elimination keys, similar to those found in plant identification hand books, require the user to consider the various characteristics of an object or feature to be identified and step by step eliminate all but one item in a category.