CHAPTER 3

Aerial Films

3.1 AERIAL FILMS

Aerial film is similar in construction to the film popularly used in handheld 35-mm cameras. It comes in rolls that are 10 in. wide and range in length from 200 to 500 ft. Figure 3.1 depicts the basic structure of aerial film.*

3.1.1 Types of Film

Although there are a number of aerial films in use, many serve unique situations. Two commonly utilized films employed in planimetric and/or topographic digital mapping are panchromatic and natural color. These two films plus infrared and false color form the basic media used in image analysis procedures.

*3.1.1.1 Panchromatic***

Panchromatic, more often termed black and white, is the most commonly encountered film employed for photogrammetry. The sensitive layer consists of silver salt (bromide, chloride, and halide) crystals suspended in a pure gelatin coating which sits atop a plastic base sheet. Visible light waves react with the silver particles in the emulsion, causing a chemical reaction that creates a gray-scale image. The emulsion is sensitive to the visible (0.4- to 0.7-μm) portion of the electromagnetic spectrum that is detected by the human eye.

*3.1.1.2 Color****

Natural color film is also called true color or color. The multilayer emulsion is sensitive to the portion of the electromagnetic spectrum that is visible to the human

* For a broader discussion of film components refer to Chapter 3 in *Aerial Mapping: Methods and Applications,* Lewis Publishers, Boca Raton, FL, 1995.

** Refer to http://www.kodak.com/US/en/government/aerial/products/film/blackWhite.shmtl on the Internet.

*** Refer to http://www.kodak.com/US/en/government/aerial/products/film/color.shmtl on the Internet.

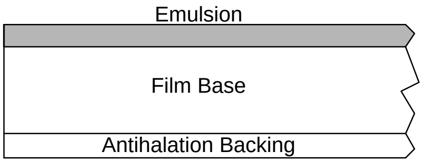

Figure 3.1 Basic components of panchromatic film.

eye. There are three layers of gelatin containing sensitized dyes, one each for blue (0.4–0.5 μm), green (0.5–0.6 μm), and red (0.6–0.7 μm) light. Green and red layers are also sensitive to blue wavelengths. Visible light waves first pass through and react with the blue layer and then pass through a filter layer which halts further passage of the blue rays. Green and red waves pass through this barrier and sensitize their respective dyes, causing a chemical reaction and thus completing the exposure and creating a true color image.

*3.1.1.3 Infrared**

Current aerial infrared film is offered as two types: black and white infrared and color infrared.

Black and White Infrared

Infrared film is also known as black and white infrared. The emulsion is sensitive to green (0.54–0.6 μm), red (0.6–0.7 μm), and part of the near infrared (0.7–1.0 μm) portions of the spectrum and renders a gray-scale image. Positive images appear quite like panchromatic film, except that water and vigorous vegetation tend to register as darker gray to black. The film structure resembles panchromatic with the exception that the emulsion sensitivity range is shifted upward, eliminating blue wavelengths and including a portion of the near infrared. In the past this film was used extensively in vegetation and water studies, but its popularity seems to be declining in favor of color infrared.

Color Infrared

Color Infrared film is commonly termed false color. The multilayer emulsion is sensitive to green (0.5–0.6 μm), red (0.6–0.7 μm), and part of the near infrared (0.7–1.0 μm) portions of the spectrum. A false color image contains red/pink hues in vegetative areas, with the color depending upon the degree to which the photosynthetic process is active. It also images water in light blue/green to dark blue/black hues, depending on the amount of particulates suspended in the water body. Clean water readily absorbs near infrared radiation. As the amount of foreign particulates

* Refer to http://www.kodak.com/US/en/government/aerial/products/film/infrared2443.shtml on the Internet.

increases, the near infrared rays reflect increasingly more of these particles. The film structure resembles natural color, except that the blue sensitive layer is eliminated and replaced by a layer that reacts to a portion of near infrared (0.7–1.0 μm).

3.2 SENSITOMETRY

Sensitometry is the science pertaining to the action of exposure and development on photographic emulsions.

At the instant of exposure, flux passes through the emulsion, causing minuscule silver salt crystals to be chemically converted into metallic silver. The number of transformed silver crystals is high in areas that are exposed to a great light intensity. Conversely, in areas of lesser exposure the amount of converted silver is restricted.

When a light source is passed through a developed negative, areas appear where much light passes through the film. There are also areas where small amounts of light pass through this medium. These gradations of metallic silver concentrations, which render portions of the film transparent to opaque, are manifestations of density. This montage of variegated densities creates a latent image. Relative amounts of density can be measured with a densitometer, which is an instrument that senses the proportion of a projected light beam passing through the film. Image contrast is the distinct discrimination of these various densities.

3.3 FILTERS*

Aerial photographs are usually exposed through a glass filter attached in front of the lens, so as to enhance the image in some fashion. Filters absorb unwanted portions of the spectrum to enhance image quality by reducing problems such as haze or darkening of the image at the edge of the exposure. There are a variety of filters that can be employed depending upon the type of film and the purpose of the imagery.

3.4 FILM PROCESSING**

Aerial film is developed in automatic processing machines, where the exposed film enters one end and the processed negative exits the other. Chemical temperatures and development timing sequences are critical, more with color as compared to panchromatic films. These thermal ranges and temporal periods during which the film is immersed in the various liquid baths should be regulated per specifications established by the manufacturer.

* For a broader scope of filters refer to Chapter 3 in *Aerial Mapping: Methods and Applications,* Lewis Publishers, Boca Raton, FL, 1995.

** For a broader scope of film processing refer to Chapter 3 in *Aerial Mapping: Methods and Applications,* Lewis Publishers, Boca Raton, FL, 1995.

3.5 RESOLUTION

Two terms, definition and resolution, are often used interchangeably when discussing images:

- Definition is the clarity of the image detail.
- Resolution is the size of the smallest unit of data that forms the image.

In the field of photogrammetry and remote sensing, resolution is thought of as resolving power. When referring to sensed images, resolution has several connotations: spectral, spatial, and radiometric.

3.5.1 Spectral Resolution

Spectral resolution is the wavelength band to which a sensor is sensitive. For example, natural color film is sensitive to blue, green, and red visible colors, a bandwidth spanning 0.4–0.7 μm. Wavelength bands should be selected so as to produce the best contrast separation between an object and its background.

3.5.2 Spatial Resolution

Spatial resolution is the smallest unit which is detected by a sensor. In a scene created from data captured by a resource satellite, the resolution may be a pixel (picture element) that is 15 m^2. By way of contrast, the resolving power on an aerial photograph may be 50 line pairs per millimeter.

3.5.3 Radiometric Resolution

Radiometric resolution is the sensitivity of a detector to measure radiant flux that is reflected or emitted from a ground object. For instance, full sunlight reflecting from the metal roof of a building will register as a brighter intensity than from a dark-shingled roof.

3.6 APPLICATION OF AERIAL FILMS

Dual camera systems can be used to expose two different types of film simultaneously. This might be the case where it is desirable to obtain natural color and false color imagery for a vegetation stress study.

Although some films are processed to a positive form, no opportunity exists yet to produce positive paper prints from these exposures. When processed to a positive form, natural and false color films offer advantages over paper contact prints. Film transparencies provide a first-generation product that enhances the definition as well as the image analysis capabilities. Transparencies can be studied with appropriate stereoscopic viewing devices over a light table while the film is on the roll. This procedure provides abundant image backlighting as well as ease of film handling.

Panchromatic and natural color enlargements are in great demand by the general public. These are used for such purposes as wall hangings, site promotion, product display, court trials, accident scene records, and informational presentations. Color infrared enlargements are often required by the image analyst or photogrammetrist for promotional or illustrative purposes.

3.6.1 Panchromatic

Panchromatic film can be used for mapping or image analysis and is developed to a negative form. Applications for this type of film require the use of contact prints and/or film diapositives. Diapositives are film plates that are utilized in stereocompilation.

3.6.2 Infrared

Infrared film is employed in image analysis and is developed to a negative form. Applications for this film require the use of contact prints and film positives.

3.6.3 Natural Color

Natural color film is utilized to some extent in planimetric and/or topographic mapping, but not as much as panchromatic film. If used for mapping, natural color is developed to a negative. Then contact prints and diapositives are produced in positive form. If the exposures are to be used in image analysis, some natural color films can be processed to either a positive transparency or a negative form. Color film, when processed to a negative, exhibits subtractive color primaries of cyan, yellow, and magenta. When processed to a positive, the additive color primaries of blue, green, and red are exhibited.

Figure 3.2 illustrates how the color image is processed to a negative and then produced as a positive.

3.6.4 Color Infrared

Since there is no blue-sensitive layer on color infrared film, each layer is "bumped up" to the next wavelength bandwidth. Refer to Figure 3.3 to understand this color transferal process. This shift in color coding of emulsions is the reason green foliage appears as a red image and exposed red clay is rendered as a green tone. Color infrared is usually developed to a positive transparency. The transparency can be used directly in stereocompilation or image analysis. This provides the benefits inherent in first-generation image definition, which may include sharper detail and ease of interpretation.

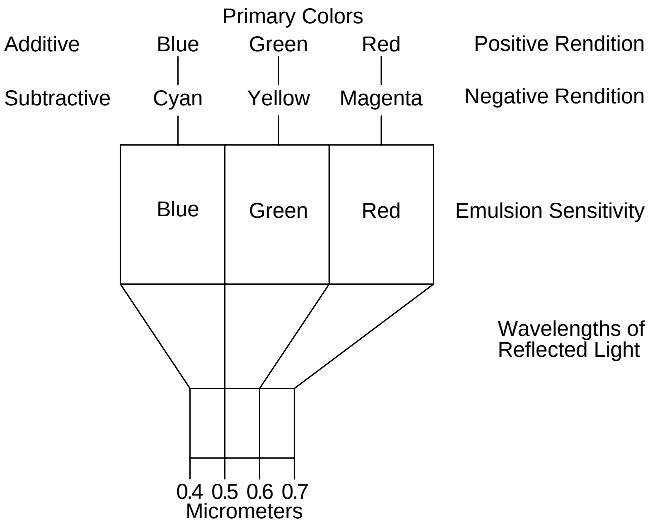

Figure 3.2 Spectral light compared with negative and positive color rendition on natural color films.

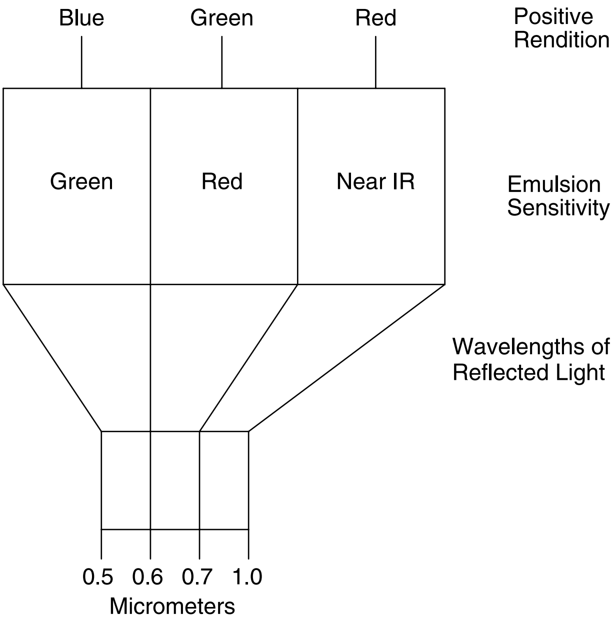

Figure 3.3 Spectral reflections compared with positive color primaries on false color film.