

Airborne Sensor Platforms

4.1 INTRODUCTION

Historically, photogrammetric applications have relied upon aerial photographs as a basic tool. Aerial photography, as the name suggests, requires the use of an airborne platform from which to expose the film. Although airplanes, helicopters, and lighter-than-air craft are employed as aerial photography vehicles, fixed-wing aircraft are the primary aerial photographic platform. Recent technological advances have changed aerial image collection drastically. Historically, aerial images have been collected with the aid of analog camera systems, but technology advances in digital camera systems have made great strides in recent years. Single image digital cameras and digital videography have a place today in photogrammetry. Near future technology advancements will bring these camera systems to the forefront. Global Positioning System (GPS) techniques, digital cameras, and image motion units may improve the accuracy of image collection and speed future mapping processes by collecting images and their location data in near real time. The basic platforms have remained unchanged, but the collection options are undergoing amazing changes.

4.2 FIXED-WING AIRCRAFT

A conventional fixed-wing aircraft, which allows for flexible schedules and cost-effective data collection, is the usual airborne sensor platform of choice. The type of aircraft to be used depends upon the requirements of the data collection.

4.2.1 Single-Engine Platform

Many projects require large-scale imagery over a relatively small area. The commute to and from the project site is often short, and the image collection mission can be completed in less than a single day's available flight time. Many of these types of projects can be accomplished with a single-engine aircraft when the required



Figure 4.1 Twin Otter aircraft, typical aerial photographic platform. (Courtesy of Surdex Corporation, Chesterfield, MO.)

altitude of the flight remains below about 18,000 ft above mean sea level. Image collection projects that require altitudes above this altitude and/or require longer commutes may mandate a more powerful multiengine airplane.

4.2.2 Multi-Engine Platform

Twin-engine aircraft, such as the Twin Otter seen in [Figure 4.1](#), can also be successfully operated at lower altitudes. Multiple engine aircraft are normally faster, but are also more expensive to amortize, operate, and maintain. These aircraft also generally have the ability to carry more equipment, which may allow for more than one camera port in the aircraft and multiple, simultaneous data collection. The higher cost of these aircraft must be redeemed by project requirements, such as long commutes, higher altitude requirements, and large project areas requiring massive amounts of image collection, and/or multiple image type requirements.

4.3 FLIGHT CREWS

A variety of aircrew and camera system arrangements are possible. An aircrew can be comprised of one, two, or three persons, and the aircraft may have the capability to simultaneously collect data from more than a single image collection system. One example would be to collect both panchromatic and color infrared imagery of the same site at the same time, which would require two aerial cameras mounted in different ports in the same aircraft. Another example would be to collect digital multispectral data and panchromatic imagery of the same site at the same



Figure 4.2 Typical aerial photographic installation. (Courtesy of Surdex Corporation, Chesterfield, MO.)

time. The purpose of this setup might be to collect and analyze vegetation health from the multispectral data and georeference it with planimetric and topographic mapping most economically obtained from panchromatic film.

Some setups today allow the pilot to safely navigate the aircraft as well as operate and monitor multiple image and sensor collection devices. Most aerial sensor platforms use a two-man crew consisting of a pilot and a photographer, such as the setup shown in [Figure 4.2](#). The pilot flies and navigates the airplane, while the photographer ensures that the camera system is functioning properly.

Advances in airborne GPS navigation, digital cameras, and image motion units are changing the technical complexity and duties of the aerial photography crew. The pilot often navigates the aerial mission by following a predetermined path programmed on a video screen. Aerial images are collected with either an analog metric aerial camera or a digital camera system. The second crewmember is often an image specialist with specific knowledge of analog aerial cameras, film, and digital camera systems, including computer software and hardware for collecting and storing images and GPS surveying.



Figure 4.3 Electronic preflight planning station. (Courtesy of Surdex Corporation, Chesterfield, MO.)

4.4 NAVIGATION

Preplanning a photographic mission includes establishing the project area, the flight height, and the required number and position of the flight lines.

Aircraft navigation along photographic flight paths can be by visual recognition, where the pilot guides the flight of the aircraft by visually following identifiable ground features. Perhaps more commonly, electronic guidance methods are employed which are based upon GPS technology. GPS aircraft navigation systems for aerial image collection require electronic preplanning of the project. An electronic flight preplanning station is depicted in [Figure 4.3](#). Once the approximate coordinates of the beginning and ending frames in each flight line are calculated and input into the flight planning software, the system allows the pilot to view and monitor the flight path on a computer screen during the mission. This type of system ensures complete image collection of a project in an efficient preplanned configuration.

4.5 HELICOPTER PLATFORMS

A limited amount of specialized mapping photography is acquired using a helicopter as a platform. Helicopters can be put to use with great advantage in situations where very large-scale photography or videography is required. Reduced speed and hovering capabilities of a helicopter allow the photographer to better compose the camera perspective than with an airplane. Large-scale mapping, oblique photography,

and reconnaissance imagery can be accomplished for small area projects with a helicopter platform. The largest limitation of this platform type is the fuel capacity of the vehicle, since helicopter platforms generally have less fuel capacity than fixed-wing aircraft platforms, which translates to longer mission times and higher costs for larger projects.

4.6 AERIAL CAMERAS

Several precision aerial mapping camera systems are on the market; all are very expensive because of rigidly controlled construction and meticulous lens polishing. These cameras are finely adjusted precision photographic instruments. Aerial camera systems include both analog and digital cameras.

4.6.1 Camera Mount

For an aircraft to operate as a high-quality photographic platform, it is necessary to cut a hole in the bottom of the aircraft. A camera mount is attached to the floor and centered over the hole, and the camera then slips into this mount. A camera can rotate horizontally and be tilted several degrees in two directions, permitting compensation for the inconsistencies in the flight attitude.

4.6.2 Analog Camera Components

A cross-sectional representation of the pertinent components of a typical analog aerial camera is shown in [Figure 4.4](#).

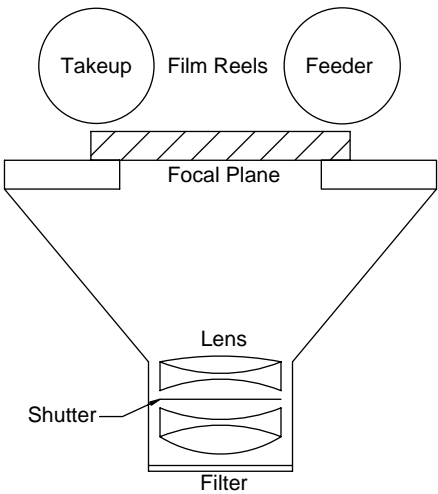


Figure 4.4 Major components of an analog aerial camera.

4.6.2.1 Magazine

A detachable magazine fits on top of the camera cone. It is separate from the frame of the camera and can be transported as a disengaged unit. This film magazine contains the aerial film supply and takeup spools as well as the pressure plate for flattening the film. Also included is a built-in forward image motion compensation device which eliminates photo image motion in the forward direction of the line of flight.

4.6.2.2 Film Reels

Contained within the magazine are two film reels. The feeder reel contains unexposed film, while the takeup reel holds the exposed film. After the exposure is made, a motor pulls the exposed frame onto the takeup reel. At the same time, a length of unexposed film is pulled from the feeder reel.

4.6.2.3 Focal Plane

A frame of unexposed film lies along the underside of the focal plane before the exposure is made. A vacuum is applied to the film at the instant of exposure so that the film is held flat against the focal plane. Otherwise air bubbles would collect beneath the film, causing uncontrollable distortions on the photographic image.

4.6.2.4 Lens Cone

The lens cone is a stable framework which separates the lens assembly from the focal plane. The lens cone contains a compound lens element between the lens shutter and motorized drivers. The lens system is compound, meaning that there are several elements of polished glass.

Camera shutters are constructed as a series of thin metal plates that overlap one another. The shutter mechanism is located between the front and rear elements of the lens system. When the shutter is activated, these plates slide open to form an aperture which admits light to expose the film. This opening is known as the diaphragm. The photographer uses f-stop/speed exposure setting combinations to control the amount of admitted light and length of time that the film is exposed to light.

The length of time that the shutter remains open is contingent upon factors that allow the entrance of sufficient light to make a normal exposure. Shutter speeds can vary through an interval ranging from $\frac{1}{60}$ to $\frac{1}{1000}$ of a second.

4.6.2.5 Image Motion

A photographic exposure is not instantaneous. Rather, when an exposure is made the shutter is open for some period of time, which varies with the type of film and the amount of radiant light. During this interval the camera is in motion and is subjected to movements.

The camera moves forward as the aircraft advances along the flight path. Since the film is stationary within the camera, this movement of the camera platform during an exposure period can cause blurring of the image. This is especially true during periods of marginal lighting when the shutter remains open for longer time spans. Additionally, engine vibrations are conducted throughout the airframe, and cameras fitted into a solid mount respond to the influence of this movement.

Camera mounting systems that reduce the effects of these types of vibrations and subsequent image blur are used in most aerial image platforms. These systems are commonly referred to as forward motion compensation (FMC) mounting systems.

4.6.3 Camera System

An analog aerial camera system is a complex arrangement of interrelated, high-technology, electromechanical accessories. Refer to Chapter 4 in *Aerial Mapping Methods and Applications* (Lewis Publishers, Boca Raton, FL, 1995) to view a schematic showing the essential components of a “state-of-the-art” precision aerial camera system.

4.6.4 Focal Length

Imbedded within the rear lens elements is a point, measurable with optical calibration equipment, known as the rear nodal point. The focal length of a given camera is the finitely measured distance from the rear nodal point within the lens to the focal plane (see [Figure 4.5](#)). Focal length is important to the planner in that it is a function of flight height determination.

There are several common focal lengths available: narrow angle (12 in.), normal angle (8.25 in.), wide angle (6 in.), and superwide angle (3.5 in.). Image analysis projects may utilize all of these various focal lengths, whereas photomapping projects use 6 in. predominantly and 3.5 in. to a limited extent.

4.6.5 Camera Calibration Report

Periodically, every two or three years, precision aerial mapping cameras are submitted to the U.S. Geological Survey (USGS) to be tested. This procedure

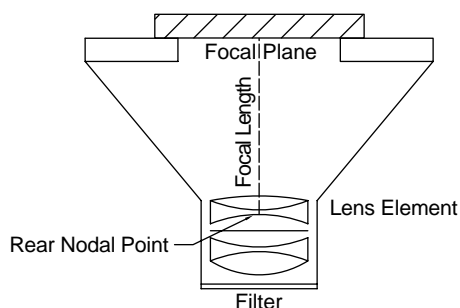


Figure 4.5 Focal length of an aerial camera.

precisely measures a number of operating procedures to assure that the camera consistently functions in an approved manner. The USGS inspector provides the owner with a comprehensive report detailing the results of the calibration test procedures. Some of the items enumerated in the report are input into the control matrix of the stereoplotter to aid in stereomodel orientation.

4.6.6 Digital Camera Components*

Digital camera systems are relatively similar to analog systems. These digital imagery systems can collect black and white, natural color, and color infrared imagery. The option of having natural color and color infrared imagery collected from a fixed winged or rotary winged aircraft can be very advantageous. Environmental assessment often requires imagery data collection at a specific and often narrow band of time. Digital imagery such as that shown in Color figures 1 and 2** allowed for the collection of both natural color and color infrared video of a site in Alaska. Digital imagery such as this may be incorporated into a softcopy workstation immediately after collection. No intermediate steps such as film processing, prints, or film positives are required prior to data manipulation and analysis. The most significant differences between analog and digital camera systems are the charge-coupled device (CCD) and the digital image storage device. Digital camera systems do not utilize photographic film to record an image. Rather, they utilize a CCD to record an image as a matrix of pixels along with a computer data storage device to record a group of image data sets (images). Figure 4.6 shows a schematic of a digital camera system.

The CCD can vary in storage capacity and resolution, which affects the clarity of the digital image. Clarity and resolution of a digital camera image is improved by capturing the imagery at lower altitudes. However, lower altitudes require more image files for a specific project ground area and more image storage capacity. Recent advances in CCD development, computer processing, and data storage capacities are beginning to make digital camera systems competitive with analog systems for many projects.

Those who wish to gain further information about digital cameras may benefit by accessing the keyword phrase “digital aerial camera” on the Internet. Several specific sites may be beneficial:

- <http://Possys.com/>
- http://www.ziimaging.com/Products/AerialCameraSystems/RMK_Top.htm
- <http://www.lh-systems.com/photogrammetry.htm>

A discussion on ADAR multispectral cameras found at <http://www.geo.wvu.edu/geog455/spring98/01/intro.htm> may also be of interest.

* Aerospace Corporation offers a primer on the airborne digital camera at the web site <http://www.aero.org/publications/GPSPRIMER/GPSElements.htm>.

** Color figures follow page 42.

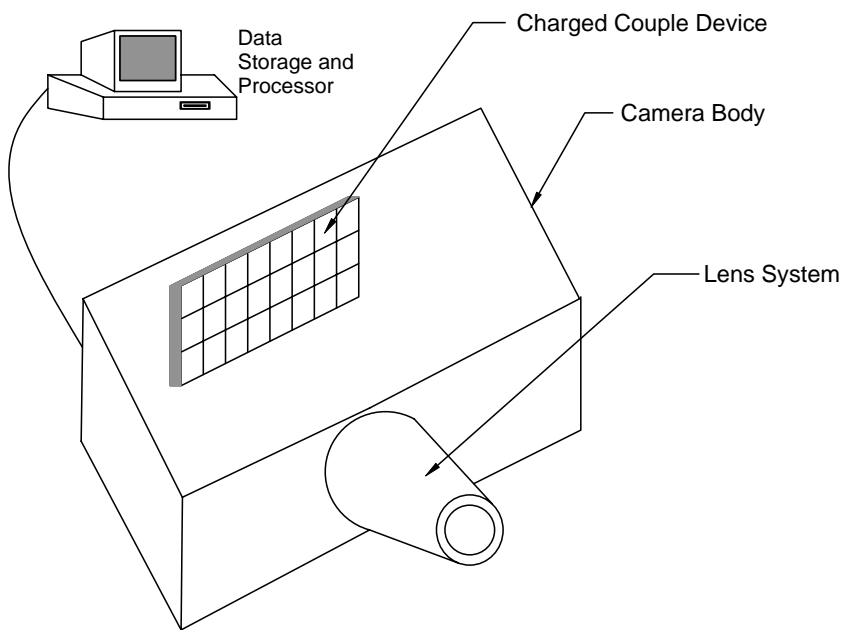


Figure 4.6 Schematic of a digital camera.