Using 35mm Digital Cameras in the Aerial Compliance Program

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Executive Summary

Background

With the implementation of GIS in USDA Service Centers, the 35mm film slides traditionally used for aerial compliance will no longer be "system compatible" unless they are scanned. One of the possible options for acquiring new compliance imagery is to use a 35mm Digital SLR camera in the aircraft, and import the digital images into the Service Center GIS system where they can be rectified.

This report was commissioned to evaluate a number of digital camera systems, and recommend one or more that will meet the requirements of the aerial compliance program.

Methodology

Criteria for a suitable digital camera was established that would lead to an image similar in properties to the 35mm film slide. To achieve the equivalent resolution of the film slide, you would need about an 8 megapixel digital image. The best 35mm digital cameras on the market now are about 6 megapixels. The primary criteria for this report included the following:

- Image resolution (6 megapixels)
- Shutter speed (at least 1/1000 sec.)
- Data transfer/storage (IEEE 1394 Fire Wire connectivity to a hard drive)
- SLR camera body (lens interchangeability, aperture setting, etc.)
- Power capacity (battery, access to aircraft power, etc.)
- Price (digital camera, lens, laptop computer, software, camera mount, etc.)

The evaluation process was carried out using numerous data sources, including: phone calls to manufacturers; company websites; visits to other government offices using digital aerial cameras; a visit to a leading digital camera vendor; researching magazine & journal camera reviews. More than 100 digital cameras were evaluated before the field was narrowed to three.

Recommendations
The three cameras identified as meeting the technical criteria for the aerial compliance program are listed in the table below.

Camera	Camera Price	Lens Price	Megapixels
Nikon D1X	$ 5,500	$ 290	5.89
Kodak DCS760	7,400	290	6.1
Contax N1D	7,000	315	6.0

Any one of these three cameras, when combined with the laptop computer, software, and suitable camera mount will produce an acceptable digital image we believe. It is recommended that a field test with one or more of the cameras be conducted before any large procurement is initiated. Detailed specifications and specific components are listed in the body of this report.

A mission planning software program is available at no cost (see CD ROM included with this report) that, together with a GPS connection, will allow the aircraft pilot to plan flight lines, determine flying parameters (flying height, shutter speed, image resolution, etc.) and automatically trip the shutter at the appropriate interval.

It may be advisable to integrate the components of the digital camera system (camera, laptop, software, etc.) at a single site. This would help standardize and simplify the configuration as well as ensure the system is working properly before delivery to the user. A tutorial, and detailed documentation could also be included with the system to provide a user friendly reference.

Camera Selection

To select a digital camera for use in the aerial compliance program it was first necessary to determine the features and capabilities the camera would need to possess. The principle factor (as suggested by Glenn Bethel) was that the digital imagery mirror as closely as possible the resolution capabilities of 35mm slide film. It was determined through conversations with several photography experts that 35mm slide film has an equivalent resolution of 8 to 10 million pixels. Digital cameras use the term megapixels rather than millions of pixels, so in this case the camera would need to be rated as 8 to 10 megapixels. Currently there are no 35mm digital cameras with this high of a resolution capability. The best 35mm digital cameras at this time have slightly over 6 megapixel resolution. To achieve higher resolution it is necessary to use a medium format or larger camera such as a 9" X 9". These are available with a much higher megapixel count but they are also much more expensive and much more difficult to use than the 35mm cameras.

Information on more than 100 digital cameras was gathered from a number of sources. Much of this information came from individual company websites and internet magazine sites. Several phone calls were also made to manufacturers and vendors. To see some of the equipment first hand and talk with people who use and sell these cameras a visit was made to a local vendor. A visit to the Utah state FSA office was also made. A great deal of information was also gathered from the Forest Service Remote Sensing Applications Center (RSAC).

To narrow down this large amount of camera information to a handful of candidates a matrix was created containing the required features the camera would need. The principle selection criteria were: SLR camera body, shutter speed of at least 1/1000 second, resolution of 6 megapixels, and IEEE 1394 firewire connection. This would provide a camera with lens options, a fast enough shutter speed for aerial photography, the highest possible resolution, and the rapid transfer of images to an external storage device or laptop computer.

All of the cameras were compared to the list of required features. The following 3 cameras met all of the requirements. Each has slight differences in the number of pixels, shutter speed, lens quality, and price.

	Megapixels	**Shutter Speed**	**Lens Type**
Contax N1D	**6**	**1/8000**	**Zeiss**
Kodak DCS760	**6.1**	**1/8000**	**Nikon**
Nikon D1X	**5.9**	**1/16000**	**Nikon**

Image Storage

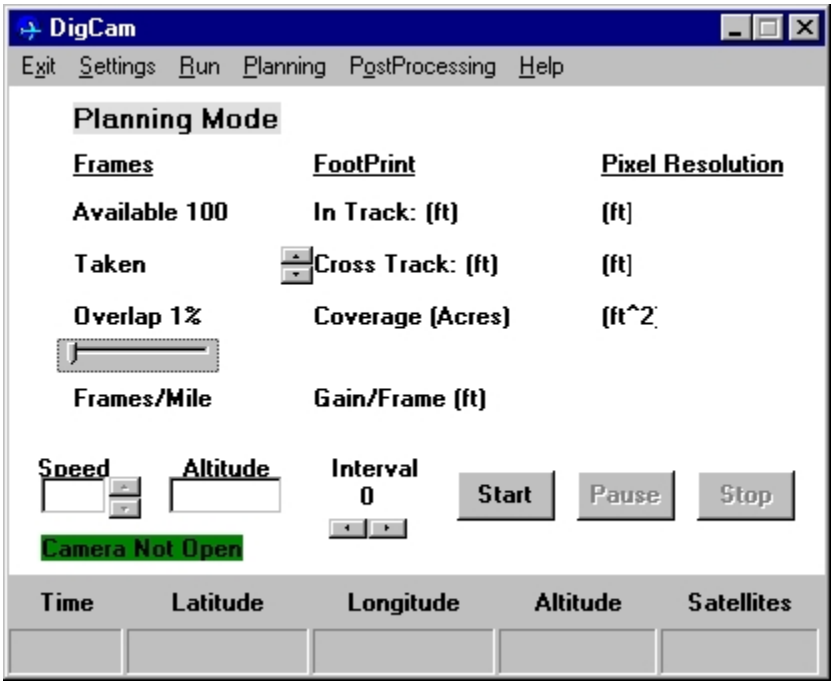
The higher the number of pixels the larger the file size will be. A 2 megapixel digital camera designed for the consumer market produces images of about 6 Mb each. The high end professional cameras with 6 megapixel resolution produce images that are about 18 Mb each. For the average user taking a few photographs of the family the files will easily fit on a compact flash memory card of 64 Mb. Taking aerial images of an entire county can require hundreds of images. The largest image storage device currently available for digital cameras is the 1 GB microdrive. Although the storage capacity for such a small device is impressive it will only hold about 54 images from a 6 megapixel camera. This is hardly enough for an average county.

The ability to store the hundreds of images needed for a typical county can be done using several methods. One would be to have on hand multiple 1 GB microdrive cartridges. At a price of $499.00 per cartridge this option could become quite expensive.
A second method for data storage would be to use a laptop computer. These computers are currently available with hard drives up to 32 GB. This would hold approximately 2000 images from a 6 megapixel camera. In the event that more than 2000 images were needed images could be written to CD while in flight thus freeing up more space on the hard drive. By using a laptop hard drive for image storage very large counties or multiple smaller counties could be photographed in one flight session.

Preflight Planning and In-Flight Operation Software

Another reason for using a laptop computer in this image acquisition process would be for in-flight control of the camera as well as for pre-flight planning and post-flight image index production. The Forest Service Remote Sensing Applications Center (RSAC) has created an easy to use computer program for use in obtaining 35mm digital aerial photography. This program can be obtained from RSAC at no cost for use in the aerial compliance program.

This software, know as DigCam has been used by the Forest Service in obtaining 35mm digital imagery in numerous locations. It is also being used by several other private and public organizations for various types of digital image acquisition. RSAC has offered to fly a test area for APFO during their next outing. The menu screen can be seen on the next page.



Menu screen for DigCam Beta Version 3

GPS

Obtaining GPS data can provide several very useful bits of information. The image center point location data are used by the DigCam software for creating an index map. This map shows the location of each photograph and can be overlaid on a map or imagery to clearly see the coverage area of each image. The GPS data can also be used by programs such as ArcView Image Analysis, Idrisi, ER Mapper, Geographic Transformer, or Imagine in the georectification process.

Many if not all of the aircraft that would be used for the aerial compliance program already have on-board GPS. A means of connecting the camera or laptop computer to the aircraft GPS would need to be determined. If the aircraft does not have a GPS on board then there is the possibility of purchasing some handheld GPS units with an external antenna option. These external antennas generally have a screw mounting system. The best option for the aerial compliance program would be to require that all aircraft be required to have their own on-board GPS with an output for connecting to the computer or the camera.

Aerial Camera Mount For 35 mm SLR Frame

The device mounting the digital camera to the aircraft should, if possible, meet the following criteria:

- The Mount must have the ability to absorb the majority of the vibrations emitted by the aircraft. This will eliminate damage to the camera shutter and/or electronic camera components. The only wear to the camera should be a result of "normal use wear".
- The mount will attach to the aircraft inside the fuselage to keep the camera protected from atmospheric elements (rain, snow, etc.). Another advantage of this location is it will allow the camera to be easily connected to a portable computing device (laptop computer), and monitored by either the pilot or the person managing the photographic session.
- The mount must be easy to use. The hardware used to connect the camera should be designed to eliminate the use of any tools for a photographic session. It should be designed to allow the user to connect the camera and any peripherals by hand only. The only time tools should be use is for the initial installation of the mount onto the aircraft, and routine service maintenance. [Tools would include such things as wrenches (socket or open-end/box wrenches) and/or screw/nut drivers, and pliers.]

Camera mount used by the Utah state FSA Office

Camera mount and GPS connection used by
Infoterra of Farnborough, UK.

Power Source

A method of supplying electrical power to the camera, laptop computer, and GPS needs to be determined. All of these devices can run for a number of hours on their own battery power. Insuring a reliable, long lasting power source needs to be found. One option is to purchase a battery pack. These are often used by professional photographers doing work away from the studio. Another option is to use the electrical power from the aircraft. An inexpensive transformer could be used to provide the proper voltage and amps for the imaging system. Many aircraft may already have the needed plug-in or posts for bare wire hook up. Using the aircraft as a power source would definitely be the preferred method.

Image Georeferencing

Once the digital imagery has been obtained it will need to be georeferenced for use in a GIS. Since each of the images will have accompanying GPS data, this process will be much easier to do. Using a combination of GPS data and control taken from maps or previously georeferenced images such as DOQQ's, the 35mm digital imagery can be georeferenced. This imagery will be georectified but not orthorectified. Georectification (rubber-sheeting, warping) is sufficient for the accuracy level needed for the aerial compliance program. Orthorectification of the images would far surpass the necessary accuracy level and would be much more expensive and time consuming.

Relatively inexpensive and easy to use programs such as ArcView Image Analysis, Idrisi, ER Mapper, Geographic Transformer, or Imagine can also be used to georeference the digital images. Several of the previously mentioned programs including ER Mapper and Imagine could also tone match and mosaic all of the images in a county.

Image Compression

After georeferencing the images it would be advisable to compress them. The compressed imagery would take up much less space on the workstation hard drive. This would also make it possible to fit the images for an entire county on to one CD. Compressed images would require less space for archiving and make it easier to sell large areas of imagery to the public. The compressed images maintain sufficient image quality and accuracy for many different uses. By compressing the imagery it would also be easier to create mosaics of an entire county. Compression programs such as MrSID or ER Mapper work very well and can be viewed in most GIS programs, including ArcInfo and ArcView. Several no-cost viewers are available which can view compressed images. These programs could be included on the image CD.

Disclaimer: The mention of software or products in this report does not constitute an endorsement or guarantee by the USDA, FSA, or APFO over other comparable products.