STEREOSCOPIC VIEWING OF SOFTCOPY AIRBORNE VIDEO IMAGERY FOR LOW ALTITUDE APPLICATIONS

by

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Abstract: In recent years, the field of videography (the process of obtaining video imagery) has taken on greater significance in remote sensing applications. Today studies are being conducted to determine the potential uses and capabilites of airborne video imagery. In the past, satellite or aerial photography analysis and interpretation has been performed using hard copy imagery. Difficulty in obtaining hard copy imagery from video sources has resorted to other methods of analysis. This paper evaluates the technique of using stereoscopic viewing on soft copy video imagery.

I. Introduction

The process of obtaining imagery with video cameras was conceived in the mid-1980s, and has become known as videography. Since that time, its acceptance as a new remote sensing tool for both environmental and military applications has continued to expand. Recent studies conducted in forestry, agriculture, and rangeland have shown that the use of airborne video imagery can contribute significantly to natural resource assessment. The Unites States Department of Agriculture (USDA) has conducted extensive research on the development and use of different types of airborne video systems to assess vegetation conditions, discriminate between plant species, pest management, and for detecting soil surface conditions. For instance, they have found that video data using seven multispectral video images of a soil surface showed a direct linear relationship with reflectance measurements made at corresponding wavelengths (Everitt 1989, 470). In another study, false color video composites of a particular rangeland site were found to be comparable to color infrared aerial photos of the same site (Everitt 1985, 676).

The military has also discovered the importance of using airborne video systems, with the most recent application being the Gulf War. Successful acquisition of video imagery during this war, coupled with decreased funding, has forced the military to look at cheaper alternatives for obtaining aerial imagery. One such alternative has been the use of airborne video systems on Unmanned Aerial Vehicles (UAV) (Figure 1a).

During the Gulf War, there existed a shortage of usable imagery to supply ground forces with to assess battlefield conditions. To eliminate this problem, the military sent dozens of UAVs, attached with a five pound color video camera and a video cassette recorder, to fly over the battlefield. (Fulghum 1991, 59-60). The video cameras recorded vital video imagery of the battlefield on the UAV's video cassette recorder, as well as down-linking the data to both mobile Ground Station Modules (GSM) (Figure 1b) and Remote Video Terminals (RVT), where it was displayed, recorded and stored for evaluation at a later time (US Army 1992, 7).

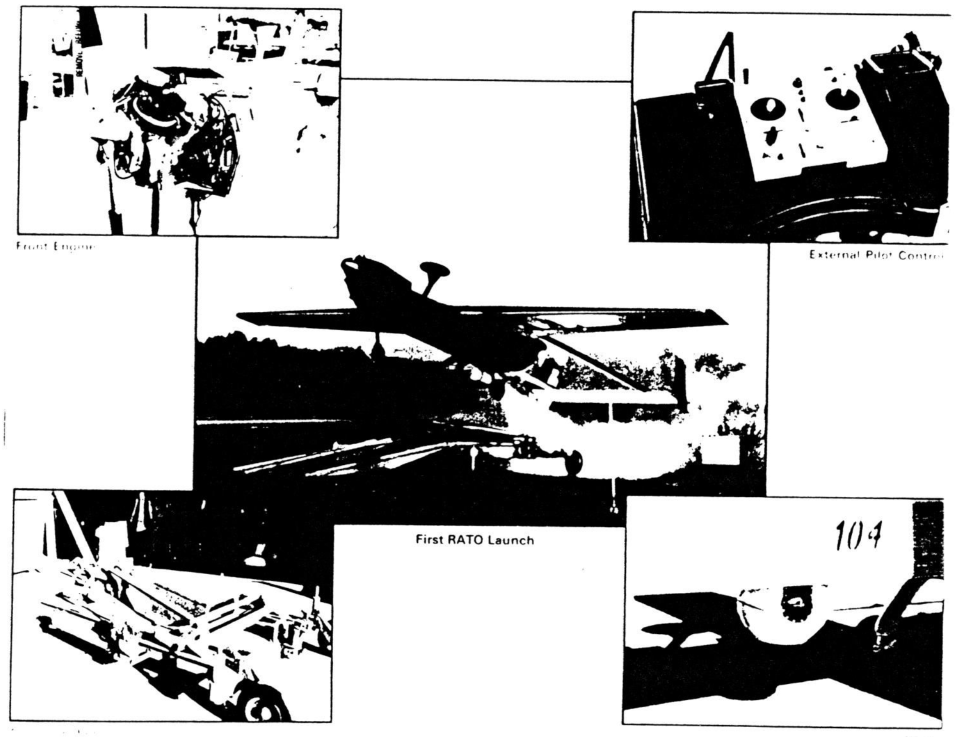
A. Purpose of this Study:

Increased emphasis on a more timely cost effective means of obtaining airborne imagery has created an opportunity to evaluate the capabilities of airborne video imagery. In the past, the preferred method of imagery analysis has been to use hard copy imagery from small format aerial photography. But for video imagery, obtaining a hard copy has proven to be a difficult task. Attempts to obtain hard copy video imagaery have involved the use of a 35-mm camera, with a zoom lens, to photograph a video image from a color monitor which have resulted in poorly defined and coarse photographs that are difficult to interpret and analyze.

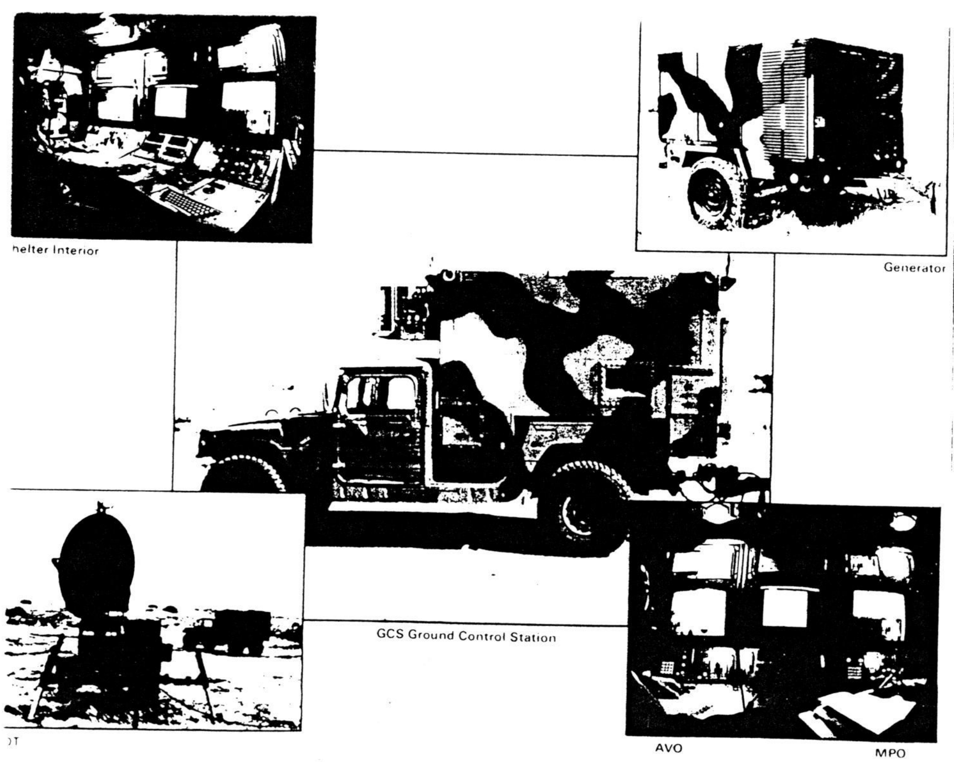
An alternative method of video imagery analysis, which is the basis of my research, involves using a micro-computer with a video image frame grabber, a VGA color monitor, a video cassette recorder with still frame capability, and an image processing program to produce a soft copy of two overlapping images which can be analyzed using stereoscopic viewing. A method which should provide a quick and accurate assessment of the imagery.

Figure 1
Photograph of an UAV (a) and GSM (b) (US Army 1992, 7)

(a)



(b)



II. Advantages and Disadvantages of Video Imagery

Choosing the most useful and appropriate aerial imagery technique to satisfy specific imagery requirements is an important concern in remote sensing studies. It is vital, therefore, that the advantages and disadvantages of each technique are known in order to obtain the most accurate and detailed imagery possible.

A. Advantages:

The increased acceptance of using video imagery in airborne operations has been primarily due to the great number of advantages it offers. These advantages include:

1. Near-Real-Time Monitoring: As the major advantage, the recording and monitoring of live video imagery allows it to be immediately available for both visual interpretation and digital processing.

2. Equipment Portability: Video equipment has always been very portable, and as technology has advanced over the past few years,video equipment has become even lighter, smaller, and more compact.

3. Ease of Use: Individuals working with video systems who have little or no backgound in remote sensing, can be trained quickly to operate video equipment efficiently (Myhre 1992, 9)

4. Low Operating Cost: The low cost of video tape coupled with the elimination of film processing expenses, makes videography the most inexpensive of all remote sensing techniques.

5. System Sensitivity to Varying Light Conditions: Video cameras have higher visible and infrared sensitivity than film cameras, which permits imaging in narrow spectral bands (Everitt 1987, 292).

6. Digital Format. The digital format of video data allows for compatability with many computer image processing systems and programs.

7. Remote Location Use. Video data can be obtained easily in remote locations, unlike aerial photography which is restricted by available film types and local processing capabilities (Everritt 1987, 292).

8. Reduced Turnaround Time for Analysis. Video data can be used immediately within a matter of hours instead of the days, weeks, or months that other remote sensing or photographic equipment reguire (Meisner 1985, 559).

9. Verification of Ground Surveys: Video imagery provides a permanent record of ground conditions as they exist at the time of the survey.

10. Audio Track: The majority of video camera systems include an audio recording capability which permits imagery to be annotated in flight.

11. Acquired Under Various Weather Conditions: Video imagery can be acquired under high overcast or broken cloud conditions which is not possible with conventional photography (Myhre 1992,9).

B. Disadvantages:

There are a small number of video imagery disadvantages which are worth noting, but are not enough to warrant eliminating its use. They include:

1. Low Resolution: The low resolution of video imagery is a limited capability of video cassette recorders (vcr) to produce higher resolution. Typical vcr resolution for color or black and white video imagery is approximately 240 to 300 lines, where photographic film is 720 lines. However, in many video imagery applications such as vegetation assessment, data interpretation is based on the spectral patterns of pixel groups and very high resolution is unnecessary. Also as technology becomes more advance, video capabilities will improve (Meisner 1985, 559).

2. Greater Intital Cost of Equipment: The initial cost a video system can be expensive if technically advance video equipment is obtained rather than off-the-shelf equipment. However, compared to the use of aerial photography (which includes equipment, film and processing costs), or the cost of owning and operating a

multispectral scanner. a video system is considerably more cost effective in the long term.

3. Interpretation Difficulties. Much of the airborne imagery obtained today is interpretated using hard copy imagery. But with video imagery, the skills and knowledge to obtain a hard copy, or interpret directly from the "soft copy" monitor is still in its beginning stages (Meisner 1985, 559).

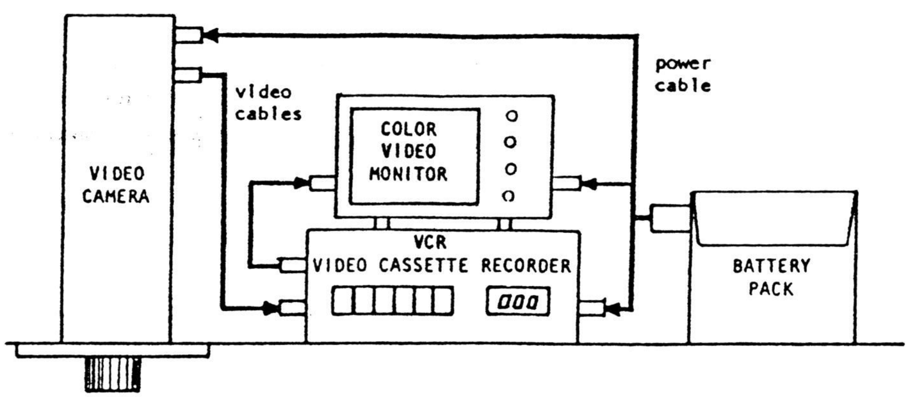
4. Alignment of Multi-Camera Systems: Video systems using two to four video cameras must be aligned before operation in order to produce registered composite imagery (Everitt 1991, 47).

III. Video Equipment

A video system can be constructed using four basic electronic components: a video camera, video cassette recorder, video monitor, and a power source (Figure 2). There are numerous levels of technology for each of these components, and in this section I will describe the different equipment alternatives available. However, before I begin this discussion, it is first necessary to understand video signal generation and how it relates to obtaining video imagery.

Figure 2

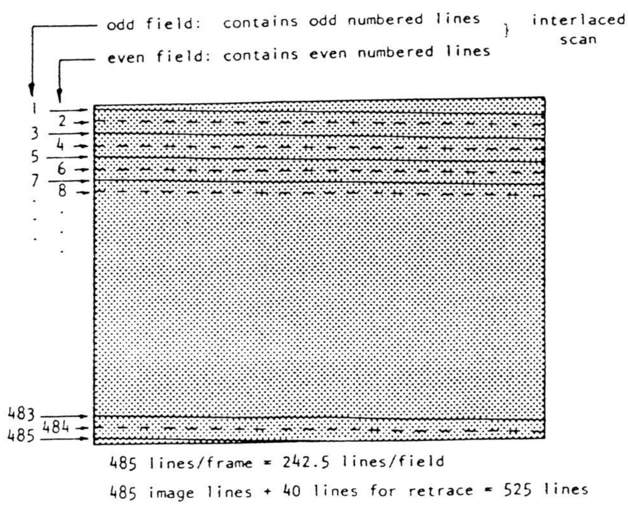
Typical airborne video equipment configuration (Meisner 1986, 64)



a. Video Signal:

In the United States, the most common video signal is the RS170 standard which sets the standard for black and white format. The RS170 standard requires that a video image be scanned at a rate of 1/30 second, which is a slow scan rate and causes the video image to flicker. A video image is made up of a series of horizontal scan lines which are scanned from left to right and top to bottom. Each scan line is associated with a signal voltage that changes with image brightness. To eliminate flicker, the image is divided into two fields, an odd and even field, which are scanned alternately every 1/60 second. The odd field contains all the odd scanned lines, and the even field all the even scanned lines. This type of signal processing is called an interlaced signal, and is used to eliminate flicker in television. However, in airborne operations, image motion can still be detected between the two fields of a video image, so a lower resolution, which has only one field, is sometimes used to eliminate this problem. The RS170 standard uses 525 scan lines per video image with each field having 262.5 scan lines. Twenty scan lines for each field though are not used to allow time for the scanning electron beam to reposition itself from the bottom to the top of the image. Therefore, each video image only uses 242.5 scan lines per field giving it a total of 485 lines (Figure 3). There are also 512 pixels per line for a RS170 signal.

Figure 3
RS170 video standard interlaced scan pattern (Meisner 1986, 67)



A color signal can be generated from either a RGB analog signal or a color composite signal. The RGB analog signal is the easiest to generate. It sends three RS170 signals in parallel, one for red, green, and blue, which are recorded on three separate video cassette recorders, sychronized, and run together on playback. This signal results in the highest quality data, but causes problems for airborne operations because of the increased amount of equipment needed for the separate signals. The RGB analog signal has 512 pixels per scan line like the RS170 signal.

A color composite signal called the National Television System Committee (NTSC) standard signal, involves a more complex method of generating a color signal. With this method, red, green, and blue signals are added together with different weighting factors to produce a signal called the luminance signal (termed Y). The luminance signal represents the average brightness of the three signals. The NTSC signal has only 256 pixels per scan line.

Other color video standards, which are incompatiable with the RS170, analog RGB, and NTSC (also found in Japan) signals, include the SECAM standard found in France and Eastern Europe, and the PAL standard used in Great Briain and the rest of Europe. The PAL and SECAM are of a higher resolution and have 625 scan lines per video image (Meisner 1986, 66-68).

b. Video Cameras:

As with the progression of aerial photographic cameras and film, there are several types of video cameras: black and white, color, black and white infrared, and the most recent, color infrared.

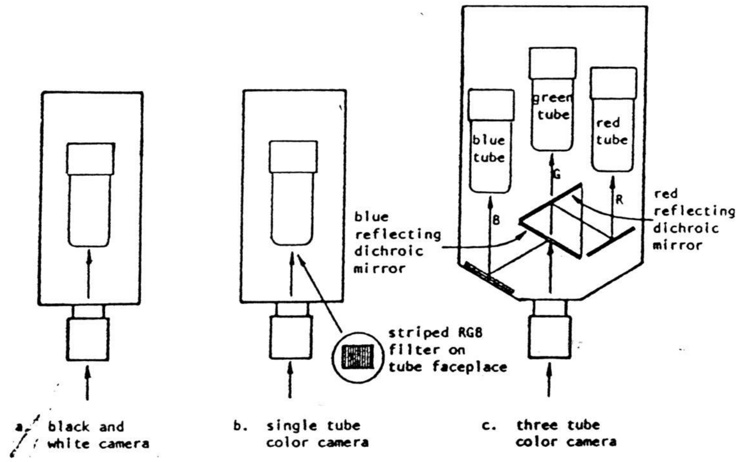
The simplest and oldest type of video camera is the black and white single tube camera (Figure 4a). An image from the camera lens is formed on the faceplate of a video tube which is electronically scanned to generate a video signal. The size and type of tube, therefore, become significantly important in determining spectral sensitivities. Tube size refers to the diameter of a video tube, and is important in determining the size of the image on the faceplate. Tube size can be related to film size in photographic cameras, with 2/3 inch (17mm) or 1 inch (25 mm) tubes being the most common sizes used in airborne video cameras. Tube types are chosen on the basis of their sensitivity and spectral characteristics, and are similar to the film types found in photographic cameras. Black and white video cameras are normally equipped with visible and near-infrared sensitive tubes to allow sensing of a wide magnitude of wavelengths. Filters of different colors are often added to a video camera lens to change the spectral sensitivity of a tube. Common filters used for video cameras and their associated wavelength sensitivities are listed in Table 1.

Table 1
Narrowband Filters Used on Video Cameras (Everritt 1989, 468 and Everritt 1990, 344)

Filter Color	Sensitive Wavelength (um)
Blue	0.467-0.473
Green	0.516-0.524
Yellow-green	0.543-0.552
Yellow	0.573-0.583
Orange	0.586-0.595
Orange-red	0.614-0.625
Dark orange-red	0.633-0.645
Red	0.644-0.656
Dark red	0.656-0.668
Deep dark red	0.712-0.725
Near-infrared	0.815-0.827
Mid-infrared	1.45-2.0

Video cameras that display color, can be either single-tube video cameras or three-tube video cameras. The single-tube video camera creates primary colors by adding a striped RGB filter to the video tube's faceplate (Figure 4b). These cameras have a low resolution, inexpensive, and are used more in non-technical applications. Three-tube video cameras are more professional, and have been the preferred choice in colored video remote sensing applications (Figure 4c). These cameras use an optical beamsplitter with dichroic (bi-colored) mirrors that spectrally separate light into red, green, and blue wavelengths as it passes through the camera lens. Video images are focused onto three video tubes which are scanned simultaneously (Meisner 1986, 64-65).

Figure 4
Basic video camera configurations (Meisner 1986, 65)



A recent advancement in video cameras has been the elimination of video tubes for solid state sensors, which are being used in both color and black and white video cameras. The sensors consist of an x-y array of detectors on a silicon chip and use integrated circuit technology. They are technically termed Charge Couple Device (CCD), Charge Injection Device (CID), and Metal on Silicon (MOS). Video cameras with solid state sensors are popular because the cameras are more compact, shock resistant, and consume less power. The drawback is in the fact that they cost approximately twice as much as the video tube cameras (Meisner 1986, 66).

c. Video Cassette Recorders:

The advancement in technology over the past decade has created an increase in the selection and availabilty of video cassette recorders. Recorders used in airborne video operations, however, require several special effect features which include: fast and slow motion, audio track, on-screen annotation, and a still frame capability which is considered the most important feature. Still frame capability refers to the number of heads in a video cassette recorder. A recorder that has four heads will have a better still frame capability than a video cassette recorder that has two heads, which has become the standard. This special effect feature is necessary to reduce the amount of image motion when capturing an image from a monitor. Many of the more advanced video cassette recorders which are also expensive, heavy, and not very portable, do not provide the still frame capability. This limits airborne video operations to video cassette recorders that offer middle of the line technology.

Video cassette recorders come in several video formats. The most advanced models use a one inch wide tape called C format that has not been very popular. A three-quarter inch tape called U-Matic format, is less expensive, technically superior in its performance, and is often found in many airborne video applications (Meisner 1986, 69). The most common video cassette recorder format is the half inch format which is available in two forms, Beta and VHS. Both Beta and VHS are less expensive and more portable than any other video format sold. VHS is more popular than Beta and usually offers a better selection and availabilty. It comprises approximately 75% of the half inch format market. A smaller version of the VHS format is called VHS-C. It can be played on a standard VHS video cassette recorder using an adapter. It is more compact than the other formats, but is also more expensive. It has only twenty minutes of recording time (compared to the two hours for standard VHS), which can restrict airborne video operations if used(Meisner 1985, 556).

The video cassette recorder is considered to be the most inefficient part of the video system. With video cameras providing up to 500 lines of resolution, the video cassette recorder can only provide 240-300 lines of resolution. The lower resolution significantly affects the interpretation and analysis of video imagery. Recently, a new video format called Super VHS (S-VHS) was been developed, which has remarkably increased resolution to greater than 400 lines (Everitt 1991, 232). It also claims to have improved color quality and signal to noise ratio through increased band width (Myhre 1992, 3). Five years ago these video cassette recorders and tapes were very expensive, but today they can be found costing between $600 to $1000. As a result of these new advances and lower prices, S-VHS has become the preferred video recorder format.

d. Video Monitor:

The video monitor is the video system component that displays the video image. The major concern for video monitors is choosing the correct screen size. Because most video systems emphasize portability, a five inch (127mm) black and white screen has become the standard in airborne video operations. Each monitor is designed to take a particular video signal. Black and white monitors take a standard RS170 signal while color monitors takd a composite color signal with the most common being the RGB anlog signal.

e. Power Source:

Rechargeable built-in battery packs are available for each component of the video system. The batteries, however, are only operational for about an hour, which is inadequate for airborne video applications. A lead acid (gel cell) battery with a higher capacity is used instead to generate the power required by the video system. This type of battery has an output of 12 volts DC that can last up to four hours. A disadvantage with this lead acid battery, is that it takes approximately 20 hours to recharge (Meisner 1985, 71).

f. Camera Mount:

A camera mount is not considered a basic component of the video system, but should be considered when evaluating a video system. Since video imagery can easily become blurred as a result of aircraft vibration, it is necessary to use a camera mount which will stablize the video camera, mininmize aircraft vibration, and adjust for tilt displacement. Almost any mount that has been designed for small format aerial photography can be used for a video camera. Additional equipment such as a scanning mechanism to provide wider coverage, or a stepping motor that moves only during vertical retrace time to reduce image motion can also be attached to a camera mount (Meisner 1985, 76).

IV. Video Systems

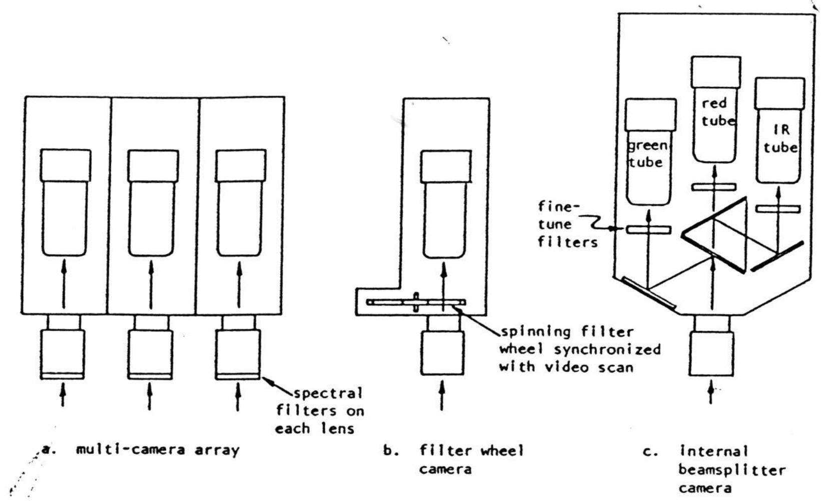
Along with changes in video equipment, there have also been changes in the configuration of video systems. Video systems which have originally used only a single camera to obtain airborne video imagery, are now using multi-camera (three or four cameras) systems to obtain registered composite imagery. Much like that used in multispectral aerial photography, except that video cameras create color composite imagery electronically without the use of a color additive viewer.

There are three basic configurations used to produce multispectral video imagery, which are similar to the approaches used to obtain conventional black and white and color video imagery . The first, and simplest, approach uses an array of standard black and white single tube video cameras (Figure 5a). The cameras are electronically synchronized and mounted to provide equal fields of view. An advantage of this type of configuration is that it can use off-the shelf video equipment. A disadvantage is the system is larger and heavier because of the additional equipment, and that it requires the video cameras to be aligned with each other .

The second configuration uses a a single tube video camera with a spinning filter wheel (Figure 5b). The rotation of the filter wheel is synchronized with the scanning of the video images. A problem with the time delay between the different images taken causes image motion to misalign the images. The adavantage is that there is only one video camera and video cassette recorder which means reduced weight and equipment.

The third and final multispectral configuration involves using a three-tube color video camera with an optical beam splitter much like the three tube color video camera discussed earlier (Figure 5c). The difference is that the multispectral three-tube video camera uses internal filters placed in front of the video tubes, rather than in front of the camera lens. The filters change the sensitivity of the video tubes to produce a false color composite image. The green wavelength is now displayed as blue, the red wavelength as green, and the near infrared wavelength as red. These multispectral video systems can be often thought of as very inexpensive multispectral scanners (Meisner 1986, 73).

Figure 5
Multispectral video camera configurations (Meisner 1986,73)



Because the selection and availability of video equipment has increased over the years, there are a number of airborne video systems that can be used in remote sensing applications. Systems should be choosen based on available funding and imagery requirements.

A. Black and White Single Camera System: Initial research conducted in videography was done using black and white single tube camera video systems. Originally these video systems were sensitive to only visible light wavelengths, but through time have been modified with visible/near-infrared (NIR) light sensitive tubes. The system is useful to evaluate vegetation.

B. Black and White Multispectral Single Camera System: This system uses a musltispectral solid state CCD video camera with a six slot rotating filter wheel to acquire sequential multispectral images at a rate of one set every 1/10 second. This system has been useful in measuring semiarid rangeland conditions.

C. Black and White Multispectral Four Camera System: Because single camera video systems involve repeatitive image acquisition using numerous narrowband filters, the development of a four camera system was inevitable. This system was developed by researchers of the United States Department of Agriculture (USDA) in Weslaco, Texas, and is composed of four nonsynchronized black and white multispectral video cameras that each have their own video cassette recorder.

D. Camcorder Color Video System: This system uses basic "off the shelf" video equipment. Compact video cameras using half inch 1/2 inch VHS or Beta format, with auto focus and a high speed shutter have proven to be useful in low altitude imagery applications that do not require high resolution, such as mapping soil surfaces. Using a S-VHS format camcorder would provide a higher resolution.

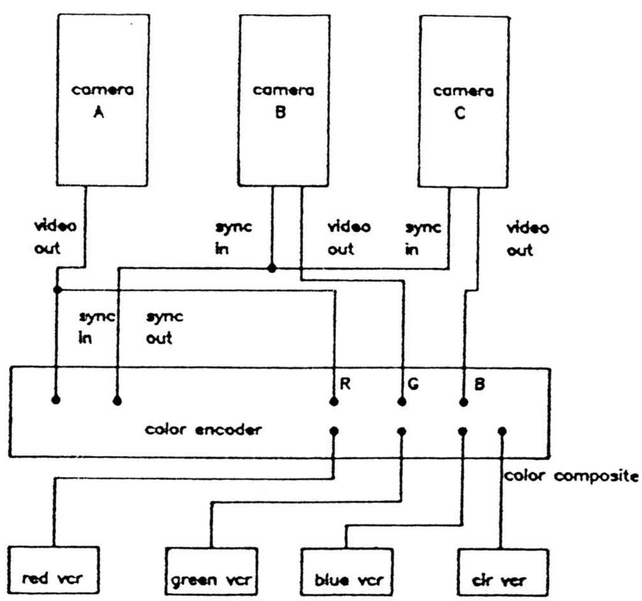
E. Color Infrared (Biovision) Single Camera: This video system was developed by the University of Minnesota's Remote Sensing Laboratory, and manufactured by E. Coyote Enterprises. The camera is a modified version of a single three-tube color video camera designed to simulate color infrared photgraphic film. Output from the video camera is recorded on a video cassette recorder, and is often used to evaluate between different vegetation and soil surfaces.

F. Multispectral False Color Video System: This system was developed by USDA and the Southwest Research Institute in San Antonio, Texas. It is composed of four black and white high resolution single tube video cameras. Three of the cameras are sensitive to visible wavelengths, and a fourth video camera is sensitive to visible/infrared (IR) wavelengths, which are recorded on separate video cassette recorders. Visible and NIR narrowband filters are used over camera lenses to record visible/NIR wavelengths. A combination of any three of the four cameras, and their different bands, allows the video system to generate a false color composite image.

G. Four Camera Multispectral Video System: This video system was developed by the University of Toronto in Canada, and is similar to the multispectral false color video system, except that is uses cameras that have solid state sensors. It can provide two kinds of images; a color composite image created from three of the four cameras; and a sequential four band image generated by a multiplexer.

H. High Resolution Mutispectral Video System (HRMVS): This video system has been recently developed by the USDA. It uses three black and white solid state sensor (CCD) cameras and a S-VHS camcorder to obtain high quality imagery. The three black and white video cameras are sensitive to the visible/NIR wavelengths, while the S-VHS camcorder camera is sensitive to only the visible wavelengths. Image signals from the three black and white video cameras are subjected to red, green and blue inputs of a color encoder which produce a CIR composite image and records the images separately on portable video cassette recorders. The S-VHS camcorder only records conventional color imagery (Figure 6).

Figure 6
Schematic of the High Resoulution Multispectral Video System
(Everitt 1991, 471)

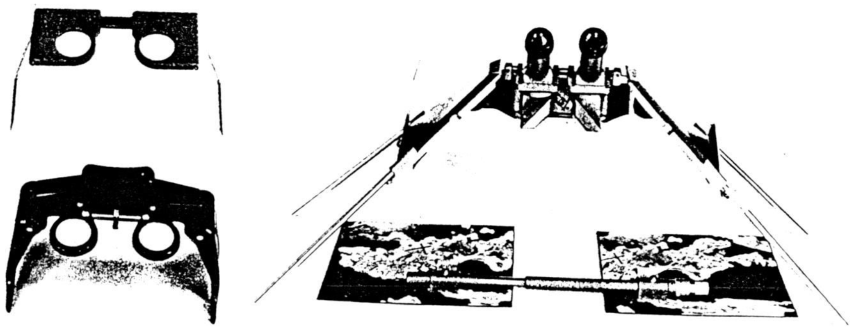


I. Mid-Infrared (MIR) Video System: The latest video research involves the use of a mid-infrared video system. Unlike other video systems, that are visible/NIR sensitive, the USDA and University of Florida has developed this video system to be senitive to mid-infrared wavelengths. The spectral region where water absorption is best detected. The video system consists of two black and white single tube video cameras. One camera has a lead sulfide (PbS) tube, and the other a lead oxide (PbO) tube. With the help of two wide band filters, the video cameras are able to sense the mid-infrared region. It has been found that MIR video imagery has been particularly useful for such applications as grassland management, crop irrigation, and soil conditions. However, low resolution and image blurring at the lower altitudes create some difficulties with its use (Everitt 1991, 232).

V. Methods and Materials

The main emphasis of this study is on the process of stereoscopy. Stereoscopy enables a viewer to see three-dimensional (3-D) objects by producing the phenomena of depth perception. Stereoscopic viewing is performed by using a pair of adjacent overlapping images from the same flight line (at least a 60 percent overlap) and an optical instrument called a stereoscope (Paine 1981, 40). The stereoscope aligns the sight of each eye to one of the two overlapping images, enabling the area of overlap to be perceived as 3-D. There are three types of sterreoscopes, (1) lens ,or pocket steereoscope, (2) mirror, or reflecting stereoscope, and (3) a zoom stereoscope. A lens stereoscope is the simplest and least expensive, and will be the type of stereoscope used in this study. It consists of two magnifying lenses mounted in a hand held frame of a fixed height. Stereoscopic vision is acheived by adjusting the distance horizontally between each eye piece while viewing the overlapping images. The disadvantage of this type of stereoscope is that it has a narrow field of view (Avery 1992, 60). The mirror stereoscope is a larger, more sophisticated version of the lens stereoscope. It has a pair of binocular eyepieces and a mirror on each side of the frame to provide a greater field of view (Figure 7). The mirror stereoscope was not used in this study because of its size and the inability to achieve stereoscopic vision with the video images produced on the monitor. The images could not be separated far enough apart. The zoom stereoscope is often found associated with a light table in laboratories and, even though it provides the best optic viewing, could not physically be used in this study to view images from a monitor.

Figure 7
Photograph of two types of lens stereoscopes and a mirror stereoscope (Avery 1992, 61)



The study was developed and conducted using a process that incorporated the acquisition, image processing, and stereoscopic viewing of video imagery. The process involved a series of five steps which have been discussed below individually in detail. The steps include:

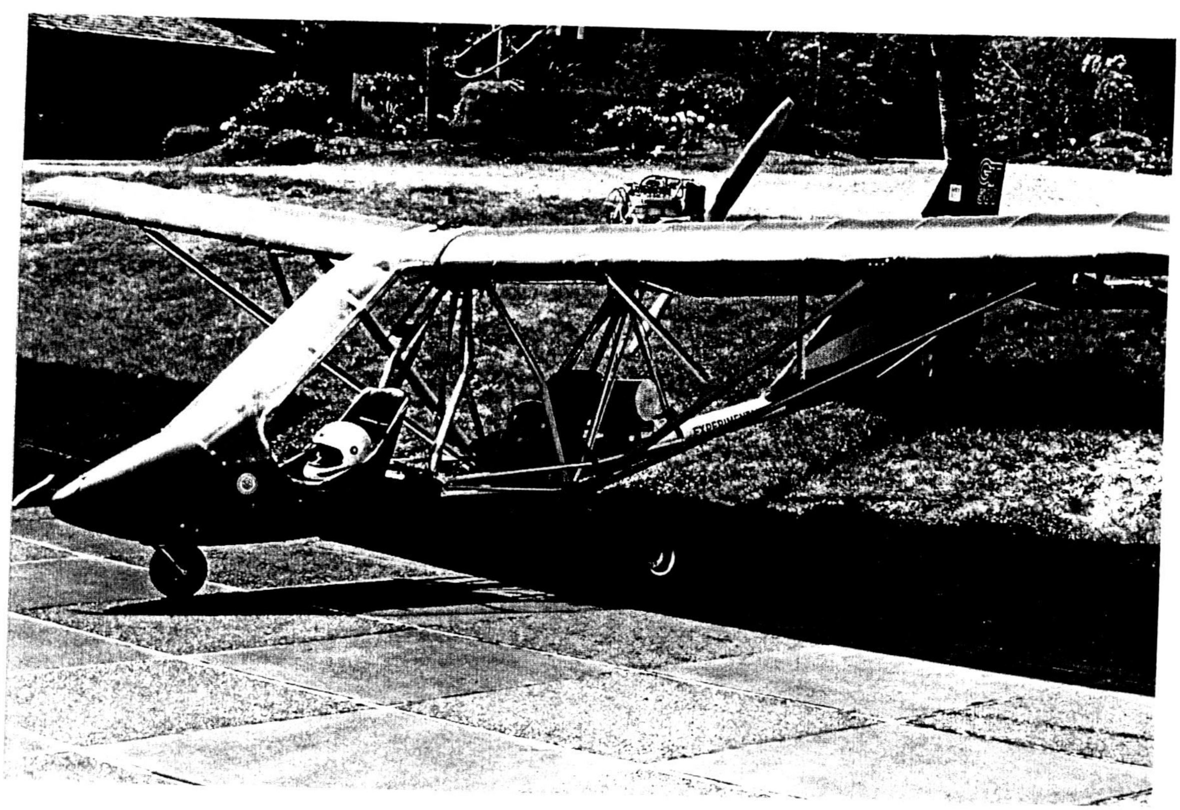
A. Obtaining airborne video imagery of a specified study area using a video system and a low altitude aircraft.

Video imagery of the city of Corvallis and Oregon State University (OSU) campus was obtained in this study through the use of a Quicksilver Model GT500 ultralight aircraft operated by Dr. Richard W. McCreight of the College of Forestry at OSU (Figure 8). The ultralight, which flew at an altitude of 4,000 feet above sea level (ASL), is a double seat aircraft configured with 3-axis control surfaces (wheels) to insure adequate stability of the aircraft in turbulent weather. It has sufficient wing area and power (65 hp) to handle the weight (a load capacity of 195 kg) of the instrument package and pilot (Figure). A 0.5 by 0.5 meter instrument mount is attached to the airframe unobstructed view of the ground below. Depending on a study's needs, three or four detectors can be attached to the mount at one time.

Video imagery was obtained using a Sony Model TR5 (Beta) 8mm camcorder. The camcorder provided an instantaneous field-of-view (IFOV) of 3 cm (1.18 in) at a 100 m (328 ft) altitude to 5 m (16.4 ft) at a 1000 m (3280 ft) altitude. The camcorder's RGB separation of the recorded signal also provides an approximation of visible wavelength spectral patterns at relatively high resolution. Over 230,000 images can be recorded by this system using a two hour tape (McCreight 1992, 4-5). The Beta tape format was converted over to a VHS format to be compatiable with the video cassette recorder used in the study.

Figure 8

Photograph of the Quicksilver Model GT500 Ultralight



b. Ground verification and on-site analysis of the study area.

Ground verification and photographs of the study area taken similutaneously with the video imagery provides additional information about a site that can be used during the interpretation and analysis phase. Because of the nature of this study, which was concerned with the abiltiy to use video imagery as an imagery tool, and not on specific site analysis, only a visual survey of the imaged area (OSU's Peavy Hall) was conducted to note significant changes that might have occured since the time of the video imagery.

c. Select and capture an image from the video tape that best represents the study area.

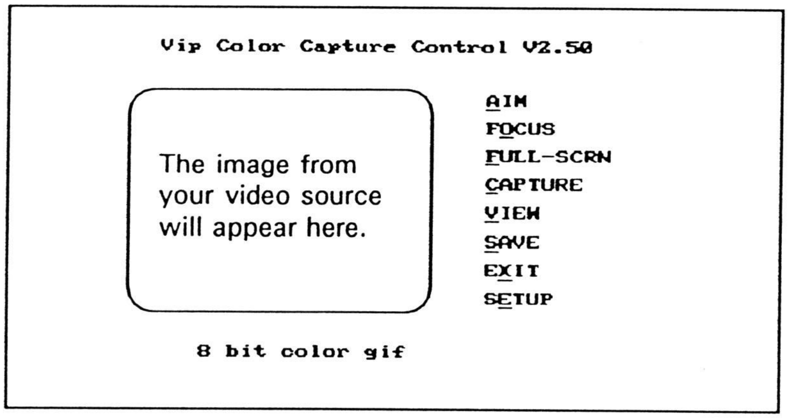
During this step, a video cassette recorder with still frame capability (a video camera can also be used if it is equipped with video cassette recorder features), a VGA color monitor, and a micro-computer equipped with a frame grabber were used to capture a video image. The frame grabber provides the ultimate stil frame capability by converting an image frame to digital data which can be used during computer image processing. This capability can be obtained by installing in a frame grabber circuit board and its associated software.

For this study, a *Ventek Video Capture System* was used to provide the frame grabber capability. A color capture card was inserted into an expansion slot of a Department of Geosciences (OSU) 386 IBM compatiable micro-computer. Because the video cassette recorder used during this study could not provide either a S-VHS or RGB video input, jumper pins on the capture card were configured to allow for the only option available, which was a RCA (composite) video input. A RCA video cord was used to connect the video cassette recorder to the computer. A video capture software program entitled *VIP* was loaded next onto the computer's hard drive (C:) and configured for use with the video cassette recorder. The following steps were then taken to capture a video image:

1. Turn the power on for both the computer and video cassette recorder.

2. From the C: prompt change to the *VIP* directory by typing **CD \VIP [Enter].** Start the program by pressing play on the video cassette recorder (tape must be going in order for the program to start) and type **VIP [Enter].** A screen with the video tape playing will appear (Figure 9).

Figure 9
Example of the VIP main screen (Ventek User's Guide #7900, 3-2)

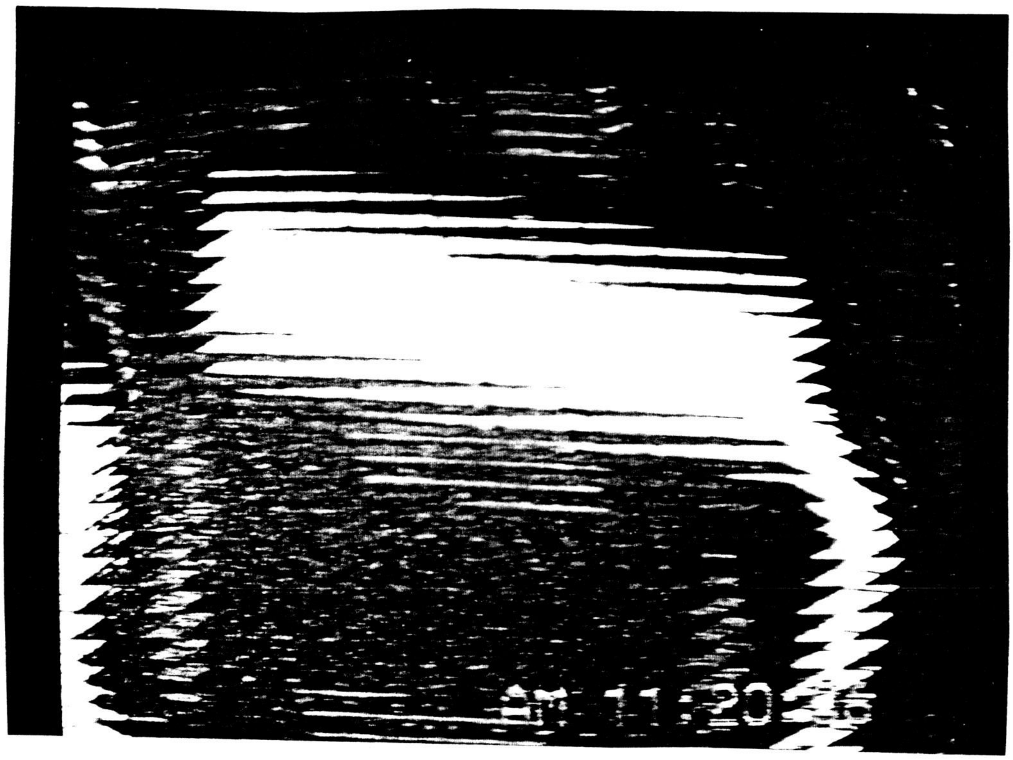


3. To capture and save an image, first type **C** which will momentarily pause the image, and then immediately type an **S** to save the image. You will then be asked to give the image a file name. The prompt will look like this **C:\VIP\VIP.XXX.** Back space over the VIP.XXX to retype your own file name and press [Enter] to save the file. The command **Save** will appear when it is finished. The file, which will be a TIFF file, can be found in the VIP directory. Two images, that overlap each other by approximately 60 percent, will be captured and saved in order to conduct stereoscopic viewing.

4. Type **X** to exit the program, and turn off the video cassette recorder.

If a video cassette recorder does not have a good still frame capability, or if the image is moving too fast, which is a major problem in airborne video imagery, captured images will appear blurred as a result of the image motion (Figure 10).

Figure 10
Example of a video image displaying image motion



d. Convert the video image TIFF file into a readable image processing program IMG file.

Video image data files are not compatible with most image processing programs, and must therefore, be converted into a usable data format. Most image processing programs incorporate conversion modules which will allow them to convert TIFF files into a more readable IMG file, such as with the image processing program called *IDRISI* (Clark University). *IDRISI* was chosen as an image processing program for this study because of it's affordability ($140) and simplicity. The Ventek Image Capture System produces a video data file that is a TIFF file. The following steps were used to make the conversion in the*IDRISI* program:

1. Copy the captured video image TIFF files onto a floppy disk. Then copy the files on the disk to the IDRISI\DATA directory using the command **A: COPY *.* C:\IDRISI\DATA**.

2. Enter IDRISI by typing at the **C: IDRISI.** Start the program by typing **IDRISI** again.

3. At the IDRISI prompt, type the command **TIFIDRISI.** This module is used to convert TIFF files to IDRISI files. Answer the questions. TIFIDRISI will provide information about the video data file which will be used to answer questions in the BIPIDRISI module. Copy the information down.

4. Hit **ESCAPE** and return to the main IDRISI prompt.

5. Enter the BIPIDRISI module by typing **BIPIDRISI** at the prompt or going to the main menu and clicking on the File Exploration/Conversion module and click on BIPIDRISI. This module is used to go from a band-interleaved by pixel (BIP) image file to a series of band sequential (BSQ) images in IDRISI format.

6. Using the information that was copied down from the TIFIDRISI module answer the questions. **When answering the minimum x and y coordinates type 0, and for the maximum x coordinates use 30 x # of columns, and 30 x #of rows for the maximum y coordinate (e.g. 30 x 512 = 15360).** The program will now process each of the bands. Video data files normally have three bands, one

   each for red, green, and blue. Hit **ESCAPE** when it is finished and return to the IDRISI prompt.

7. Check the IDRISI\DATA directory to verify that three separate files (one for each band) with the IMG extension have been created. A false color image can be produced at this point using the three band files and the module called COMPOSIT if it is desired.

e. Adjust and display both video images to achieve stereoscopic viewing.

1. Enter the CONCAT module by typing **CONCAT**. This module is used to join together the two overlapping video images which have been already processed into IMG. files. Before

starting this module decide on one band that will be used from each image (i.e. band 2 from image one and band 2 **from** image two). It will first ask for the name of a main image to use as a positional reference (i.e. image one) and then ask for the number of images to be joined together. Answer **1** to this question. Next it will ask about the positions of these images. For these questions answer the following:

Reference Corner: **Upper Left**
Column Position: **Between -256 and -512**
Row Position: **0**

Using a negative number for the column position will paste the second image to the left of the original image. This number is very important because the varying of this number will allow the images to become adjusted for stereoscopic viewing. If images overlap, it is the later (second) specified image that will over lap the earlier (first) specified image.

f. Display the image and use a lens stereocope to stereoscopically view and interpret the imagery.

1. Type **DISPLAY** or choose DISPLAY from the main menu to enter the module. A second menu will appear. Choose **COLORA**, and answer the questions. Answer the questions the following way:

   Palette: **Greyscale (2)** This produces an image that is sharper and clearer for analysis.
   Legend: **No (2)**
   Reference Corner: **Upper Left (1)**
   Display factors by Hand: **Yes**
   Expansion Factor: **- 4** The negative number produces an image that is small enough to be viewed in its complete form sterescopically.

2. Repeat the CONCAT and DISPLAY procedures as necessary to adjust the images for stereoscopic viewing (Figure 11).

3. Use a lens stereoscope to view the images from the screen. Compare the video images to aerial photographs of the same study site (Figure 12).

Figure 11
Stereopair of the video images used for stereoscopic viewing

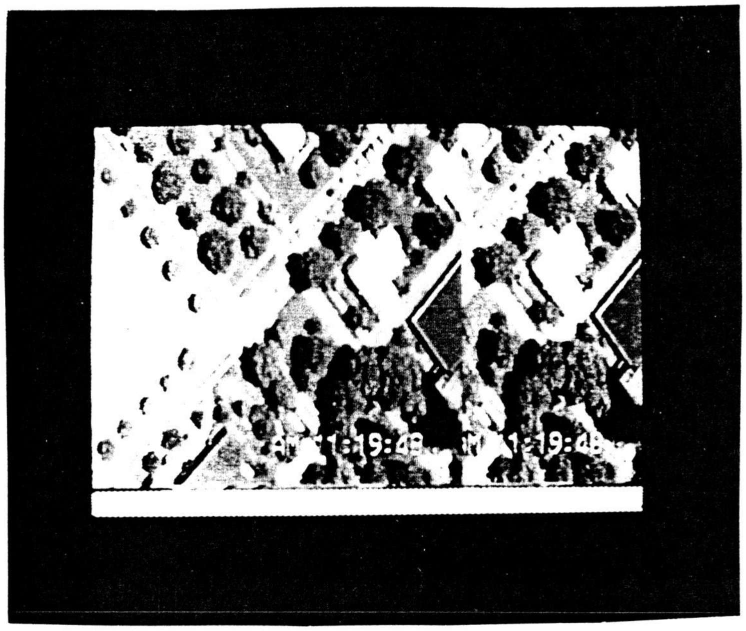
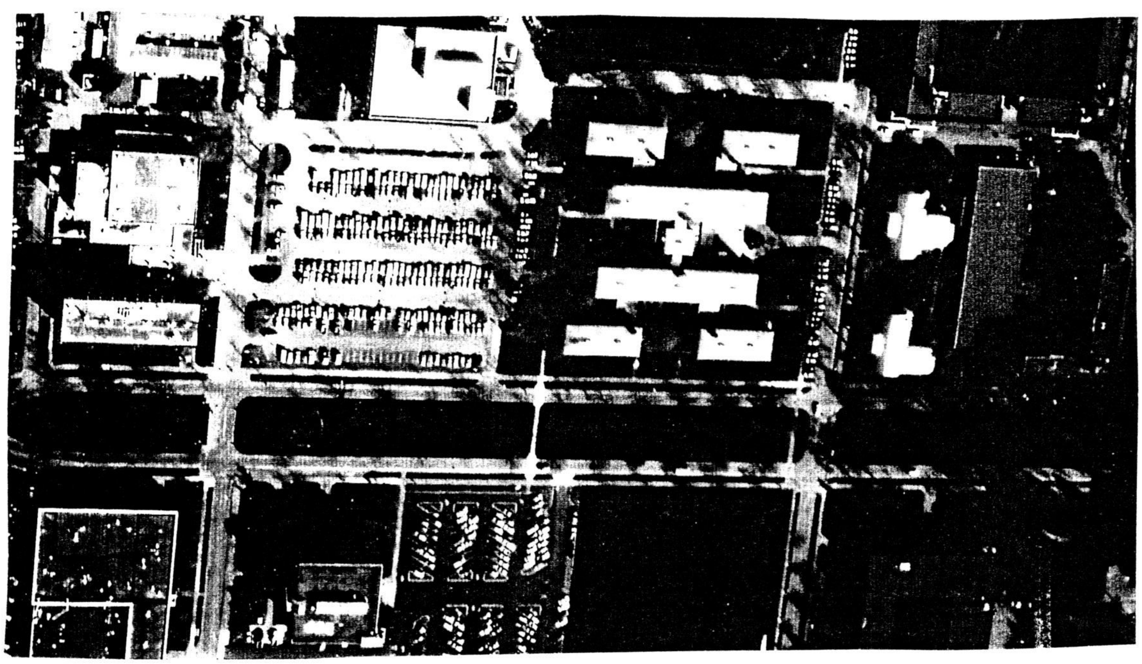


Figure 12
A 1990 aerial photograph of the study area



A comparison of the use of video imagery from a computer monitor to aerial photgraphs revealed several interesting factors:

1. Video imagery provided a low cost, fast, and convenient method of analyzing imagery.

2. Stereoscopic vision could be achieved, but the ability to use the phenomena of depth perception to measure the height of objects was limited.

3. Objects in the video imagery were recognizable, but because of the low resolution they appeared fuzzy, making it difficult to make accurate measurements. Vegetation appeared to be more fuzzy than buildings and other objects in the image.

4. Good video equipment is necessary to provide higher resolution and eliminate blurring and image motion problems which is evident in the video imagery, and not the aerial photographs.

VI. Conclusions

Further investigation into the usefulness of stereoscopic viewing could have been made if more time was allocated to this study. However, with a basic understanding of video systems, and the discovery of a simple procedure to stereoscopically view video imagery, I feel that the objective of this study was met. Stereoscopic viewing is a viable technique to use with airborne videography even though the development and design of video systems for use in remote sensing applications has shown that videography is still in its exploratory stages. As research continues in this area improvements in the performance, portability, and cost of video systems can only further enhance videography's attractiveness. Even with the draw back of low resolution, video imagery is still able to provide a cost effective and timely means of assessing airborne imagery. The results of studies conducted in the past, and those that will occur in the future, are evidence that videography is a useful remote sensing technique for both natural resource assessment and military applications.

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