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AERIAL PHOTOGRAPHY AND LEGAL APPLICATIONS

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AERIAL PHOTOGRAPHY AND LEGAL APPLICATIONS

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INTRODUCTION

Aerial photographic interpretation is the process of examining objects on aerial photographs and determining their significance (Quackenbush 1960, Avery 1968). It is often defined as both ART and SCIENCE because the process, and the quality of the derived information, is often of a qualitative nature and much depends on the training, ability, dedication and imagination of the photo interpreter to make specific identifications and complex inferences.

It is difficult to describe photographic interpretation without also discussing two other related disciplines, *photogrammetry* and *remote sensing*. Photogrammetry is defined as the science of obtaining reliable information about physical objects and the environment by measuring photographic images (Thompson and Gruner 1980). Remote sensing is the broader field of techniques that utilize some type of electromagnetic energy to record information about a target surface without physical contact (Sabins 1986). Photo interpretation is one of the original forms of remote sensing and probably still one of the most practiced forms, although the use of satellite and aircraft imaging sensors has increased dramatically in the past twenty years and will undoubtedly increase in utilization in the environmental sciences.

Aerial photographs have been used successfully in courtroom proceedings for many years and provide distinct advantages for gathering and presenting information about the earth's surface and its processes. However, extracting useable information from aerial photographs is often more complex than it may seem to those unfamiliar with the technology.

This paper will review the basics of aerial photographic interpretation and discuss some of the issues related to its utilization in a legal arena.

HISTORY

The first recorded aerial photograph was taken from a balloon by Frenchman Gaspard Felix Tournachon in 1858. By 1860, Americans Samuel King and J.W. Black had taken photographs of Boston from a balloon and General George McClellan used balloon-based aerial photographs extensively to determine enemy positions during the United States Civil War (Quackenbush 1960).

The widespread use of aerial photography and photo interpretation began with the first world war, obviously correlated with the expanding use of aircraft for military purposes. By the 1920's, government agencies, such

as the U. S. Geological Survey and the Army Map service had realized the tremendous economic potential of aerial photographs in making maps. Other agencies, such as the Department of Agriculture and the Forest Service, began using aerial photographs extensively in resource inventories, crop assessments and land use planning.

World War II was the impetus for the formalization of photogrammetry and photo interpretation as accepted sciences. Photo intelligence played a paramount role in World War II. Highlights include the air photo discoveries of the Nazi concentration camps and the V1 and V2 missile capabilities. An interesting account of World War II photo interpretation can be found in "Air Spy", by Constance Babington Smith (1957).

After World War II, the utilization of aerial photographs and the subsequent expansion of science in the field of remote sensing has been phenomenal. Avery (1960, page 8) lists 58 different routine applications of aerial photographs ranging from aeronautical engineering (calibrating aircraft parts) to zoology (populations inventories).

Photography even found its way into space. Military and intelligence programs of many countries recognized the strategic value of orbital photographic platforms. Research on developing and deploying earth-orbiting photographic sensors began in the 1950's and early intelligence satellites were successfully operating as early as 1960. A fascinating account of one such program can be found in the recently released and declassified CIA document "CORONA: America's First Satellite Program", (Ruffner 1995).

THE PRINCIPLES OF AIR PHOTO INTERPRETATION

The art and science of air photo interpretation is often minimized and misconstrued with the simple process of everyday vision. Indeed, aerial photographs that are taken from oblique angles and represent 'normal' viewing perspectives, are often easier to interpret and understand. However, most aerial photographs are taken for metric mapping purposes and are therefore taken from a vertical perspective which allows much greater mathematical fidelity but presents a perspective unfamiliar to untrained observers. In terms of courtroom applications, critical mistakes can be made by professionals using aerial photographs but without experience, training or credentials in the process of formal aerial photo interpretation. The following is a summary of some of the fundamental elements of the photo interpretation process.

Characteristics of Aerial Photographs

The are several important characteristics of the aerial photograph that are important to the process of extracting meaningful and accurate information from them. It should be remembered that nearly all photo interpretation is performed with the aid of optical instruments that magnify and enhance the interpretation process.

VISIBLE LIGHT: It is important to note that aerial photographs capture visible light onto photographic emulsions or digital sensors. This should be differentiated from other remotely sensed images, that may also capture reflected electro-magnetic (EM) energy in other non-visible parts of the EM spectrum. This difference is important in that other parts of the electromagnetic spectrum react very differently with objects on the earth's surface and a full understanding of these interactions is necessary for accurate interpretation. An in-depth discussion of visible light and the electro-magnetic spectrum can be found in Sabins (1986).

SCALE: Scale refers to the simple ratio of the distance between two points on an image or map, and the corresponding distance on the ground (Sabins 1986). A common scale on U.S. Geological Survey mapping products (and aerial photographs) is 1:24,000, indicating that 1 inch on the map equals 24,000 inches on the ground. Aerial photographic scales vary widely, from satellite images that have scales of 1 to several million to engineering applications that have scales of 1:100. Scale is critical to the ability to distinguish small objects of fine detail. Scale is determined by several factors including the altitude of the aircraft, the focal length of the camera and the magnification factor of photographic reproduction.

RESOLUTION: Photographic resolution refers to the ability to distinguish between closely spaced objects on an image (Sabins 1986). It is determined by a number of factors including scale and the optical properties of the camera system.

CONTRAST: Contrast or the contrast ratio refers to the mathematical relationship between the darkest parts of an image and the brightest parts of an image. Higher contrast ratios usually improve the image's interpretability.

Object Recognition

From Avery (1968) and Colwell (1960), there are seven principles of object recognition that are utilized, consciously or unconsciously, by the experienced photo analyst in extracting information from aerial photographs. These are:

SHAPE - Many objects have unique shape as a primary factor in their identification.

SIZE - Both the absolute size, as mathematically computed and relative size of objects with respect to surrounding objects are important clues to the identification of features on aerial photographs.

TONE/COLOR - Objects have different qualities of light reflectance and this is often a major clue in their identification. Color, as recorded on aerial photographs, has obvious identification characteristics and levels of gray, on black-and-white photographs, tell the photo interpreter

important characteristics of an objects interaction with light

PATTERN - The spatial arrangement of features, especially in the natural sciences, is a fundamental key to the photo interpreter. Trees planted in rows in regular intervals display a pattern indicating an orchard as opposed to a natural forest.

SHADOW - Shadows are a undamental element of the photo interpretation process. Analysis of the shadow of an object often reveals critical structural characteristics that may not be readily apparent from the object itself due to the vertical viewing angle.

TOPOGRAPHY - Many objects and processes on the earth's surface are fundamentally related to the topographic setting or 'lay of the land' in which they are located. Especially important for the identificacion of plants and trees, the relative elevation, drainage features and geologic and soil conditions are important elements for understanding natural objects and processes.

TEXTURE - The degree of coarseness or smoothness of an area on photo images can be a critical element for identification purposes.

Other Factors

There are two other factors in the interpretation process that should be mentioned as they are critical to air photo interpreters.

STEREOSCOPIC VIEWING - One of the most important tools in aerial photographic interpretation is the ability to view objects in three dimensions via stereoscopic parallax. Nearly all standard aerial photographs are imaged in such a way that approximately 60% of each frame of imagery overlays the previous frame. As a result, any particular object is imaged twice, on successive photographs, and at slightly different angles. By optically combining both images with some type of viewing device, a three dimensional scene is observed, greatly enhancing the ability to discriminate and interpret various objects and situations.

CONVERGENCE OF EVIDENCE - One final point that should be made about aerial photographic interpretation is what Rabben (1960) termed "Convergence of Evidence". This term refers to a more complex process of deduction to determine the identification of an object or situation. After identifying the simpler landscape components on an image, the interpreter, through logical deduction is able to make judgements of probability. The background and experience of the interpreter plays an important role here. An excellent example of this concept can be found in Colwell (1960, page 109-111) where the analysis goes through a step by step process to determine that a large landscape feature on an aerial photograph is, in fact, a military cemetery.

LEGAL FRAMEWORK

Aerial photographs and the information derived from them are of course highly valuable to the courtroom and to legal proceedings. This is especially true for those involving natural resources or the environment, although any applications of aerial photographic analysis could conceivably be important to litigation. Photographs represent reality at a given point in time and present a powerful demonstrative tool in evidentiary applications. Ciccone (1986) demonstrated that the 'information retention' of an average person is increased dramatically when visual aids are used in addition to simple verbal information alone. In this regard, photographs present an extremely powerful tool in the courtroom. Photographs can powerfully depict altered landscapes, changes in natural condition, vehicular activity and many other conditions that can have direct bearing on legal issues.

Latin, et al (1976) and Uhlir (1990) categorized three remote sensing applications in the legal arena: (1) applications primarily aimed at the development of public formal policy, (2) investigatory applications, and, (3) applications expected to produce admissible evidence. Admissibility and the formal rules of evidence would apply to all data to varying degrees of scrutiny depending on whether the application was criminal, civil or administrative. Although there has been significant utilization of aerial photography and other remote sensing systems in the first two above categories, the actual use as evidence has been somewhat limited, mostly due to a general lack of knowledge and uncertainty over privacy and search and seizure issues, which are not yet fully addressed through judicial decision. Also, another possibility is that the effectiveness of the photographic medium is so strong in the pretrial and discovery stages that many cases are settled before the actual trial phase (Uhlir 1990).

Advantages

Aerial photographic and other remote sensing products offer several distinct advantages for environmental monitoring (Kroeck and Shelton 1982).

1. Imagery creates a permanent record of morphological characteristics and activities at a single point in time that is generally admissible as demonstrative evidence in U.S. Courts.

2. Imagery archives dating back to the 1920's and sometimes earlier, can be used to create a historical profile of environmentally significant activity.

3. Imaging techniques are often cost-effective alternatives to labor-intensive, ground-based techniques. Also, they are an excellent

alternative when ground-based methods are impossible or impractical.

4. In general terms, legally-admissible remote sensing can be accomplished without a search warrant.

5. Remote Sensing products can be easily converted into highly accurate measurements, maps, Geographic Information Systems (GIS) data or other cartographic products.

Examples

Remote sensing and aerial photography have been successfully used in a number of environmental monitoring applications. Some examples include:

1. Sludge deposited for years in Lake Champlain by a pulp and paper company eventually moves across the center line of the lake which is also the boundary between Vermont and New York (and also between EPA Region 1 and 2). Vermont claims that its waters have been degraded and wants the company to pay for clean up. A Special Master, assigned by the Supreme Court, studies the issue and rules in favor of Vermont. The key piece of evidence is a multispectral scanner image from the LANDSAT satellite (Felsher 1993).

2. A steel plant on the shores of Lake Michigan is charged with polluting the waters from which Chicago draws its drinking water supplies. EPA scientists use a thermal infrared image and a SKYLAB photograph to prove that the heated discharge water does in fact migrate to the City of Chicago's water supply intake (Felsher 1993).

3. In the first defense of the Comprehensive Response Compensation and Liability Act (CERCLA), better known as "Superfund", aerial photographs play a critical role in establishing liability for a drum re-cycling facility and the operation of a caustic disposal lagoon, suspected of polluting the local groundwater (Tejada 1986).

4. In 1982, EPA requests a second inspection of air-pollution control equipment at the Dow Chemical Facility in Midland, Michigan. When denied the second visit, EPA secures the services of a commercial aerial photographer to overfly and photograph the facility. Upon discovering the aerial overflight, Dow sues, claiming violation of trade secrets and invasion of privacy. The case eventually ends up in the Supreme Court of the United States, where on May 19, 1986, the case is decided in favor of the government - a landmark legal decision (Dow Chemical v. United States 1986, Koplow 1992).

Aerial Photography and the Constitution

The use of aerial photography by government for purposes of domestic law enforcement has naturally raised a number of legitimate concerns relating to individual privacy and the bounds of legal authority. The legal issues surrounding the use of overhead remote sensing techniques for monitoring and enforcement revolve largely around the history and interpretations of the Fourth Amendment guarantees against unreasonable search and seizure. The constitutional guarantee against unreasonable searches is a complex concept in the American model of civil liberties. Since 1914, in Weeks v. United States, the Supreme Court ruled that evidence obtained through an illegal search (without a warrant on probable cause) could not be used in a federal crimir Subsequent Supreme Court decisions have further extended t unwarranted searches to include remote monitoring activiti involve physical trespas , such as wiretapping and ic eavesdropping (Volkomer 1972). In the 1967 *Katz* v. *United St* the seminal case in search and seizure issues, the Supreme Court set t two lines of inquiry to define searches that may be permissible without a warrant. First, has there been exhibited an actual, subjective expectation of privacy and, second, is this expectation one that society is prepared to accept as reasonable?

To date the landmark legal decision concerning remote sensing and law enforcement is *Dow Chemical Company* v. *The United States* (Koplow 1992). In an attempt to enforce Clean Air Act regulations, EPA sought access to the DOW Chemical plant in Midland Michigan. When access was refused, EPA contracted for an aerial photographic overflight, using a standard mapping camera. Upon discovering EPA actions, Dow brought suit claiming that EPA violated trade-secrets law, acted outside of its authority and conducted an illegal search under the Fourth Amendment. Eventually, the Supreme Court ruled, in a close 5-4 decision, that EPA had acted legally in the acquisition of the aerial photographs. Although there were two other key elements in the Dow decision, trade secrets law and the statutory authority of the EPA, the main issue focussed on whether an aerial photographic overflight was an unreasonable search under the Fourth Amendment.

Expectation Of Privacy: Curtilage and Open Fields

Expectation of privacy is a key element of the Fourth Amendment interpretations, especially as applied to the individual in society. Dow Chemical relied heavily on this principle, based primarily on trade secrets laws and the right to be protected from industrial espionage. The question to be posed simply becomes 'Do Industrial facilities have the same right to a reasonable expectation of privacy that we grant to the individual in society?' Two key legal concepts are relevant to this question, curtilage and open fields. Curtilage is simply defined as the yard or courtyard surrounding a dwelling, usually within a fence or some other type of perimeter security device. The curtilage of the individual home, under traditional common law, has enjoyed almost the same Fourth

Amendment protection that is afforded inside the home. An individual within the curtilage of his/her home has a reasonable expectation of privacy that cannot be intruded upon, except by warrant (Dow 1986, page 8). Open Fields, on the other hand, have been defined as out-of-doors areas, not immediately surrounding the home, where the individual does NOT have a reasonable and legitimate expectation of privacy (*Oliver v. United States* 1984). Dow tried unsuccessfully to claim that the open areas of a large industrial complex were analogous to a concept of industrial curtilage.

Although the court held that a company has a reasonable and legitimate expectation of privacy within their covered buildings, this expectation of privacy does NOT translate to the outdoor areas of a manufacturing plant (Dow 1986, page 10).

Societal Acceptance

The second key inquiry from Katz is the test of whether the expectation of privacy is one that society is willing to accept. Traditionally, in cases of the rights of individuals, this ruling has been very broad. However, it is clear that the court was not willing to extend this same standard to commercial enterprises. Justice Burger wrote that the homeowners interest in his dwelling is very different from the interest of the owner of commercial property with respect to being free from inspections (Dow 1986, Page 10).

However, the legal debate surrounding aerial photographs, satellite remote sensing and related issues is likely to continue. The Dow decision, in many ways, raised as many questions as it answered. Several commentators such as Koplow (1992), Gootee (1990) and others have asserted that the Supreme Court simply erred on key points of the technology and its limitations. Further, the rapidly advancing technology of remote sensing science is likely to create legal considerations beyond the limitations of visible light and human vision which were fundamental to the Dow decision and simple aerial photography.

PRACTICAL CONSIDERATIONS

The are several practical considerations that should be kept in mind when considering the use of aerial photography in a legal framework.

OBTAINING AERIAL PHOTOGRAPHS - Obtaining historical and current aerial photographs is a non-trivial process that routinely involves months of research and effort. Historical aerial photographs are generally available through a number of government and private sources and obtaining current aerial photographic overflights requires planning and contracting. The Earth Science Information Center of the U.S. Geological Survey is an excellent starting point.

INTERPRETATION EXPERTISE - Although aerial photographs are routinely used by many professionals in a wide variety of fields, the occasional interpretation of photos does NOT necessarily equate to being an expert in all aspects of photo interpretation. This is especially true if the application of interest starts to deviate, even slightly, from the narrow focus of an analyst's routine use of photographs. Photographic experts are available from a variety of private and public institutions and the American Society for Photogrammetry and Remote Sensing (ASPRS) operates a certification program for practitioners in remote sensing, aerial photography and related disciplines.

RULES OF EVIDENCE - Depending on the legal application, getting aerial photos introduced as evidence requires time and special handling. Simply obtaining an aerial photograph that may have special significance to a case, is often just the first step. In many situations, a CERTIFICATION OF ORIGINAL COPY is required and CHAIN-OF-CUSTODY rules and handling of photographic materials are required. These often take significant amounts of time and effort and requires months of prior planning.

FOR ADDITIONAL INFORMATION - additional information on aerial photography, photogrammetry and remote sensing is available in several excellent documents produced by the USGS Earth Science Information Center (703-648-6045) and the American Society for Photogrammetry and Remote Sensing (301-493-0290).

NOTICE

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16. ABSTRACT

Aerial photographic interpretation is the process of examining objects on aerial photographs and determining their significance. It is often defined as both art and science because the process, and the quality of the derived information, is often a qualitative nature and much depends on the training, ability, dedication and imagination of the photo interpreter to make specific identifications and complex inferences. It is difficulty to describe photographic interpretation without also discussing two other related disciplines: photogrammetry and remote sensing. Photogrammetry is defined as the science of obtaining reliable information about physical objects and the environment by measuring photographic images. Remote sensing is the broader field of techniques that utilize some type of electromagnetic energy to record information about a target surface without physical contact. Photo interpretation is one of the original forms of remote sensing and probably still one of the most practiced forms, although the use of satellite and aircraft imagining sensors has increased in utilization in the environmental sciences. Aerial photographs have been used successfully in courtroom proceedings for many years and provide distinct advantages for gathering and presenting information about the earth's surface and its processes. However extraction useable information from aerial photographs is often more complex than it may seem to those unfamiliar with the technology. This paper will review the basics of aerial photographic interpretation and discuss some of the issues related to its utilization in a legal arena.

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