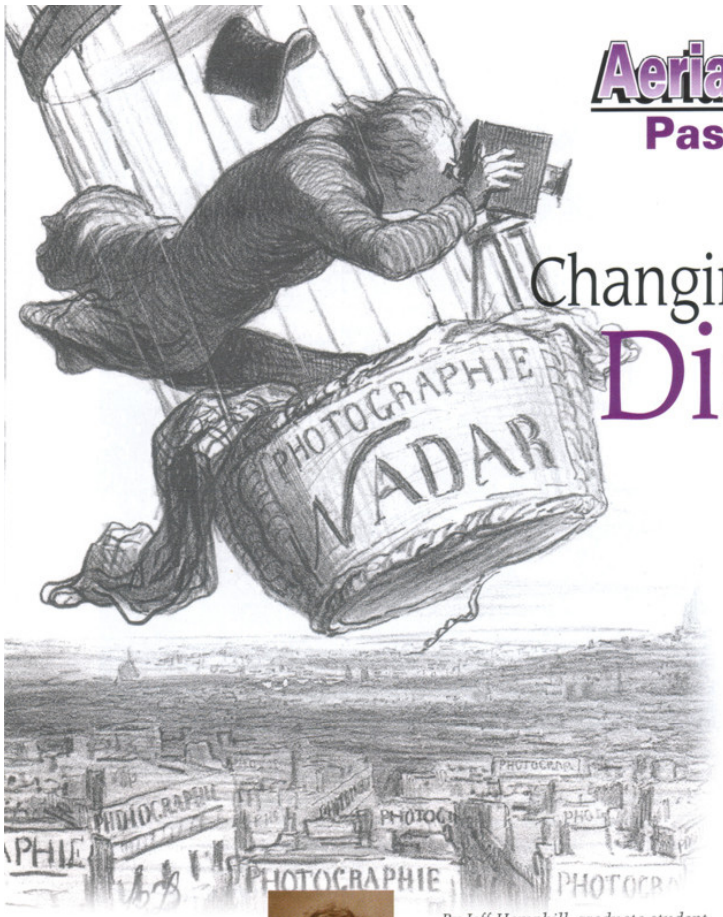
Aerial Imaging
Past, Present and Future

Changing Times Reflect Discovery



By Jeff Hemphill, graduate student researcher, Geography Department, University of California, Santa Barbara (www.geog.ucsb.edu).

Gaspard Felix Tournachon

1858

Gaspard Felix Tournachon (1820-1910), also known as "Nadar," took the first aerial photograph from a captive balloon 1,200 feet above Paris. His goal was to make land surveys from aerial photographs. Although not fully successful in his attempt, he set the stage for the future of remote sensing.

On Jan. 13, 2004, Eastman Kodak Company announced it would stop selling traditional film cameras in North America and Western Europe. Prompted by the digital camera revolution and sagging profits, Kodak's announcement marked a turning point in the photography industry.

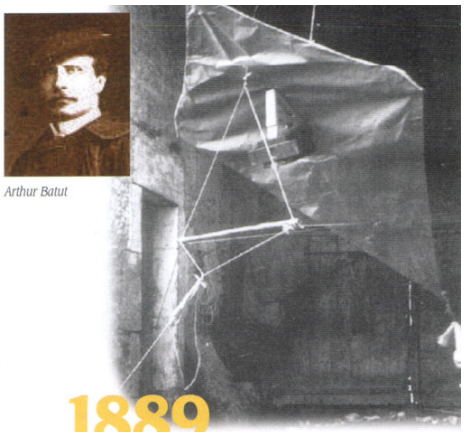
Aerial photography also is transitioning from film-based to digital systems, forcing changes in corporate directions and research. Unlike consumer photography, however, the change is occurring more gradually, and most of today's professional aerial photography and its applications remain film-based. This is partly due to costs, and in some cases resolution limitations, but it also has a lot to do with tradition. This tradition is examined here in a brief history of aerial remote sensing. For a comprehensive look at the current state of aerial imagery, see "Technical Advances Support Diverse Solutions," page 18.

The Forefathers

The contemporary history of aerial remote sensing was founded on a few critical theoretical contributions. One of the first events occurred in the late 1600s, when Sir Isaac Newton observed the nature of light by using a prism to split white light into a rainbow according to wavelengths. Newton's experiment, and his subsequent mathematical description of the results, spawned widespread debate.

Similarly, Thomas Young's work in the early 1800s demonstrated the validity of the wave theory of light. His theory of color vision was critical for laying the academic foundation of optics. The same could be said of James Clerk Maxwell's work on additive color theory, which he and Thomas Sutton presented in 1861, and of his later work linking electricity and magnetism, which paved the way for the development of quantum physics in the early 1900s.

In 1887, Heinrich Hertz proved the existence of electromagnetic waves, which eventually led to radio, television and radar. While conducting his investigations, Hertz accidentally discovered the photoelectric effect (the phenomenon of electrons being emitted from a metal when struck by incident electromagnetic radiation). Einstein's explanation of the photoelectric effect was one of the first triumphs of quantum mechanics, earning him the 1921 Nobel Prize in physics.



Arthur Batut

a History of and Invention

The magnitude of these contributions and others wasn't fully realized for some time, but many of the technological innovations that have driven the field of remote sensing can be attributed to these pioneers.

Heinrich Hertz

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The Early Years

Joseph Nicephore Niépce is credited with taking the first photograph in 1827. Called a lithograph, the image was produced using a camera obscura containing a coated pewter plate. The plate was exposed to reflected sunlight for eight hours, and contrast was enhanced using the vapor of heated iodine crystals.

After Niépce's death in 1833, his partner, Louis Jacques Mande Daguerre, improved the plate-photography technique by developing a more sensitive plate medium and a way to fix the images. In 1839, he announced the invention of the "daguerreotype." Also in 1839, William Henry Fox Talbot invented a new method of photography that used an acid solution to develop a negative image recorded on a specially treated paper medium. The process he invented would later become the "Calotype" and the basis for the negative-positive process used in modern film-based photography.

Other advances quickly followed. In 1849, Col. Aime Laussedat of the French Corps of Engineers proved it was possible to use image pairs to extract measurements. In 1898, he successfully developed a mathematical transformation for converting overlapping perspective views into planar orthographic projections, giving rise to the field of photogrammetry. In 1858, Gaspard Felix Tournachon, who later became know as "Nadar," is credited with taking the first aerial image from a balloon over Paris. In 1860, James Wallace Black took a picture of Boston from a balloon. In 1889, Arthur Batut published a book that described using cameras with fuse timers suspended from kites. It was George R. Lawrence, however,

George R. Lawrence

1889

Arthur Batut (1846-1918) took an aerial photograph of Labruguiere, France, from a kite. Batut's simple idea of attaching a timed camera to a kite sparked a sensation that continues to this day.

who drew national attention to the use of kites for aerial photography. He tethered together multiple kites to hoist a massive camera aloft and take dramatic panoramic photographs of the damage caused by the fires ignited by the 1906 San Francisco earthquake. Although aerial photography had proved useful for cartographic applications, and possibly for military intelligence gathering via balloons in the Civil War, the 1906 images of San Francisco had the most wide-ranging public impact.

1906

George R. Lawrence (1869-1938) achieved widespread recognition and acclaim with his "San Francisco in Ruins" photograph. Taken in May 1906, a few weeks after a devastating earthquake and fire had destroyed much of the city, the image was captured from 2,000 feet with a camera that was elevated by a train of kites.

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Wilbur Wright

1908

Wilbur Wright (1867-1912) piloted the plane from which the first photographs from an aircraft were taken. The next year, the first aerial motion pictures were taken in Italy when another photographer accompanied Wright.

Global Conflict

The perception of aerial photography as a curious art form began to change in the early 1900s, but its adoption was delayed due to the inadequacy of early camera systems. Aerial photographic reconnaissance didn't take off until the end of 1915, when Lt. Col. J.T.C. More Brabazon of the Royal Air Force (RAF) developed a suitable camera system. Image interpreters became the eyes of the military, and aerial intelligence became a vital component of military planning. During the Allied Offensive of 1918, RAF aerial reconnaissance missions produced 10,000 prints per night, and it was reported that during the Meuse-Argonne offensive 56,000 prints were produced and delivered to the American Expeditionary Force in four days.

After 1918 and the Armistice, the focus turned toward scientific and commercial uses. Indicative of the growing interest in this field was the publication in 1934 of the first issue of the American Society of Photogrammetry's *Photogrammetric Engineering*. Beginning in the 1930s, U.S. government agencies began to make extensive use of aerial photography for mapping and resource assessment. The Forest Service inventoried timber resources; the Geological Survey began topographic and geologic mapping; the Tennessee Valley Authority began using aerial photography for planning; and the Chicago Planning Commission published the *Master Plan for Residential Land Use* in 1943, which was based on aerial photography.

The onset of World War II prompted another phase of rapid innovation in the field of aerial remote sensing. In 1938, German Chief of Staff General Werner von Fritsch said, "The nation with the best photoreconnaissance will win the next war." The United States lacked this capability upon entering the war, but soon adopted the technology and methods developed by the Allies. The legacy left by the success of aerial war-time remote sensing has been realized by succeeding generations through numerous technological and methodological innovations, as well as by the trained professionals who adapted what they had learned to scientific and commercial applications.

Beyond Blue

A breakthrough came in 1924. Working in the Eastman Kodak Research Lab, Leopold Mannes and Leopold Godowsky invented multilayer color film. In 1935, "Kodachrome" went to market. Although color film was used during World War II, its widespread use was inhibited due to slow exposure time, lack of lenses suitable to color transmission and the inability to reduce atmospheric haze. However, color film was useful for mapping shallow bathymetry and submerged objects. Photo reconnaissance wasn't widely used by the U.S. military prior to the 1941 attack on Pearl Harbor, but soon after efforts began in earnest to map the coral reefs of the Pacific. Based on the techniques developed during this period, Capt. L.W. Swanson of the U.S. Coast and Geodetic Survey demonstrated it was possible to map bathymetry using aerial photography in 1960.

1914-1918

Aerial reconnaissance in World War I changed the nature of war forever, as the biplane replaced the balloon for observing enemy positions. By the end of the war, the value of photographic reconnaissance was recognized by both sides. The Germans acquired 4,000 photos a day to help plan for their last great offensive of 1918, and the U.S. Army made more than 1 million prints in the last four months of the war. After the war, interest in the peaceful uses of aerial photography increased in areas such as agriculture and forestry.

The historical development of color infrared film isn't as well documented. What is known is that in 1940 the U.S. Army Corps of Engineers asked the Massachusetts Institute of Technology to form a faculty committee to investigate a photographic way to detect camouflage. The group, led by S. Q. Duntley, discovered the "chlorophyll dip" beyond 700 nanometers in 1940. In 1942, the first successful false-color camouflage-detection film test was conducted, but color infrared film was discontinued for military use due to its slow speed and the fact the chlorophyll-based dyes in fabric would negate any detection advantages in the near-infrared wavelengths.

In the early 1960s, two events occurred that had a significant effect on aerial remote sensing. In 1960, a U-2 spy plane flown by Francis Gary Powers was shot down over the Soviet Union. He was convicted of spying and confined to a Russian prison until exchanged for a captured Russian spy. Known as the U-2 Affair, the incident set in motion a pattern of mistrust that culminated in the Cuban Missile Crisis in 1962. In September and October of that year, Soviet officials had persistently denied their intent to install offensive weapons in Cuba—only 90 miles from U.S. shores—despite intelligence reports to the contrary. On Oct. 14, two U-2 reconnaissance planes photographed portions of Cuba, and analysis confirmed that bases were being constructed for intermediate-range missiles within striking distance of the United States. Both of these events brought aerial remote sensing into the public eye in a dramatic way and induced radical policy changes that eventually led to the launch of a civilian satellite remote sensing program.

Another important event in 1962 was the U.S. Defense Department's development of a camera system that included nine cameras with identical lens and film configurations, but with different filters. The system, and others like it, acquired some of the first multispectral images. In the mid-1960s, NASA began sponsoring projects to test the feasibility of using multispectral photography for applications in agriculture, forestry and geology.

As for the development of thermal-infrared imagery, the exact invention date is obscured by conflict. The ability to detect and image heat at a distance was an important military advantage, and many countries were trying to develop such technology. Samuel O. Hoffman's work in this region of the electromagnetic spectrum was published in 1916, but it's likely that thermal-infrared imagery originated earlier.

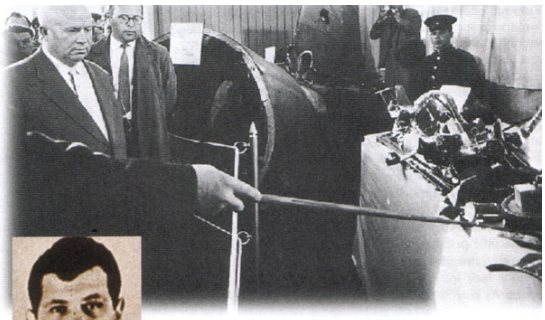
1938-1945

Tremendous strides in aerial photography and photogrammetry were made during World War II. These included rapid advances in the development of black-and-white and color infrared film for camouflage detection and haze penetration, protocols for various photo-interpretation tasks, and nighttime aerial photography equipment for various planes and situations.

Other significant developments maximized the use of radar and laser technologies for Earth imaging. In 1951, Carl Wiley, while working for Goodyear Aircraft Inc., made a key discovery related to airborne Synthetic Aperture Radar (SAR). By using the Doppler principal, the dispersion of the signal could be "synthesized," allowing for much finer resolution than preceding "real-aperture" systems. In 1960, Theodore Maiman, while working for Hughes Inc., developed the first optical wavelength laser system, but it wasn't immediately realized how lasers could be useful for nonmilitary purposes. Today, multispectral and SAR imaging capabilities have become established in aerial remote sensing applications, while those based on laser imaging, Light Detection and Ranging (LiDAR), are becoming a viable commercial technology.

Historical Links

A more detailed study of the events mentioned in the later part of this article clearly shows the link between experimentation, refinement and demonstration and the development of commercially viable applications. Although primarily military in origin, many of the key discoveries, such as color infrared film and radar, left a lasting impression through their application in science and industry. Moreover, throughout aerial remote sensing's long history, it's interesting to note how the discovery and refinement of new techniques relate to technological and societal changes. Today's aerial imaging systems are an exciting reflection of the digital age.



Francis Gary Powers

1960

While on a reconnaissance flight deep inside the Soviet Union, a U-2 flown by Francis Gary Powers (1929-1977) was shot down on May 1, 1960. On May 7, Soviet Premier Nikita Khrushchev informed the world press about the American spy plane and placed recovered parts of the wreckage on display. Powers spent 21 months in prison and then was exchanged in February 1962 for Soviet intelligence officer Rudolph Abel. The incident, known as the U-2 Affair, set in motion a pattern of mistrust that culminated in the Cuban Missile Crisis.

References

Manual of Remote Sensing, First Edition. Robert G. Reeves et al., editors. American Society for Photogrammetry and Remote Sensing, Falls Church, Va., 1975.

Manual of Remote Sensing, Second Edition. Robert N. Colwell, editor. American Society for Photogrammetry and Remote Sensing, Falls Church, Va., 1983.

Jensen, John R. *Remote Sensing of the Environment: An Earth Resource Perspective*, Second Edition. Prentice-Hall Inc., Upper Saddle River, N.J., 2000.

1962

The U.S. Department of Defense developed the nine-lens camera to test multispectral remote sensing.