The Art and Science of Photoreconnaissance

In the 1950s and 1960s, photointerpreters devised ways of extracting valuable information from recondite images. Oftentimes, their work profoundly affected international relations

by Dino A. Brugioni

Every morning for the past 35 years, a Central Intelligence Agency officer has appeared at the White House with a printed intelligence digest and a fistful of images. These aerial and satellite photographs, perhaps half a dozen chosen from the thousands shot the previous day, show current hot spots, with attached explanatory notes. Similar packets are delivered to the secretaries of state and defense, selected members of Congress and other key officials. Over the decades, these images have had a powerful influence on U.S. policy.

Reconnaissance photographs have aided every presidential administration since that of Dwight D. Eisenhower in watching over troops stationed abroad, monitoring disarmament agreements, assessing hostile military forces and planning counterweapons programs. During its early years—the late 1950s and early 1960s—modern photoreconnaissance repeatedly provided timely intelligence, sometimes even helping to bring the superpowers back from the brink of conflict. More often than not, these images prevented dangerous surprises and showed arsenals to be less imposing, and intentions less sinister, than had been thought.

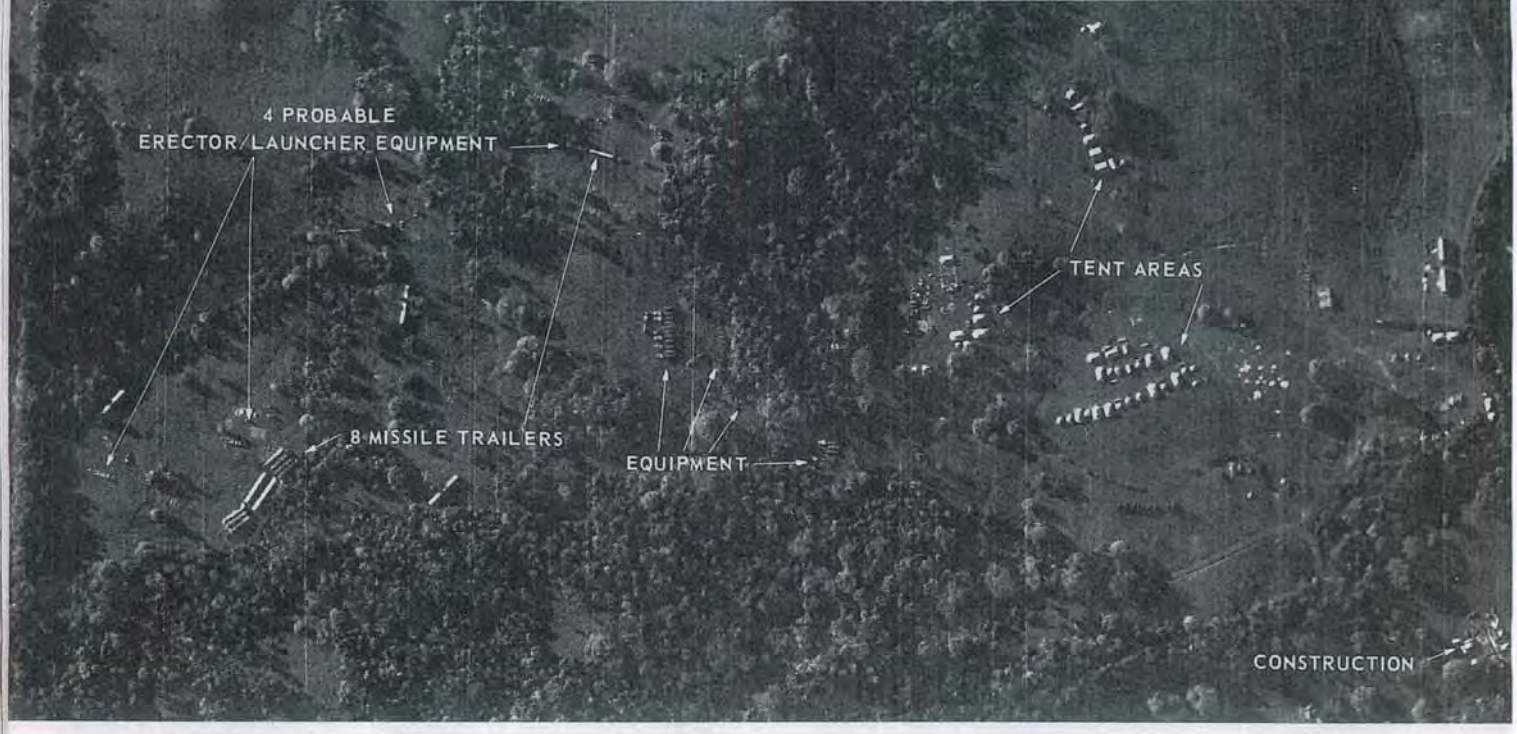
Those of us who handled these photographs every day saw an ever changing and fascinating pageant. Now almost a million of the images from a formative period in photoreconnaissance are being made public. In conformance with an executive order signed on February 23, 1995, the U.S. government is to release more than 800,000 satellite photographs collected by the CIA during the first 12 years of satellite photoreconnaissance, from 1960 to 1972. So far thousands have been released, with the remainder to be made available by August.

The period covered was a pivotal one, during which the Soviet Union built its first intercontinental ballistic-missile launch sites, the Vietnam War was fought, the number of nations with nuclear weapons expanded from four to at least six, and the U.S. and the U.S.S.R. conducted the Strategic Arms Limitation Talks (SALT). The era began with the construction of plutonium-reprocessing facilities in Israel and continued with the Cuban missile crisis, the detonation of the first Chinese atomic weapon, the space race and the Six-Day War in the Middle East. All these events took place in full view of the U.S.'s eyes in the sky. The photographs they took revolutionized the country's understanding not only of the Soviet Union and China but, arguably, of the entire world.

Continued on page 82

NOVEMBER 10, 1962
LA COLOMA, CUBA

From above, Soviet SA-2 surface-to-air missile sites each resemble a six-point Star of David. In the center is the guidance-and-control radar station; surrounding it are six missiles on launchers (each near a star point). First deployed in the late 1950s and still in use today, SA-2 batteries were designed to shoot down attack or reconnaissance aircraft, so detection of these signatures in images of Cuba made shortly before the missile crisis helped to tip off U.S. photointerpreters that something worth shielding was being installed. The objects being protected by these batteries turned out to be medium- and intermediate-range ballistic-missile sites.



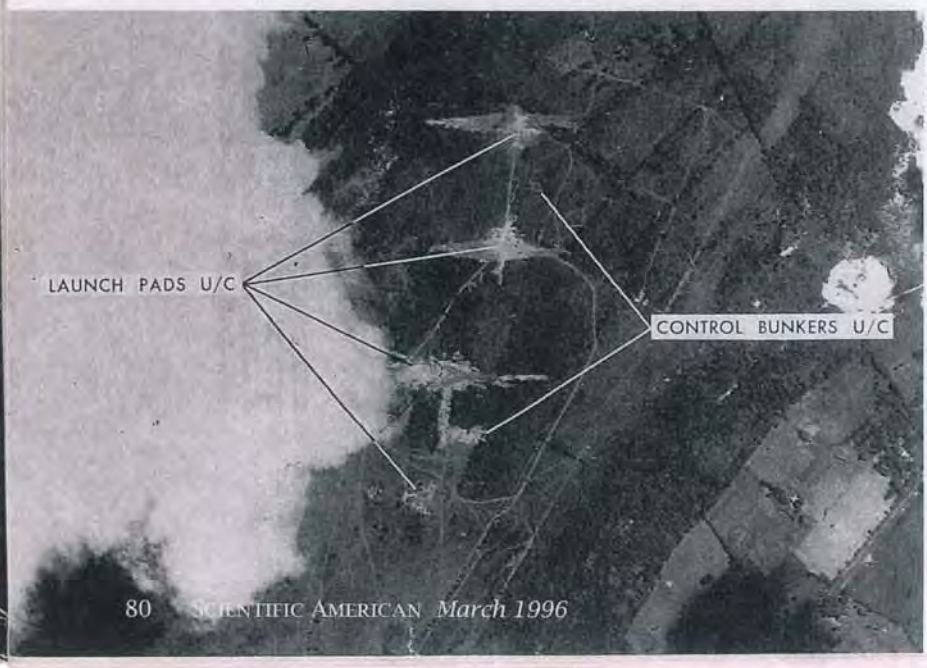
OCTOBER 14, 1962
SAN CRISTÓBAL, CUBA

On the morning of October 16, 1962, a 48-year-old career intelligence officer named Arthur C. Lundahl stood nervously before a lectern in the cabinet room of the White House, presenting this photograph to President John F. Kennedy and his key advisers. Lundahl, then the U.S.'s top photointerpreter, was explaining why this image, taken two days earlier, suggested that Soviet medium-range ballistic missiles had been deployed on the island of Cuba. With a range of 1,800 kilometers, the missiles could reach Washington, D.C., and many other U.S. locales to the south. Snapped by a U-2 spy plane at an altitude of 21,300 meters, the picture shows a cluster of seven missiles, a few launchers and "missile-ready tents," which were used to prepare the missile and warhead for launch.

Carefully spacing his words and looking Lundahl in the eye, Kennedy asked, "Are you sure?"

"Mr. President," Lundahl replied, "I am as sure of this as a photointerpreter can be sure of anything. And I think, sir, you might agree that we have not misled you on anything we have reported to you. Yes, I am convinced they are missiles."

Kennedy ordered enough U-2 flights to permit complete coverage of the island. They revealed that in addition to the medium-range missiles, launchpads for intermediate-range missiles—with twice the range—were under construction. These IRBMs could reach targets anywhere in the continental U.S., except for the Pacific Northwest. During his showdown with the Soviets, Kennedy knew, thanks to photoreconnaissance, that the U.S. had at least seven times as many strategic assets—long-range bombers, ICBMs and missile-launching submarines—as did the Soviets.



U.S. AIR FORCE

OCTOBER 15, 1962
GUANAJAY, CUBA

During the Cuban missile crisis, photointerpreters relied heavily on the distinct appearance, or "signature," of missile launch sites in the Soviet Union. The unique slash marks indicative of an SS-5 intermediate-range missile site in an early stage of construction had been seen many times in the Soviet Union, so interpreters knew exactly what they were. As soon as they were identified in Cuba, Kennedy was informed that the medium-range missiles already in Cuba would soon be joined by the much longer range intermediate missiles. The president's quick response—a blockade of the island—kept Soviet ships from delivering the SS-5 missiles to Cuba.

NOVEMBER 20, 1962
HOLGUÍN MILITARY CAMP, CUBA

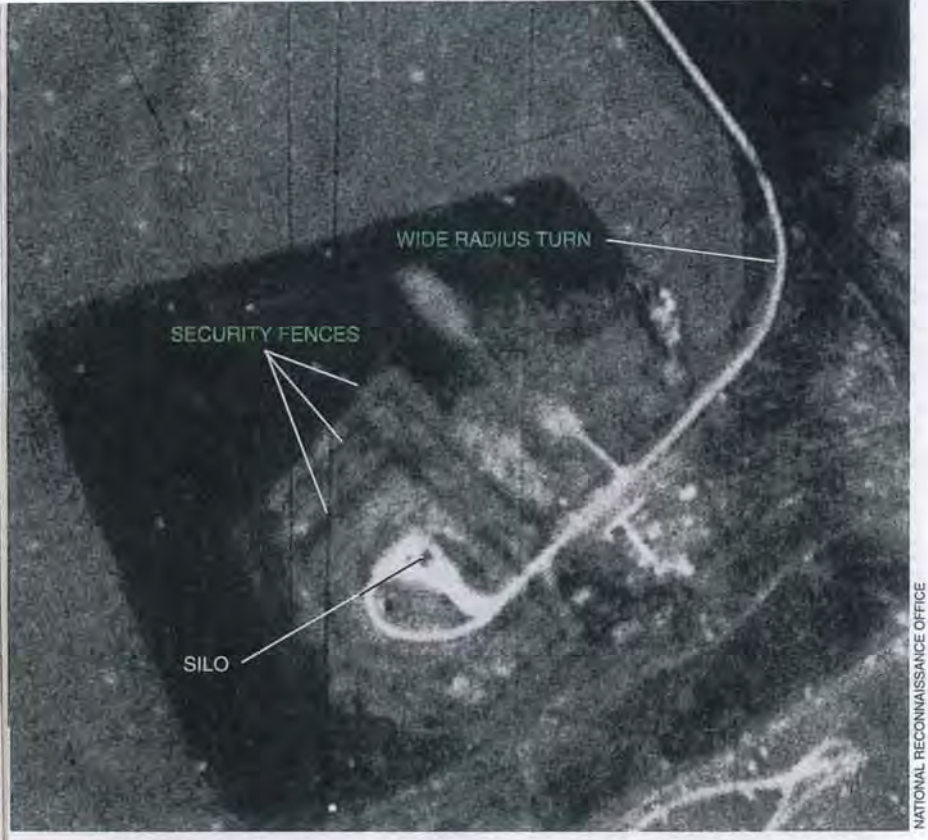
Image analysts developed some unique disciplines, including "tentology," the numerical assessment of a military force by counting the tents that are sheltering it. The number and types of tents at four Soviet compounds in Cuba during the missile crisis indicated that each compound had a force of about 1,500 troops. The precise positioning of the tents and the orderly arrangement of the latest military equipment led interpreters to conclude that these were elite Soviet troops rather than Cuban forces.

U.S. AIR FORCE

AUGUST 18, 1962
ATLANTIC OCEAN OFF CUBA

"Crateology" is the scrutiny of the shape, protrusions and shipping hooks of the crates within which military equipment is shipped. The crates protect the equipment from the weather, salt spray on board ships—and prying eyes. But crates still may be photographed being loaded or unloaded by eyes in the sky (or spies in the port). Even if they are not, careful analysis and photogrammetry, along with the crates' point of origin, often allow the contents of crates to be identified. In 1962 photointerpreters were able to identify crates containing Komar guided-missile patrol boats (shown here in a photograph taken by a low-flying U.S. Navy aircraft). MiG-21 jet fighters, Il-28 Beagle bombers and Il-14 Crate transport aircraft being sent by ship to Cuba were also recognized.

U.S. AIR FORCE



NATIONAL RECONNAISSANCE OFFICE

SEPTEMBER 8, 1967
IMENI GASTELLO ICBM COMPLEX, U.S.S.R.

U.S. photointerpreters were fortunate that the lack of roads in the vast U.S.S.R. forced the Soviets to rely on their rail network for the establishment of ICBM complexes. This reliance on rail required a few additional steps during the construction of the missile sites, which proved of great use to U.S. analysts in ascertaining that an ICBM complex was, in fact, being built. First-class roads, which were wider than ordinary roads and had wide-radius turns to accommodate the long missile transporters, were built to move the missiles to the silos. In this image the silo appears as a dark spot against the light-colored, triangular expanse of concrete, at the end of an access road. Three high-security fences surround the silo, offering more evidence of the site's importance.

Continued from page 78

Arthur C. Lundahl, the first director of the National Photographic Interpretation Center, once estimated that the intelligence community skimmed only about 15 percent of the information contained in these films. The released imagery will open new vistas (literally and figuratively) on the political history of the mid-20th century as well as on subjects ranging from archaeology to zoology.

All the released images, and those yet to be released, were made under a CIA program code-named Corona, the U.S.'s pioneering project in satellite reconnaissance. (The air force carried out a smaller, competing program, called Samos, between 1958 and 1963.) The Corona and Samos satellites were the most revolutionary of the several platforms that formed the foundation of modern reconnaissance in the U.S. The others were the aerial photographic balloons (under a short-lived program known as Genetrix) and the fast, high-flying U-2 and SR-71 airplanes.

President Eisenhower, who championed photoreconnaissance, was briefed on the results of every U-2 and satellite mission. At a time when the surprise attack on Pearl Harbor still resonated, Eisenhower saw the technology as a means of preventing another such traumatic experience in the future. He also seized on it as a way of improving the assessments of the strategic capabilities of the Soviet Union and China.

Indeed, toward the end of his administration, Eisenhower identified photoreconnaissance as one of the few recourses against an unbridled U.S. military-industrial complex that inflated Soviet capabilities to suit its own ends. Although the U.S. spent many billions of dollars over the years on photoreconnaissance, the information that was gathered more than repaid the outlay by saving untold billions in defense dollars. Besides revealing an adversary's true strength, photoreconnaissance allowed more efficient planning of counterweapons programs.

Corona officially began in January 1958. The 13th—and first successful—satellite was launched on August 18, 1960. In all, 94 satellites were successfully orbited as part of the Corona program. The orbiters themselves went through several generations, identified in the most enduring set of code names as Keyhole (KH) 1, 2, 3 and 4. They were followed by seven KH-5 satellites under the Lanyard program and one KH-6 under Argon.

When all went well, the satellites were launched into elliptical orbits ranging from about 100 to 500 miles above the earth. They would take thousands of photographs during 16 or more orbits, each about an hour and a half long. (After 1962, dual cameras were used to make stereoscopic images.) At the right moment, a retrorocket would fire the film capsule back toward the earth. Drifting down under a parachute, the capsule and its precious cargo were snatched out of the sky by an air force plane.

Telltale Signatures

The acquisition of a satellite photograph—as daunting a process as it may be—is only the beginning. Photointerpreters must then detect, identify, describe and assess the objects and patterns in a photograph. The process is painstaking, sometimes tedious and often intuitive. Photointerpreters analyze an image by identifying "signatures," which are recognizable features or patterns of special interest. For example, an interpreter can always spot a military armored unit by its associated series of bowling-alley-like lanes, which are actually tank firing ranges.

These signatures are carefully catalogued in books of photointerpretation keys. Each book covers a particular subject and country, such as the missiles deployed by China. Interpreters use the books, which are updated often, both at headquarters and in the field.

As might be expected, photointerpretation had its baptism by fire during World War II. Allied photointerpreters devised a system based on three distinct phases of information dissemination. During the first, or "flash," phase, information deemed vital in combat was rushed to commanders in the field. Second-phase reporting involved closer study of the photographs, leading to a

NATIONAL RECONNAISSANCE OFFICE

written report. The third phase was similar, but the analysis was even more detailed. With few exceptions, the system continues to this day. Since 1961 the activity has been consolidated at the National Photographic Interpretation Center, which performs the task for the entire U.S. intelligence community.

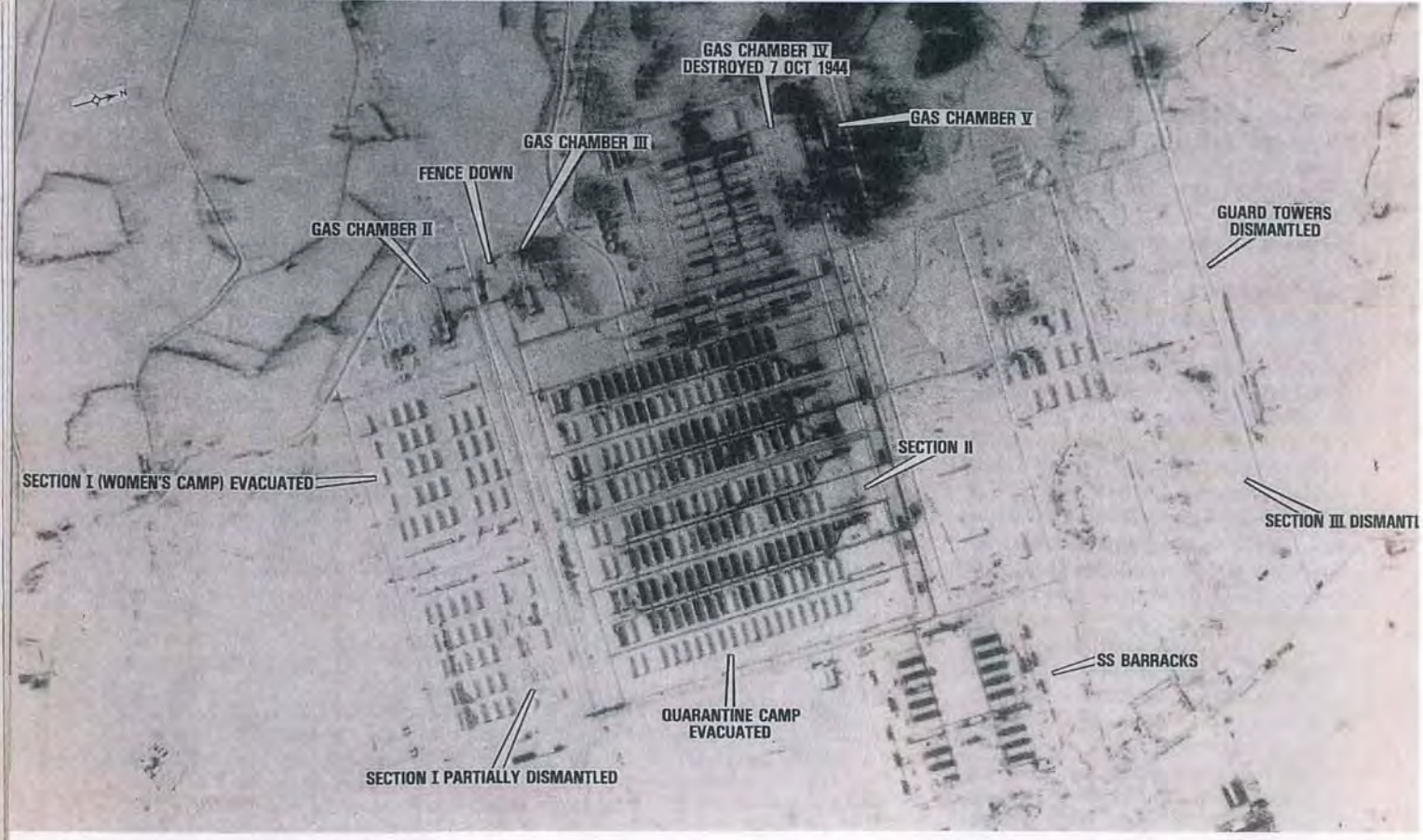
Digital-image storage and manipulation have, of course, transformed photointerpretation. These technologies enable more compact storage of photographs, faster and more controllable access to imagery, and image processing to bring out features of interest. And they allow photointerpreters to call up, for comparison, a variety of past images showing the same or similar sites, perhaps configured for different purposes. Photogrammetrists can determine the dimensions of any object or site in the picture by entering satellite and camera data (such as the altitude and attitude of the satellite and the focal length of its lens) into a computer-based device called a comparator.

Other important resources of the photointerpreter are human nature and, sometimes, the climate and weather. People in general, and military personnel in particular, live according to hab-

OCTOBER 20, 1964
LOP NUR, CHINA

As more nations began building missiles and weapons of mass destruction, deserts and other remote areas became proving grounds. Analysts always searched photographs of such regions carefully, and occasional discoveries allowed them to forecast momentous events. In December 1961, photographs of the Lop Nur area in the Taklimakan Desert in western China revealed a unique circular road, 4,000 meters in diameter. The road's location and dimensions made it a likely part of a planned nuclear test site; the area encompassed by the road was large enough to enclose an aboveground nuclear test while leaving the road intact. An airfield, barracks and support facilities were subsequently constructed. Still later, a 100-meter tower was erected, and when communications and instrumentation lines were being dug from the tower to electronic vans and bunkers, a test was only weeks away.

Lundahl communicated these developments to the director of the Central Intelligence Agency, John McCone. To keep the Chinese government from reaping a propaganda bonanza from the test, Lundahl noted, President Lyndon B. Johnson might wish to make an announcement about the impending detonation. Johnson deferred to Secretary of State Dean Rusk, who, on September 29, 1964, announced to the press that "for some time it has been known that the Communist Chinese were approaching the point where they might be able to detonate a first nuclear device." Analysis of October 8 photography showed all preparations for the test were complete, with workers and equipment withdrawn from the test area. There was hardly an international ripple when the Chinese did test a 28-kiloton atomic device on October 16. Images made four days later with KH-4 satellites showed the effects of an atmospheric test where the tower once stood.



JANUARY 14, 1945
AUSCHWITZ-BIRKENAU DEATH CAMP, POLAND

Allied reconnaissance in support of the bombing missions against the IG Farben synthetic rubber and fuel plant in 1944 and 1945 sometimes inadvertently produced images of the nearby Auschwitz-Birkenau death camp. The photographs were not analyzed until 1978, when the author and Robert G. Poirier discovered them in U.S. Defense Department archives. This image, taken as Russian troops approached on January 14, 1945, shows the snow that Elie Wiesel, who was in the complex at the time, wrote of in *Night*. The photograph indicates that the gas chambers have been or are being destroyed and that the evacuation of the complex had begun.

Heavy snow cover on the roofs in the women's camp reveals that it has been evacuated. (Most of the women, including Anne Frank, were sent to Belsen; most of the men were later sent to Buchenwald and other camps.) When this picture was taken, the men's camp and the SS barracks were still largely occupied, as indicated by the fact that the heat in the buildings has melted the snow on their roofs. Each barracks in the men's camp housed about 1,000 inmates, so when this photograph was made about 80,000 inmates were still incarcerated (the camp usually held 250,000). After the able-bodied were evacuated, 8,000 sick or emaciated prisoners were left behind and were liberated by Russian troops on January 27.

its, rules and customs. Want to know which are the most important buildings in a military compound? Wait for a snowfall. It has been my experience that the roads to the headquarter buildings are always cleared of snow first, along with the pathways to the latrines. The buildings that are occupied are the ones that are heated—and on whose roofs, therefore, the snow has melted.

Essentially everywhere in the world, Sunday is a day when most people relax, so Sunday mornings (and holidays) are the best time to inventory an opponent's military equipment, when it is in garrison, parked or stowed. Capabilities of ground-force units are best ascertained during training exercises, which are usually held in the spring and summer, when the ground is firm and the troops are unrestricted by heavy clothing or bad weather.

The images in this article illustrate only a minute sampling of the events captured by photoreconnaissance. Among the hundreds of developments detailed were the results of the first major nuclear accident, in 1957 at Kyshtym in the Soviet Union; the 1962 Sino-Indian border war; the effects of the Israeli air strikes on Egyptian, Jordanian and Syrian air forces during the Six-Day War; the Vietnam conflict; the India-Pakistan clashes of 1965 and 1971; the Soviet invasion of Czechoslovakia; and the buildup of military forces in the

AUGUST 29, 1962
AND AUGUST 1–10, 1994
ARAL SEA, KAZAKHSTAN
AND UZBEKISTAN

The Aral Sea, whose sources have been dammed and siphoned for irrigation, has shrunk alarmingly over the past 32 years, as shown in these two satellite images. (The recent image (*right*) was pieced together from several photographs made over a week and a half.)

NATIONAL RECONNAISSANCE OFFICE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF DEFENSE

1970s along the Sino-Soviet borders. The Corona program has also provided wide-area coverage of remote and seldom seen regions of the world—including Novaya Zemlya, where the Soviets tested their nuclear weapons; Tibet, which China usurped in 1950; and the Kalahari Desert.

Ravages Revealed

From our unique vantage point, my co-workers and I came to appreciate the exceptional fragility of our globe. Over and over again, we saw sparsely vegetated areas scoured for firewood, the cutting or burning of vast tracts of equatorial forest, the effects of industrial or natural disasters, and the pollution of the skies, streams and rivers. We watched, winter after winter, as pollution blackened the snow around Magnitogorsk, a Russian steel-producing center, to a distance of 150 kilometers. What we saw would have given pause to anyone suffering from the delusion that the earth can benignly absorb whatever ravages humankind serves up.

The release of hundreds of thousands of Corona images presents a rare opportunity to better understand this fascinating, ceaselessly changing blue planet and its inhabitants. I have, for example, tracked the steady northward expansion of the Sahara in images made periodically during the late 1960s. In the same images, I could see where the Romans had put their forts and compare their positions with those of the French Foreign Legion. One December morning in the late 1960s, I selected a series of pictures from one pass of a KH-4 over Nazareth and Bethlehem. Scrutinizing them in a stereoscopic viewer, I followed the Holy Family's biblical journey over each hill and down each valley. I have analyzed the terrain where the Charge of the Light Brigade took place, and I have followed Marco Polo on his travels (to my amazement, many of his descriptions still held).

As Lundahl noted 25 years ago, we have only glanced at many of these images. For future researchers, navigating this uncharted sea of data will prove engrossing. It was, often enough, thrilling the first time around.

The Author

DINO A. BRUGIONI received B.A. and M.A. degrees in foreign affairs from George Washington University. He flew in 66 bombing missions with the U.S. Army Air Corps during World War II. In 1948 he joined the fledgling Central Intelligence Agency and was one of the founders of the National Photographic Interpretation Center, the interagency organization responsible for U.S. imagery analysis. He is the author of *Eyeball to Eyeball: The Inside Story of the Cuban Missile Crisis* and has written extensively on the application of aerial and spatial imagery to intelligence and environmental problems.

Further Reading

THE HOLOCAUST REVISITED: A RETROSPECTIVE ANALYSIS OF THE AUSCHWITZ-BIRKENAU EXTERMINATION COMPLEX. Dino A. Brugioni and Robert G. Poirier. Central Intelligence Agency (ST-79-10001), 1979.

DEEP BLACK: SPACE ESPIONAGE AND NATIONAL SECURITY. William E. Burrows. Random House, 1986.

DRAGON LADY: THE HISTORY OF THE U-2 SPYPLANE. Chris Pocock. Airlife Publishing/Motorbooks International, 1989.

LOCKHEED'S SKUNK WORKS: THE FIRST FIFTY YEARS. Jay Miller. Midland Publishing, Leicester, 1993.

CORONA: AMERICA'S FIRST SATELLITE PROGRAM. Edited by Kevin C. Ruffner. Central Intelligence Agency History Staff and the Center for the Study of Intelligence, 1995.

CORONA: SUCCESS FOR SPACE RECONNAISSANCE, A LOOK INTO THE COLD WAR, AND A REVOLUTION FOR INTELLIGENCE. Robert A. McDonald in *Photogrammetric Engineering and Remote Sensing*, Vol. 61, No. 6, pages 689–720; June 1995.