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U.S. DEPARTMENT OF ENERGY
AERIAL MEASURING SYSTEMS

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The Aerial Measuring Systems (AMS) is an aerial surveillance system. This system consists of remote sensing equipment to include radiation detectors; multispectral, thermal, radar, and laser scanners; precision cameras; and electronic imaging and still video systems. This equipment, in varying combinations, is mounted in an airplane or helicopter and flown at different heights in specific patterns to gather various types of data. This system is a key element in the U.S. Department of Energy's (DOE) national emergency response assets.

The mission of the AMS program is twofold — first, to respond to emergencies involving radioactive materials by conducting aerial surveys to rapidly track and map the contamination that may exist over a large ground area and second, to conduct routinely scheduled, aerial surveys for environmental monitoring and compliance purposes through the use of credible science and technology. The AMS program evolved from an early program, begun by a predecessor to the DOE — the Atomic Energy Commission— to map the radiation that may have existed within and around the terrestrial environments of DOE facilities, which produced, used, or stored radioactive materials.

The mission of the AMS program is carried out by the DOE's Remote Sensing Laboratory (RSL), located in Las Vegas, Nevada, which is operated and maintained by Bechtel Nevada under contract to the DOE Nevada Operations Office (DOE/NV). Even though aerial surveying techniques were initially developed by the RSL to respond to radiological emergencies related to the DOE's nuclear weapons program, this capability has been expanded to include numerous routine environ-mental activities. The AMS technology has been used to study vegetation growth patterns, characterize environmental conditions for clean-up and remediation programs, plan sites and facilities, produce maps from aerial photographs, measure pollutants in the air, determine water circulation patterns in ponds, determine the amount of heat loss from a facility, and monitor the activities of nocturnal wildlife.

The information that is collected from aerial surveys is analyzed, compiled, and archived in the form of reports, computer-generated GIS (geographic information system) maps and overlays, videotapes, photographs, and still video recordings. These information products serve as vital resources used in the short- and long-term planning for environmental studies and restoration programs, site activities, emergency re-sponse activities, and security applications.

AMS operations are supported from two facilities: the RSL located at the Nellis Air Force Base in Las Vegas, Nevada, and the Washington Aerial Measurements Operations (WAMO) located at the Andrews Air Force Base near Washington, D.C. These two resource complexes are supported with highly trained professionals and technicians to include multi-disciplinary scientists, radiation physicists, engineers, communications specialists, FAA-certified pilots and mechanics, photo-

graphic and video technicians, and computer analysts.

Radiation Sciences —The purpose of an aerial radiological survey is to map the distribution and concentration of gamma radiation within a particular area or space. Aerial radiological survey methodology has been developed by the RSL over the past 30 years with more than 464 surveys completed at more than 300 sites. These surveys have been conducted over DOE facilities, commercial nuclear power plants, areas containing uranium mine tailings, former nuclear weapons test sites, remedial-action sites, industrial areas where radioactive materials were processed, several nuclear accident sites, the Kennedy Space Center, and a former USSR nuclear submarine training center. Most often, these surveys have been conducted in support of environmental monitoring activities.

The specially equipped aircraft are flown in a pattern of uniformly spaced flight lines at a constant altitude above the ground. A sophisticated system collects data once every second with a large array of sodium iodide, thallium-activated detectors and stores the data on magnetic tape cartridges. The data are then analyzed on field-portable computer systems to identify the iso-tope(s) or type(s) of radioactive material(s). These data are also used to produce "contour" maps that depict the radiation exposure rate and concentration of the particular type or types of radioactive materials that are present. For smaller areas that require higher-spatial resolution, the detection system can be mounted in a four-wheel-drive vehicle and driven over the terrain.

The RSL and WAMO facilities also operate aircraft that are equipped to collect gas and particulate samples and to track and map a radioactive air mass. This system consists of a broad ensemble of sophisticated instrumentation with an emphasis on in-flight analysis to provide the full gamut of air monitoring needs for both emergency responses and environmental monitoring. The Beechcraft King Air B-200 aircraft are equipped as cloud trackers — emphasizing tracking and sampling. These aircraft are instrumented to respond to missions involving the release of radioactive materials.

The AMS program also includes a type of ground-based, radiological surveying capability called "*in situ* gamma spectroscopy," which is essentially the reverse of traditional approaches to soil sampling and analysis. This system consists of a high-purity germanium detector, portable multichannel analyzer, and laptop computer. Rather than return a small sample to a laboratory for analysis, the "gamma spectrometer" is placed in the environment where the measurement is needed. Advantages include on-the-spot analysis, unam-biguous identification of radioactive materials, high sensitivity, reliable data, and fully portable field instrumentation

The *in situ* technology supports environmental monitoring in areas such as mapping of low-level radioactivity, verification of environmental compliance, waste cleanup, and nondestructive assay of potentially hazardous materials. This technology also supports emergency response activities for tracking contamination, determining exposure rates, calibrating survey instruments, and conducting noninvasive bioassay.

Spectral Image Acquisition —The AMS program includes a group that supports RSL programs, missions, and activities through the acquisition of data using various types of highly sophisticated and advanced technology and instrumentation. This group uses multi-spectral scanner systems, which are passive, electro-optical sensors designed to collect and digitally record reflected and emitted electromagnetic energy. These scanners partition the incoming radiation into 11 distinct spectral bands ranging from the ultraviolet through the visible and from the reflective infrared to the thermal infrared.

The spectral bands used by these systems have been carefully selected for their significance in using the principals and techniques of physics to explain biological phenomena (biophysics). Multispectral imagery has proven useful for a wide range of environ-mental applications such as monitoring changes in vegetation growth at several DOE facilities— those associated with hot water discharge and hazardous waste.

Thermal infrared imagers are being used by RSL scientists and technicians to detect temperature variations and sense very small thermal differences. These sensors are uniquely suited for nighttime aerial surveys of heat-producing targets. This technology has successfully been used to determine the amount of heat loss from a facility, examine the circulation patterns in cooling ponds, and monitor nocturnal wildlife.

The RSL also provides an extensive range of capabilities for acquiring ground data that are routinely used to document environmental conditions and to support aerial sensors. These capabilities include complete, portable weather stations used to contin-uously record meteorological data; radiosonde balloons used to profile atmospheric conditions at altitude; and several types of sensors to obtain continuous or spot readings of the

reflected and emitted radiance of targets. Photographic documentation of site and sky conditions is also used for most projects. A highly instrumented data van and trailer are used to transport equipment and to support data processing in the field.

Data Fusion & Analysis **—** Within the AMS program at the RSL is a multidisciplinary group of scientists that are trained and experienced in techniques for analyzing photographic, videographic, and digital imagery. Their expertise includes interpretative skills for conventional aerial photography and advanced digital image-processing procedures. Emphasis is placed on aircraft scanner imagery. Additionally, these scientists are highly skilled in using thermal, multispectral, radar, and laser imagery. Specialized input devices are used to integrate the different types of imagery, which are generated in photographic, video, and digital formats.

The geographic information system (GIS) technology provides a computer-based means to integrate and process spatially structured data such as maps and remote sensing imagery. As a major provider of remote sensing data, the RSL has been actively involved in the use of GIS technology since 1980. In 1985, RSL was the first organization in the DOE community to adopt the ARC/INFO system. Advanced GIS tech-nology handles both vector and raster data structures. In addition to the vector, or conventional map-oriented equipment, image-processing equipment is used at the RSL to process raster, or digital imaging data.

Through long-term studies conducted at the Savannah River Site in South Carolina, data acquired through the various AMS capabilities at the RSL (radiation contour maps, aerial photography, photo-interpreted maps, and thermal imagery) were integrated with base map and other environmental data (soils, elevations, well records, and population density). This database has been used at the Savannah River Site for environmental applications such as locating new facilities, habitat studies, environmental compliance reporting, and facility-closure planning. It has also been used for emergency response activities. Similar databases have been developed for the Elk Hills Naval Petroleum Reserve and the Nevada Test Site.

Photo/Video **—** A complete inventory of precision cameras and support equipment is utilized in the AMS program to provide extensive aerial photographic services resulting in very high-quality, high-resolution photographs and videos. Aerial photos can be taken vertically (shot directly over an area) with large-format metric cameras from fixed-wing aircraft for use in mapping ground and surface features and conditions. Very detailed oblique aerial photos (shot from varying side angles) can be taken from a helicopter.

Large- and medium-format cameras are used to photograph areas as small as 750 square feet from altitudes of 1,000 feet or areas as large as 21 square miles from altitudes of 43,000 feet. Specialized techniques and equipment including high-speed, low-illumination, and telephoto lens systems are available for selected applications. Unique configurations of cameras, components, and film emulsions can be used to concurrently acquire both wide- and narrow-angle photos.

The photo lab also operates a completely equipped film-processing and color-printing facility along with a portable, field deployable photographic capability. Highly customized and specialized photographic print-ing and processing tasks are performed. Electronic photography is widely used in emergency deployments to provide detailed color photographs — recorded and produced electronically — without the use of film. Color images can be transmitted over conventional telephone lines within minutes of taking the picture. All aerial photographs are archived, which is especially important for projects requiring historical comparisons and analyses.

The AMS program also utilizes a video production and post-production capability, complete with studio and full-service editing system, to create broadcast-quality videotapes. Video production personnel having commercial broadcast experience are available to produce fully scripted, professionally narrated videotapes, complete with special effects and graphics. Aerial video surveys are conducted over DOE sites for documentary and environmental purposes. Meetings, briefings, scientific experiments, and equipment operations are routinely documented with videography. Additionally, informational and training videotapes are produced for DOE and other government agencies. A field-deployable video system is also available for post-production editing at on-site locations during emer-gency events. The system is fully equipped and enables fast turnover of video documentation to management and the news media. Field crews can provide contin-uous, real-time

documentation of emergency response activities if needed.

Aviation—Aerial surveys are carried out using both fixed-wing and rotary-wing aircraft that are outfitted with a combination of remote sensing gear to include various detectors, scanners, and cameras depending on the type of data that is needed, the size of the survey area, the required degree of detail, and the survey costs. Currently, the AMS program utilizes nine aircraft including one Citation 550 high-altitude jet, two Beechcraft King Air B-200 twin-engine turbo props, two Bell 412 helicopters, and four identically equipped MBB BO-105 twin-turbine helicopters.

Each aircraft has its own unique capabilities, but each can also carry a combination of remote sensing gear to perform a variety of missions at altitudes up to 43,000 feet and at speeds ranging from 40 to 360 knots. This combination of aircraft provides a capability for supporting aerial surveys and emergency response missions in any type of environment and for worldwide deployment. The aircraft are maintained and operated at both the RSL and WAMO facilities.

Aircraft maintenance technicians are licensed and certified by the Federal Aviation Administration (FAA) and perform major modifications to the aircraft to meet the requirements of different missions as well as conduct major inspections and maintenance operations. Further, this group is certified by the FAA to repair aircraft radios and radar and navigational equipment.

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