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AN OVERVIEW OF THE AERIAL RADIOLOGICAL MEASURING SYSTEM (ARMS) PROGRAM

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AN OVERVIEW OF THE AERIAL RADIOLOGICAL MEASURING SYSTEM (ARMS) PROGRAM

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ABSTRACT

Since 1960 EG&G, Inc. has developed and maintained for the U S Energy Research and Development Administration (ERDA)* a state-of-the-art radiation surveillance program called the Aerial Radiological Measuring System (ARMS). Radiological surveys covering more than 300,000 square miles have been performed. In addition to the radiation detector gear, the system includes an inertial navigation system, radar altimeter, meteorological probes, air sampler, air sample analyzer, multispectral cameras, aerial mapping camera and infrared scanner. The recently improved data acquisition system, REDAR, records all inputs digitally on magnetic tape and is readily mounted in fixed-wing aircraft or helicopters. The data analysis system, REDAC, is mounted in a mobile processing laboratory which accompanies the aircraft on surveys. Radiation isopleth maps, both for gross counts and selected isotopes, can be prepared in the field. Special computer software enables the ARMS to detect changes of less than 1.0 μR/hr in exposure rates between successive surveys of a given site.

*Formerly a part of the U S Atomic Energy Commission (USAEC).

CONTENTS

1. INTRODUCTION

The U S Energy Research and Development Administration (ERDA)*, Division of Operational Safety, funds the Aerial Radiological Measuring System Program to provide state-of-the-art aerial measurement capabilities which enable the Administration to:

1. Respond to a major accident involving radiation sources anywhere in the continental United States,

2. Perform radiation and other remote sensing surveys at major ERDA facilities, e.g., Nevada Test Site, Hanford, etc., and

3. Conduct a large area terrain radiation mapping program around licensed facilities to form a basis for rapid assessment of a major radiation accident at such facilities.[1,2]

This paper will briefly describe the major new capabilities that have recently been added to the ARMS program.

Since 1960 EG&G, Inc. has conducted both a modest development and operational aerial radiation measurement program for the ERDA. In this period, over 120 large area surveys have been performed, covering an area of 300,000 square miles. Figure 1 shows the nationwide scope of ARMS survey activity.

On several occasions, the ARMS aircraft and crew have successfully located lost sources and have responded to emergency calls involving releases of radiation. In 1968-69, multispectral cameras and an infrared scanner were added to the remote sensing capability of ARMS. A design for an advanced data acquisition system, which would record all output information on magnetic tape, was completed in 1970. This system was further developed for a special program for ERDA's Division of Military Applications. Recently, the ARMS

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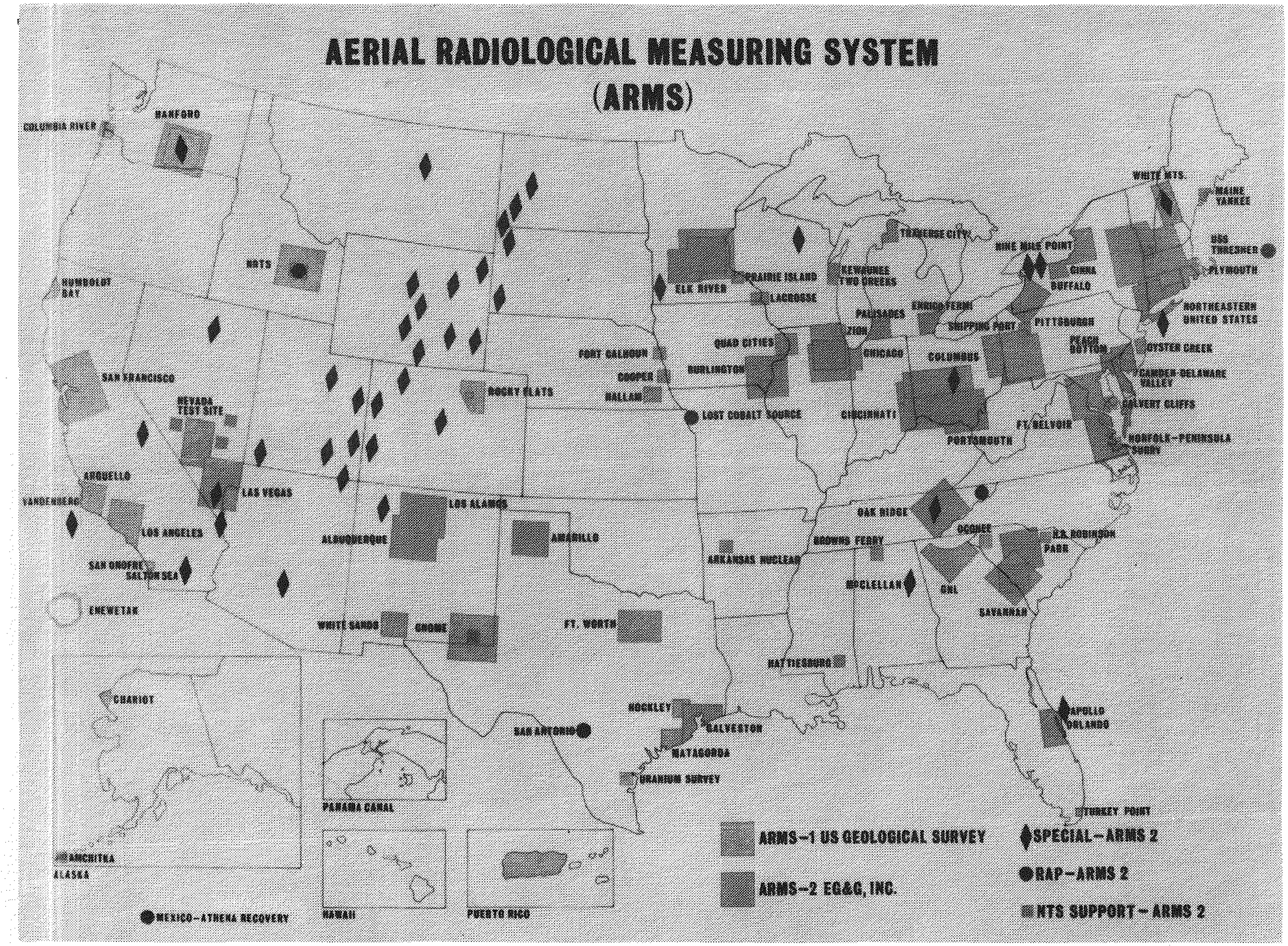

Figure 1. ARMS surveys: 1958-1973.

program has utilized this system, mounted on helicopters, to obtain extremely high resolution radiation maps of several major AEC facilities and test areas.[3] New software has been developed to compare successive years' radiation surveys of individual facilities. Radiation surveys have been used extensively in the past few years to determine the water equivalent of snowpack in watersheds.[4,5]

Finally, the ERDA/DOS has procured a new Beech Aircraft Corporation, King Air A-100 to consolidate both terrain and air sampling capabilities in a single all-weather aircraft. The King Air, shown in Figure 2, will contain state-of-the-art radiation and photo-optical systems when it becomes fully operational by 1 July 1975.

Figure 2. The Beech Aircraft Corporation King Air A-100 is used for routine, large-area surveys.

2. ARMS SYSTEM DESCRIPTION

2.1 King Air A-100 Configuration

For routine aerial surveys of large land masses, such as licensed power reactors or ERDA research facilities, the King Air is employed. It has the following flight characteristics:

1.	Maximum Altitude:	31,000 ft
2.	Minimum Survey Velocity:	120 knots
3.	Maximum Velocity:	226 knots
4.	Maximum Landing Weight:	11,210 pounds
5.	Flight Duration:	4 hours

2.2 Helicopter Configuration

For low-level or emergency radiation survey work, the helicopter is a more suitable vehicle. Various helicopters have been used, including the Marine CH-53, the Navy SH-3 and the Air Force UH-1N. In this configuration, two detector pods are used, as in Figure 3. Each detector pod contains twenty 5- x 2-in. crystals, as shown in Figure 4. The output from all crystal photomultiplier-preamp combinations is summed and fed to a recording system. Additional detector systems available include (1) an alpha spectrometer, (2) beta detectors, (3) solid state detectors, and (4) neutron counters. Figure 5 shows a Navy SH-3 equipped with both the gamma detection system (NaI pods) and a pair of BF-3 neutron detectors.

2.3 Recording System

The data acquisition and recording system common to both fixed-wing and helicopter operations is called REDAR (Radiation and Environmental Data Acquisition and Recorder), which is shown in Figure 6. REDAR provides real time displays and recording of all system sensor data.

Figure 3. The Air Force HU-1N equipped with two gamma detector pods.

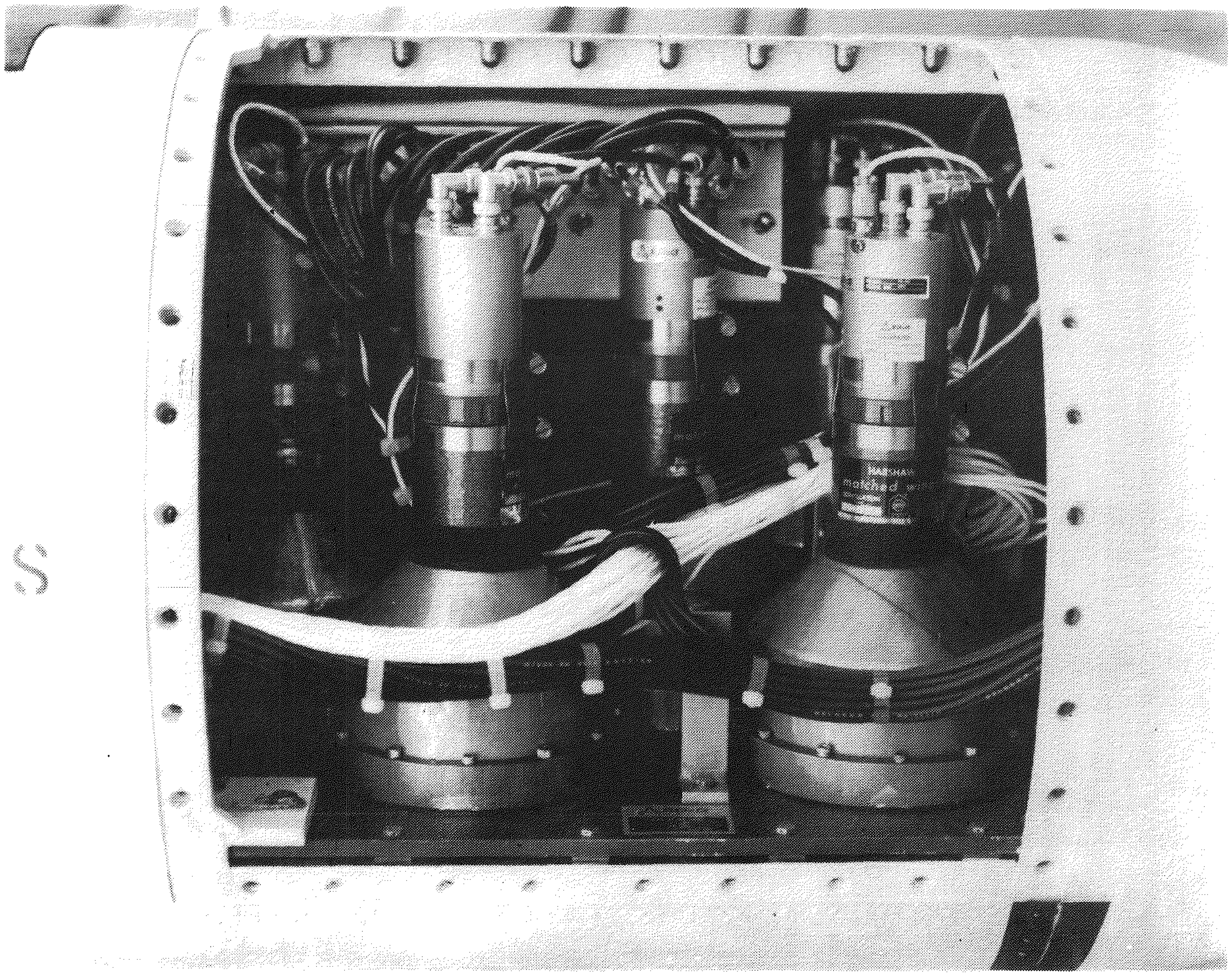

Figure 4. Interior view of a gamma pod containing twenty 5- x 5-in. NaI crystals.

Figure 5. The Navy SH-3 equipped with gamma pods (front) and neutron detector pods (rear).

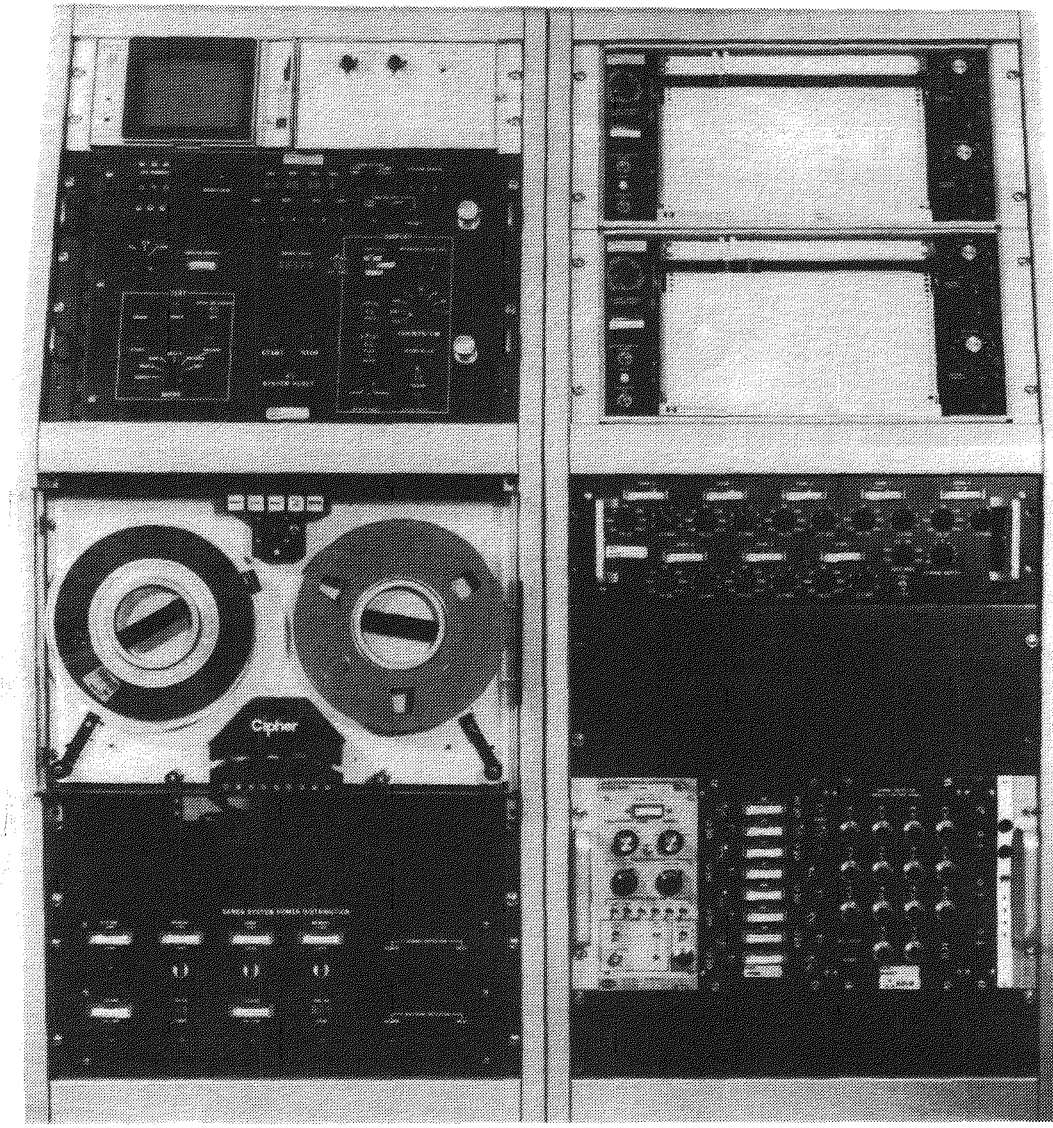

Figure 6. REDAR: Radiation and Environmental Data Acquisition and Recorder.

2.3.1 Recorded Parameters

The parameters acquired include:

	Parameter	Frequency
1.	300 channel pulse-height analyzer plus live-time	3 sec
2.	5 single channel analyzers with adjustable upper and lower discriminators	0.2 sec
3.	Gross count channel (sums all counts)	0.1 sec
4.	Inertial navigation system (latitude and longitude)	1 sec
5.	Radar altimeter	1 sec
6.	Absolute pressure	1 sec
7.	Outside air temperature	1 sec
8.	Wind speed	1 sec
9.	Wind direction	1 sec
10.	Relative humidity	1 sec
11.	True air speed	1 sec
12.	On-top marker	As required (operator push button)
13.	System configuration	
14.	Leg number	1 sec
15.	Time of day clock (HRS-MIN-SEC)	1 sec

Outputs from each detector are summed before being processed by the multichannel or single channel analyzers. Windows are set on the single channel analyzers to monitor regions of the spectrum pertinent to isotopes of interest.

2.3.2 On-board Displays

The REDAR system includes several displays which permit real-time monitoring of the data being acquired:

1. Oscilloscope for spectra
2. Two dual pen strip charts for running time history records of single channel or meteorological data.
3. LED numerical readouts of count rates or meteorological data.
4. Time-of-day clock
5. Position information

Data are permanently recorded on a nine-track digital tape recorder capable of recording continuously for five hours. All data are recorded as raw, uncalibrated information directly from the sensors. All calibration computations into appropriate engineering units are accomplished in the ground-based computer. A typical operational configuration is shown in Figure 7.

2.3.3 Inertial Navigation System

Accurate position data are obtained from a Litton Inertial Navigation System, LTN-51. The actual flight coordinates (latitude and longitude) are recorded on magnetic tape. Special software, prepared by Litton to our specifications allows these data to be recorded with a minimum detectable distance increment of 15 feet.

When these data are processed, the flight paths are overlaid on a photographic map of the survey area. The end points are matched with the known positions of the start and finish of each line. The position of the aircraft is then known at any point along the flight path with an uncertainty related to the flying time of ±1/2 second. For a typical survey conducted at an altitude of 100 feet above terrain and at a speed of 100 ft/sec, this implies that the location of the aircraft is known with a maximum uncertainty of 65 feet.

Figure 7. The REDAR (mounted here in the HU-1N) is operated by a crew of one to three technicians.

2.3.4 Meteorological Sensors

Absolute air pressure transducer, outside air temperature, wind speed, wind direction and relative humidity are also recorded to aid in data analysis.

2.4 Data Processing System

Magnetic tapes recorded during an ARMS flight are processed by a special purpose computer system called REDAC: Radiation and Environmental Data Analyzer and Computer. This unit, shown in Figure 8, is mounted in a mobile van which accompanies the survey aircraft in the field if day-to-day survey results are required.

The key components of the computer system are: a NOVA computer, two Cipher Data tape drives and two Cal-Comp plotters. The data can be reduced immediately after each flight. The software developed for the NOVA computer permits a rapid evaluation of anomalies in the terrestrial radiation signature. From the recorded information, isopleth maps are made of each predominant isotope present in a surveyed area. Further, the system calibration permits the isotopic information to be interpreted in terms of surface concentration units with a resolution of approximately 750 feet.

2.5 System Sensitivity

The sensitivity of the ARMS system is dependent on the energy of the gamma rays and the distribution in the soil of the radionuclide. The fixed-wing aircraft flying at an altitude between 300 and 500 feet and a velocity of 120-180 knots can detect point sources (energy greater than 50 keV) between 15-100 mCi, with 300 foot line spacings. For planar distributed sources, the detection limit is approximately 1.0 to 10.0 $\mu Ci/m^2$.

Figure 8. The REDAC (Radiation and Environmental Data Analyzer and Computer) mounted in a mobile van truck.

The helicopter system can detect a distributed source between 0.1 to 1.0 $\mu Ci/m^2$ and point sources of approximately 2.0 mCi or greater. The normal helicopter survey procedure is to fly at 60 knots at an altitude of 150 feet with a line spacing of 150 feet. All detection limits are for gamma-ray-emitting nuclides of energy greater than 50 keV. If the energy of the gamma rays is between 50 keV and 100 keV, the detection limit is highly dependent on the geometry of the source and its distribution in the soil.

2.6 Comparison Software

The surveillance capabilities of the ARMS system have been demonstrated at numerous commercial nuclear power stations and AEC sites. The reproducibility of the survey data is less than 1.0 $\mu R/hr$ in the exposure rate at 3 feet above terrain.[6] The computer software compares approximately 5000 data points acquired on each survey on a point-by-point basis. The computer locates data points from the two surveys that were acquired in the same area, within the field-of-view of the detector system (1500 feet). The mean and standard deviation are computed for the observed differences in terrestrial exposure rates between the two surveys. Observed differences are plotted on an overlay map for the facility to expedite subsequent field measurements with ground-based instruments.

3. SUMMARY

The ERDA, Division of Operational Safety, maintains a state-of-the-art aerial radiation measurement capability in the ARMS program. This capability is available to all elements of the ERDA for emergency use and for participation in selected survey activities. Recent additions to this capability, including the isotope mapping system and the successive survey comparison software with 1.0 μR/hr resolution, provide extremely useful tools for examining the overall gamma radiation status of major nuclear facilities.

Rapid response to an accident involving radiation sources or facilities will continue to be the primary mission of ARMS. The utility of the combined remote sensing capabilities of ARMS will be increasingly valuable to both ERDA and licensed facilities in the future.

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