CONF-9009150--3

ON-SITE METHOD FOR ACQUISITION AND ANALYSIS OF SENSOR DATA

Michael S. Emery and Michael S. Blair
Instrumentation and Controls Division

Jonathan E. Nyquist
Health and Safety Research Division

Oak Ridge National Laboratory*
Post Office Box 2008
Oak Ridge, Tennessee 37831-6005

CONF-9009150--3

DE90 011649

To be presented at

SENSORS EXPO

Chicago, Illinois
September 11-13, 1990

*Operated by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

ON-SITE METHOD FOR ACQUISITION AND ANALYSIS OF SENSOR DATA

Michael S. Emery and Michael S. Blair
Instrumentation and Controls Division

Jonathan E. Nyquist
Health and Safety Research Division

Oak Ridge National Laboratory*
Post Office Box 2008
Oak Ridge, Tennessee 37831-6005

ABSTRACT

Oak Ridge National Laboratory (ORNL) has developed an ultrasonic ranging and data system (USRADS) and interfaced the system with several types of survey instruments. The system measures the time of flight of an ultrasonic chirp between the surveyor's backpack and fixed receivers to determine location. Survey data are transmitted from the backpack to a computer via an RF data link and logged into a data file. Thus far a gamma scintillometer and a Geonics EM31 terrain conductivity meter have been interfaced to the system. An X-ray fluorescence spectrometer is in the final stages of testing, and work is presently under way to interface a photoionization trace gas analyzer. Digital output devices are connected via RS232 interface, and analog output devices are digitized by an 8-bit analog/digital converter (ADC). Future interfacing of other instruments should be relatively easy since these data structures will include most types of instrument outputs.

I. INTRODUCTION

USRADS was originally developed for the U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action Project (UMTRAP), which required ORNL to survey in 3 years ~8,000 properties where the presence of uranium mine tailings was suspected. A traditional survey consisted of one or more technicians swinging a NaI detector a few inches above the ground as they walked in a pattern designed to cover the entire property. All unusually high readings were noted and followed up with soil sample analysis. A grid pattern would have to be marked on the property so that the locations of high gamma counts could be recorded in a log. By automatically keeping track of the technician's location and logging the scintillometer data, USRADS saved both time and money.

USRADS hardware consists of a backpack, a computer, a master receiver, a set of 15 remote ultrasonic receivers, and the survey instrument of choice. The system works by measuring the time of flight of an ultrasonic chirp from the technician's backpack to at least three receivers. The computer software then uses the time-of-flight data to calculate a unique position. Readings from the survey instrument are transmitted back to the computer over an RF link and recorded in a data file along with the calculated position. This operation occurs once each second. Figure 1 is an illustration of the system.

II. THE USRADS SYSTEM

A. HARDWARE

The surveyor's backpack contains an ultrasonic transmitter, an instrument interface, a two-way RF telemetry link to the PC, and a hand-held microcomputer terminal. The ultrasonic transducer is a lead-zirconate-titanate piezoelectric crystal shaped as a hollow cylinder 3.67 cm high by 5.58 cm O.D. The crystal is driven at its natural resonance of 20 kHz, one 10-ms pulse each second. This gives uniform radiating coverage in the plane of the crystal, and it has sufficient power to be detectable up to ~300 ft, depending on local conditions. The backpack also contains the electrical interfaces for the various survey instrument interfaces.

Remote ultrasonic receivers are used to detect the ultrasonic pulses. Fifteen receivers come with the system; all fifteen or as few as three may be used in a survey depending on the size of the property. The receivers have an RF transmitter that alerts the master receiver when the remote receiver heard an ultrasonic pulse. The receivers are placed on tripods and positioned at various points throughout the property.

The master receiver contains 15 RF receivers (1 for each remote ultrasonic receiver), plus a receiver and transmitter for communication with the backpack. It is interfaced with a Compaq Portable II computer. Both of these units are powered by a small gasoline-operated generator when ac line power is not convenient.

A Victoreen gamma survey meter with a NaI detector is currently used for radiological surveys, but most any other

*Operated by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

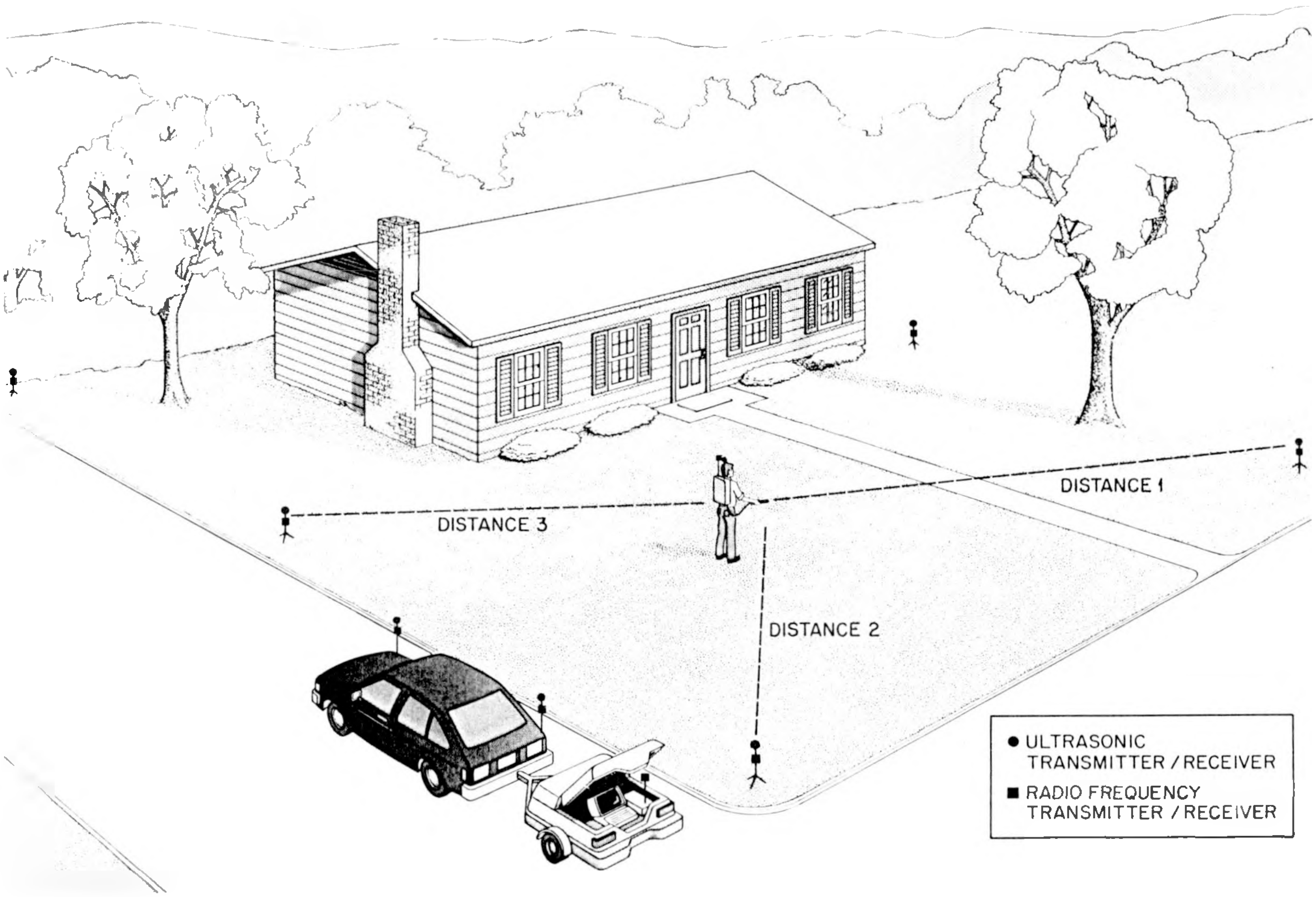


Figure 1. Illustration of the USRADS and method of locating the surveyor.

type of radiation survey instrument may be used. This instrument was used extensively in the UMTRAP work.

The Geonics EM31 terrain conductivity meter was interfaced to the USRADS system during the past year. A low-frequency oscillator is positioned in one end of an 18-ft PVC boom. Eddy currents induced in the ground and sensed by a receiver located in the opposite end of the boom generate a quadrature and in-phase signal. Both the quadrature and the in-phase analog signals are digitized and collected by the USRADS computer. The EM31/USRADS combination has been tested and used extensively in suitable areas on the Oak Ridge DOE reservation as well as federal lands in other states [1,2].

Interfacing the XMET 880 X-Ray fluorescence analyzer to USRADS is in the final stages of testing. This instrument makes a measurement at a point of interest on the property by exciting the electron shells of atoms with a small X-ray source and analyzing the characteristic X-rays emitted by the sample. It then transmits a large data packet containing spectrum and assay information, which is captured by the computer and stored for further processing.

B. SOFTWARE

Software used during a survey can generate a real-time plot on the computer screen showing the position of the remote receivers and the travel of the surveyor. Any readings above a user-determined threshold will result in a highlighted mark on the screen. These features make it very easy to see whether any portions of the property have been missed by the surveyor. If available, a digitized schematic drawing of the property can be entered into the computer prior to the survey, or a map file can be generated in the field as a text file prior to the actual survey. The survey data are then added to this information. If errors are detected in either the survey data or the position data, the computer alerts the surveyor via the hand-held terminal on the backpack. All data are written to the hard disk every 15 s. Figure 2 shows a typical display during a survey. The numbered "+" symbols mark the positions of the remote receivers. Regions marked by the dark squares designate areas where the instrument readings were above the threshold level. Each dot represents a data point at 1-s intervals.

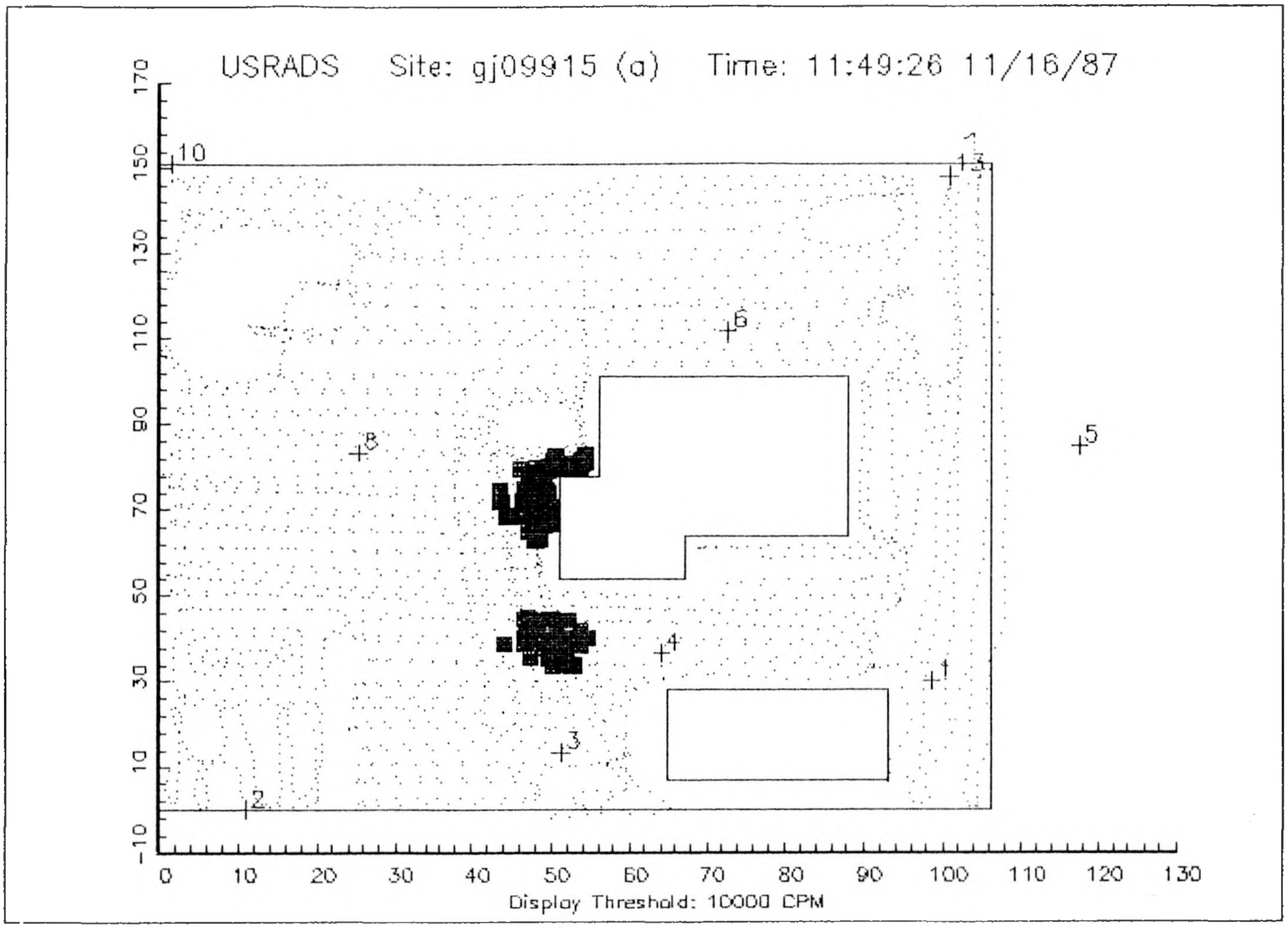


Figure 2. A typical CRT screen during a survey.

A major advantage of USRADS over conventional surveys is the ability to perform analyses in the field. Commercial PC software packages may be used, or a number of routines that are a part of USRADS may be used to ensure that sufficient data are obtained to adequately characterize the property before leaving the site. The graphics routines included in USRADS are Replay, Block Statistics, Contour, and 3-D plots of the data. Replay loads the survey data for analysis and displays the data in the order in which they were taken. Block Statistics allows the operator to select a grid block size and determine the statistical mean of the data pertaining to that block. If the mean is above the operator-specified threshold, that block is highlighted on the CRT and stored in a summary report file. Graphical representations are made in two- and three-dimensional displays. The Contour routine draws a single-level contour line outlining areas exceeding the threshold and generates a summary report file. Other commercially available software packages can also be used for analyzing the survey data.

C. SYSTEM SETUP

Setup usually takes about 30 min for a 1-acre area. The remote receivers are positioned such that the surveyor is always within range of at least three receivers at any location on the property. An ultrasonic "top hat" transmitter is placed on one of the receivers, and the time of flight to each of the other receivers is recorded by the system. The "top hat" is then moved to the next receiver and the process is repeated until a matrix of the time of flight between all receivers is complete. Only one hand-measured distance is required between one pair of receivers. This distance is used to determine the speed of sound under the current weather conditions. (The speed of sound is a function of air density, which is affected by temperature, humidity, barometric pressure, etc.) Once this process is completed, the system will display the relative positions of each receiver on the CRT and the survey can begin.

III. EXAMPLE SURVEY

A. USRADS SURVEY OF AN AIR NATIONAL GUARD BASE

USRADS was used to perform a multiblock, multisensor survey at Muniz Air National Guard Base in Puerto Rico, with the resulting track maps and data overlayed onto the original AutoCAD [3] map of the survey area. Three data files were generated for each survey block.

The data files contained information generated from an EM31 survey, a gamma scintillometer walkover, and a third data file that was used to draw or create a field map of the area.

The purpose of the survey in Puerto Rico was to identify the location of aircraft that had been buried several years ago. An approximate location was known, although there was not conclusive evidence to support it as being the true location of the burial site. The EM31 was chosen as the best instrument for identifying the exact location of the buried aircraft because the aircraft metal would appear as a change in the terrain conductivity.

The approximate location of the burial site and the complete "track map" of the survey area are shown in Figure 3. The initial survey was to be conducted within the fenced area indicated by the dashed line on the site map, but when the analysis of the original data produced no supporting evidence as to the exact location of the burial site, the survey was expanded to include the two survey blocks outside the fenced area. The data collected from the blocks outside the fenced area indicated a number of anomalies, which were interpreted as the true burial site.

To aid in interpretation of the data, USRADS was used to generate a field map of the area (Figure 4) to include any metallic object that would affect the EM31 reading. The features mapped were the metal light poles and storm drains, a car in the parking lot, and paved areas (such as roads, the running track, and a basketball court). After the field maps were linked together and exported to the AutoCAD site map, the shape and location of both the running track and basketball court could be clearly defined as the difference between the dotted and solid lines in Figure 4. The location of storm drains and light poles could also be added to the master map if desired.

The last data set was collected using a gamma scintillometer as the detector, but a complete gamma survey was not performed due to time limitations. The purpose of the survey was to illustrate the ease with which the survey instrument could be changed in the field and that multiple survey instruments could be utilized for complete characterization of a survey block. The resulting "track map" for the gamma walkover is shown in Figure 5. Data sets were collected for five of the original six survey blocks.

The Puerto Rico survey results illustrate the ease with which different survey instruments can be attached to the USRADS system and its ability to export data to other software packages such as AutoCAD or Surfer [4] to produce a complete site map or to perform analysis of the entire data set, which in many cases covers several survey blocks. The data export routines contained in the USRADS software enable the user to apply a translation and/or a rotation of the survey data, with the resulting output being a standard text file format that can be imported easily into many different commercially available software packages.

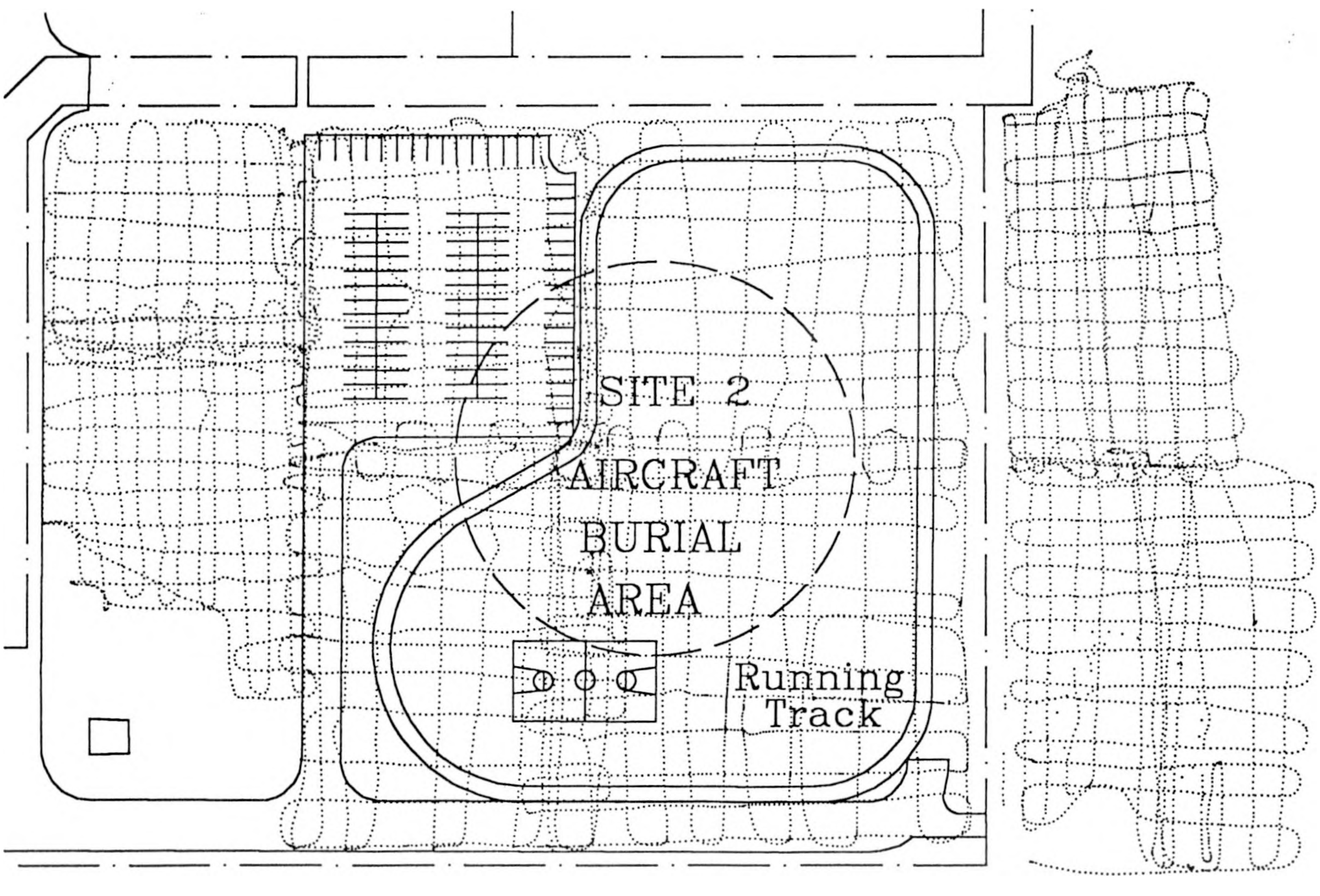
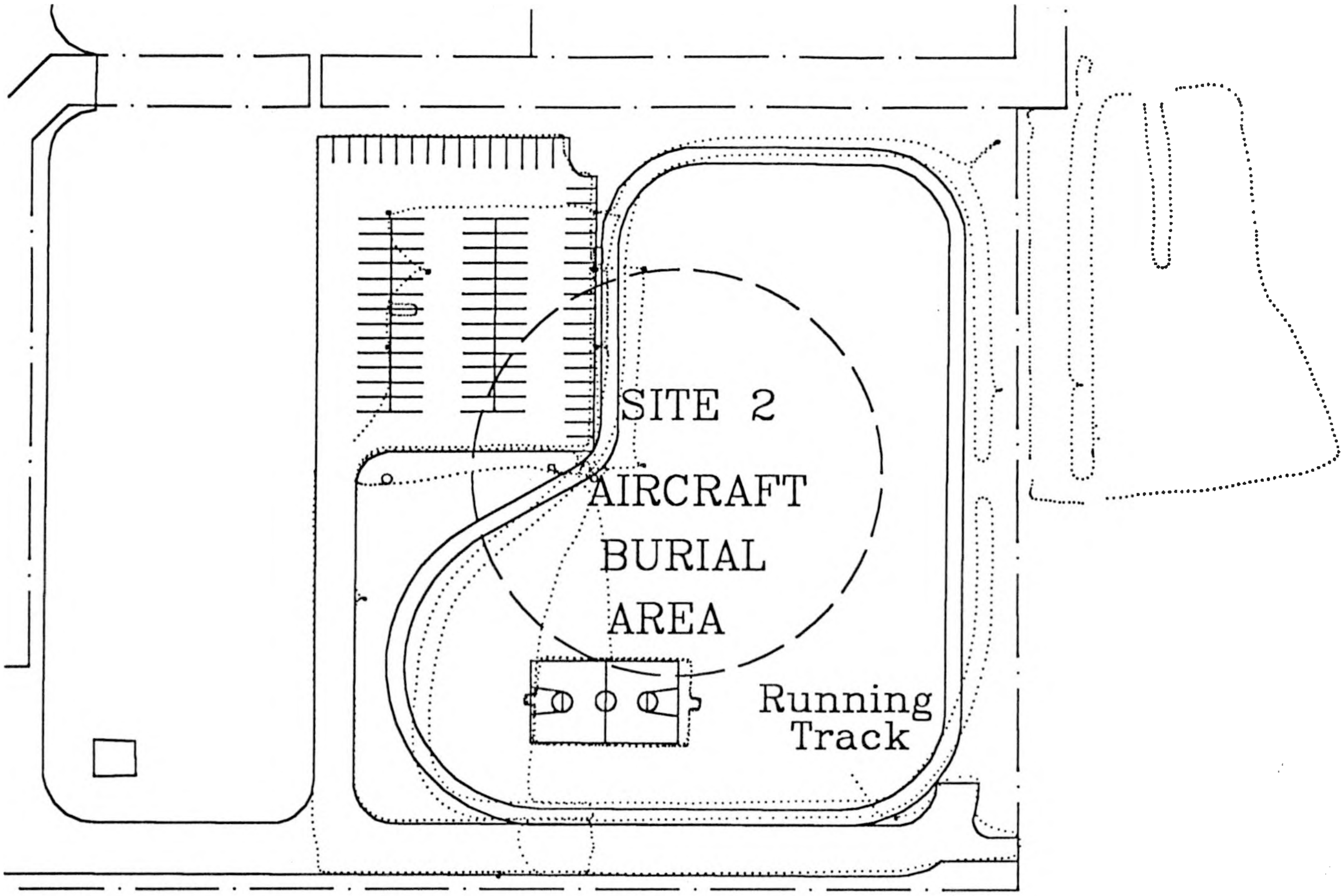


Figure 3. Survey track of Air National Guard Base.



'Figure 4. Field map indicating surface features that could affect EM31 readings.

IV. FUTURE INSTRUMENTATION EFFORTS

USRADS is potentially useful in almost all field survey applications because most measurements require both position information and data logging. As mentioned before, work is being completed (for the Environmental Protection Agency) to link USRADS with a portable X-ray fluorescence analyzer. This would allow the entire spectrum to be recorded for each measurement. Work is also beginning on interfacing a photoionization trace gas analyzer to USRADS.

Future applications being considered include linking USRADS to a portable magnetometer and/or adding a vertical position component to the surveyor's location.

V. CONCLUSION

USRADS offers some significant survey advantages. From an instrumentation viewpoint it is relatively easy to interface to new instruments. The field user has the ability to monitor data being collected and to refine or expand the survey area as the user sees fit. An interpreter of the survey data desires as much data as possible, which USRADS delivers at a rate of 3600 measurements/h. These data are stored in computer files, which may be linked with other data files containing the locations of roads, fences, underground pipelines, power lines, and other objects that could affect the interpretation of the survey data.

VI. REFERENCES

1. J. E. Nyquist and M. S. Blair, "An Automated Locating And Data Logging System For Geophysical Surveys," *Proceedings of the Fourth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring, and Geophisical Methods*, p. 99-113 (1990).

2. B. A. Berven, J. E. Nyquist, M. S. Blair, C. A. Little, and R. B. Gammage, "Automation of Geophysical Surveys Used in Assessment of Hazardous Waste," presented at Twenty-Eighth Hanford Life Sciences Symposium (1989).

3. *Surfer*, commercial software package, Golden Software, Inc., Golden, Colo.

4. *AutoCAD*, commercial software package.

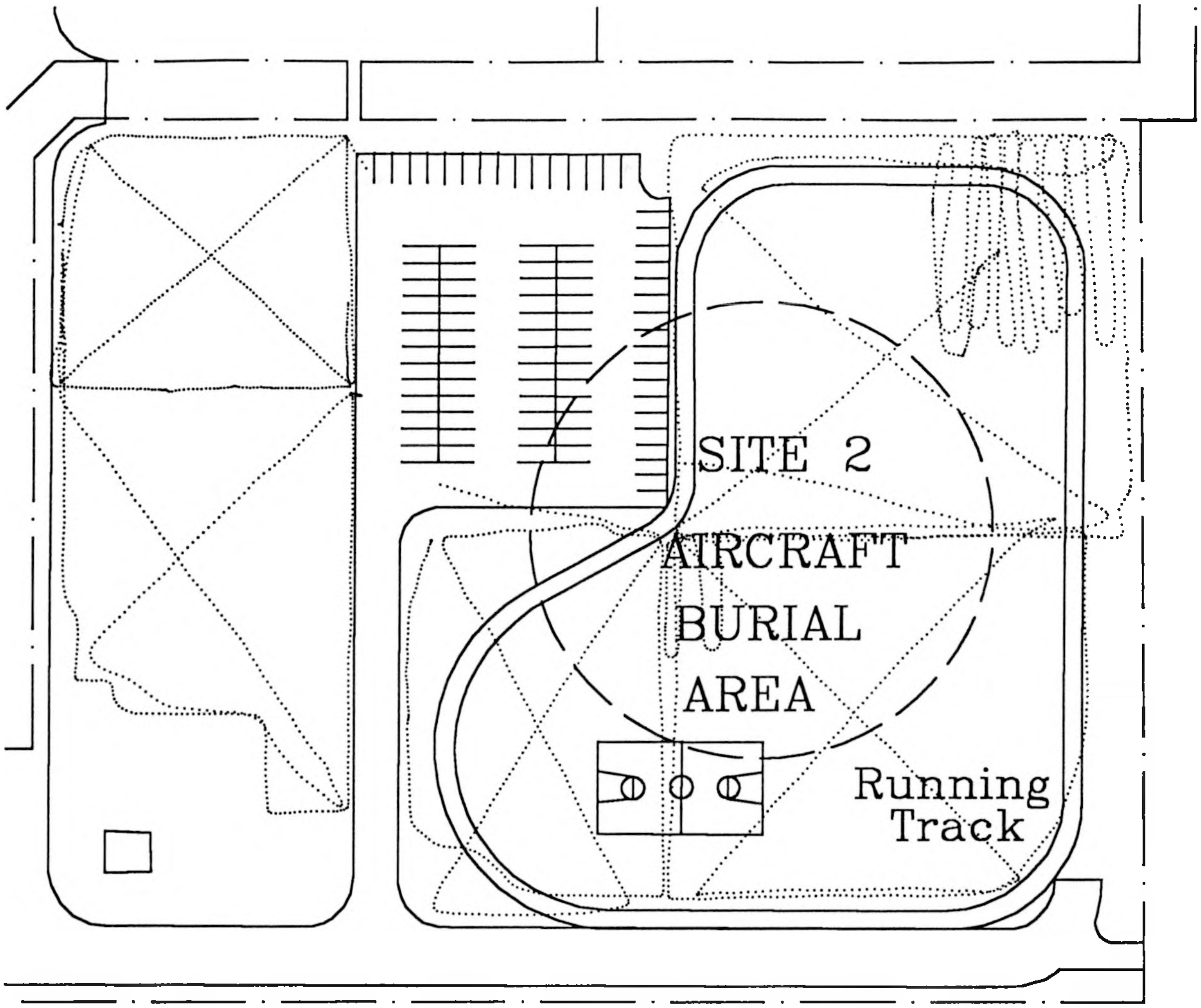


Figure 5. Gamma scintillometer walkover of Muniz Air National Guard Base site.