An Integrated, Subsurface Characterization System for Real-Time, In-Situ Field Analysis

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INTRODUCTION

This paper describes current efforts at AlliedSignal Federal Manufacturing & Technologies (FM&T) to develop and field an in-situ, data analysis platform to acquire, process, and display site survey data in near real-time. In past years, FM&T has performed a number of site survey tasks. Each of these surveys was unique in application as well as in the type of data processing and analysis that was required to extract and visualize useful site characterization information. However, common to each of these surveys were the following specific computational and operational requirements:

1. A capability to acquire, process, and visualize the site survey data in the field

2. A capability to perform all processing in a timely fashion (ideally real-time)

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3. A technique for correlating (or fusing) data streams from multiple sensors

Two more general, but no less important, requirements include system architecture modularity and positioning capability. System modularity would provide the ability for the processing of datasets from multiple sensors through the use of a common data format for all input data. Positioning capability is also a requirement to allow for the registration of the collected multiple data sets.

There are many potential applications for a workstation that meets all these requirements, providing in-situ, real-time survey data analysis. These include:

1. Survey, evaluation, and remediation of numerous Department of Defense and Department of Energy waste sites

2. Real-time detection and characterization of unexploded ordnance and landmines

3. Survey, evaluation, and remediation of industrial waste sites

4. Location of underground utility lines

5. Providing law enforcement agencies with real-time surveys of crime scenes
In order to support these subsurface characterization tasks with their real-time, in-situ requirements, we began an internally funded development effort in FY95 to build an integrated data acquisition, processing, and visualization platform that is capable of performing in-situ data processing, interpretation, and visualization in real-time.

THE INTEGRATED SUBSURFACE CHARACTERIZATION SYSTEM

The Integrated Subsurface Characterization System (ISCS) is a three-year effort (FY95-97) which is designed to provide hardware and software enhancements to the subsurface characterization programs currently being performed at AlliedSignal FM&T/Albuquerque. At the present time, our sensor suite consists of 4 different ground penetrating radars (100-MHz, 300-MHz ground contact radars, a 500-MHz air contact system, and a 1-GHz air contact system), an EM-31 conductivity meter, and a cesium vapor magnetometer.

Figure 1 shows a system concept for the ISCS project. ISCS is a field-portable, analysis workstation that serves as the focus of the data acquisition, analysis, and interpretation processes. A common data format will be used to ensure that all data streams viewed by ISCS will be correctly interpreted and placed in a format that will aid in the registration and correlation of multiple data streams.

ISCS itself consists of two main components: (1) a hardware component consisting of specially designed interface boards which are used to port and condition data from the particular sensor into the workstation and (2) a software component consisting of data
analysis and feature extraction codes which are written uniquely for each type of sensor, and data fusion and visualization codes that are written uniquely for each type of application. Data archival will also be an important task provided by ISCS.

**FY95 ACCOMPLISHMENTS**

The first year of the ISCS project was heavily oriented towards the acquisition of sensors and the collection of field data to provide a working database of subsurface data. Surveys that were performed included: (1) a survey of a classified waste landfill at Sandia National Labs; (2) two surveys in support of injected barrier experiments, one at Sandia and one at Hanford; and (3) a survey in support of a murder investigation carried out by the Drug Enforcement Agency. The surveys in (1) and (2) are the subject of two poster papers also being presented at this conference.

We subsequently used these site survey data to develop basic data registration and feature extraction routines for ISCS. We also developed a generic hardware interface that allows ISCS to acquire data directly off the commercial off-the-shelf radar units that were used for the surveys.

Figure 2 shows an example of some of the site survey data that was collected last year at Sandia’s Technical Area II. This particular waste landfill was used by Sandia for 40 years and contains a significant amount of classified buried waste from the weapons development program. Sandia now has a requirement to assess the magnitude of the
effort required to remediate this site. AlliedSignal performed a survey of this site with 100- and 300-MHz ground penetrating radar. The figure shows processed (not raw) data from the 300-MHz survey. In this figure, multiple burial sites down to 10 feet can easily be seen. The primary purpose of a survey such as this one is to provide an estimate of the amount of buried waste that will have to be dealt with during remediation:

Figure 3 shows an example of some of the data that was collected in support of a Sandia experiment on injected barriers used for waste containment. This experiment was designed to assess the viability of a subsurface grout injection technique that can be used to form subsurface barriers to contain buried waste or to mitigate waste plumes. AlliedSignal’s task was to perform post-injection characterization of the barriers to determine the extent, depth, and integrity of the barriers. This Figure shows an example of some of the GPR data collected on one of the injected barriers.

PROJECT STATUS

Currently, ISCS consists of:

- A Pentium-based analysis workstation and the capability to acquire data directly off the 100- and 300-MHz radar units.
- Feature extraction and signal processing routines to process the collected radar data.
- A survey wheel to provide data registration capability.
- A commercial plotting package to display raw and processed data.
In FY96, we expect to:

- Build additional hardware interfaces for the other sensor systems
- Define a common data format for collected sensor data
- Develop sensor fusion methodologies to fuse the multiple sensor data streams
- Design processing algorithms specific to the applications we are performing (waste site versus injected barriers versus UXO/mines)
- Incorporate GPS survey capability
- Improve our data visualization capability

SUMMARY

Development of the ISCS system will continue throughout the rest of FY96, with a working prototype completed by August 1996. When completed, ISCS will provide a capability to acquire, process, and visualize survey data in the field in near real-time. Data processing software will be customized for the particular sensor or application need.
Figure 1. Architecture for the Integrated Subsurface Characterization System (ISCS)
Figure 2. Example of survey data collected at Sandia’s Technical Area II classified waste landfill
Figure 3. Example of survey data collected on a subsurface injected barrier