



New Approaches to the Use and Integration of Multi-Sensor Remote Sensing for Historic Resource Identification and Evaluation

Project Summary/Fact Sheet

Background:

The Department of Defense administers 25 million acres of public land containing some of the nation's most significant historic and prehistoric cultural resources. Protecting these heritage resources is a fundamental part of the Department's primary mission. Heritage management issues central to that mission have focused on the economics of identifying and maintaining historic facilities, the impact of archaeological sites on construction and training programs, and the disposition and curation of artifacts. Management of these resources, in compliance with existing laws and regulations, necessitates the development of innovative and cost-effective methods for archaeological site identification, evaluation, and protection. However, archaeological methods for the identification and evaluation of most historic resources remain essentially unchanged since the early twentieth century. Surface survey and excavation, the traditional field methods for discovery of artifacts, architectural elements, and other features, predominate in spite of the fact that these techniques are extremely time consuming, expensive, and unreliable. What is needed are methodologies for "seeing" into the ground and detecting subsurface archaeological deposits over large areas. Integration of multi-scale multi-platform remotely sensed data offers an opportunity to recover a great deal of information about archaeological site content while reducing costs associated with field work and long-term curation of excavated collections.

Objective:

The objective of this project was to acquire and analyze a suite of ground, aerial, and space-based sensor data to determine which remote sensor combinations, data fusion techniques, and analytical approaches most accurately predict the presence and specific nature of subsurface archaeological features in various environmental conditions and archaeological settings.

Follow up archaeological field testing provided a quantitative assessment of each approaches' ability to successfully detect buried features. The archaeological field validation studies, patterned regularities in the data, modality correlation, and other factors were used to evaluate sensor performance and the effectiveness of data fusion methods and analytical approaches.

Summary of Process/Technology:

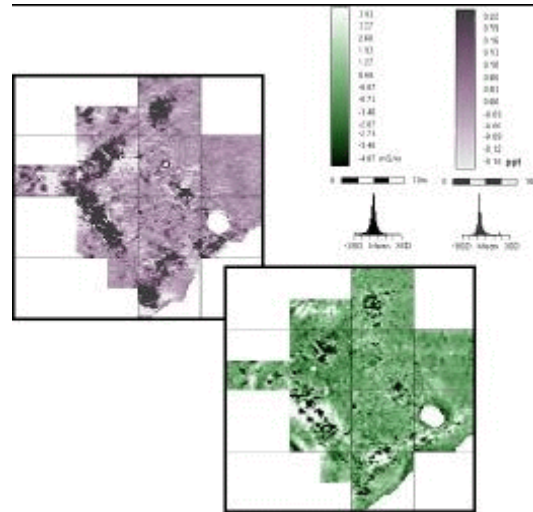
The project begins with the acquisition/compilation of geophysical data; magnetometry, magnetic susceptibility, electrical resistivity/conductivity, ground penetrating radar and terrestrial thermal infrared, aerial photography, and satellite based, high resolution multispectral (visible, near-IR) for a wide range of archaeological site types at Fort Benning, Fort Bliss, Fort Riley, and the DoE Savannah River Site. After data preprocessing, a range of multiple, alternative methods of fusion and analysis were applied for the detection of archaeologically relevant evidence (e.g. foundations, hearths, etc.); categories of fusion included multi-band visualization, pixel-based multivariate statistical methods, image segmentation and object classification, and model-based fusion. The fusion methods apply a range of pattern/structure recognition approaches to the problem of content extraction from multi-source data. In the first technique the recognition process is totally visual, in the second statistical methods are used to identify patterning, in the third method initial statistical methods are joined with user supplied rule sets, where the rule set reflects a

priori knowledge about the spatial relationships of the statistically derived object primitives. In the final model-based data fusion approach *a priori* information on instrument values and physical properties are built into the process models that then are calibrated through iterative application to data. The anomalies detected in the data fusion/analysis phase were field tested using established archaeological excavation techniques to quantify prediction accuracy by recording the ratios of detected features to false positives and to false negatives. The resulting assessment allowed the performance of the various sensing methods to be evaluated individually and together. The utility and benefits of the various data fusion/integration methods were also quantitatively measured and assessed.

Benefit:

The inclusion of fused remotely sensed data analysis in the early stages of archaeological site assessment represents an alternative approach with the potential to overcome some of the typical limitations of both traditional (non-remote sensing) site evaluation and single sensor surveys. Multi-sensor surveys permit the detection of features across large portions of sites, improving the reliability of site assessments. The benefits of improved site detection are threefold. First, thorough evaluations based on hand excavation are expensive. Remote detection of cultural resources reduces the amount of excavation needed to effectively evaluate a site, significantly curtailing the associated labor and logistics costs. Second, reliable location of archaeological features and attendant reduction of excavation reduces the volume of artifact collections, resulting in substantial decreases in curation costs. Third, detailed knowledge about the subsurface characteristics of a site can dramatically reduce the often prohibitive excavation costs while increasing the positive results. The absence of this knowledge can also lead to the unintended disturbance of human remains and other culturally sensitive deposits during subsequent construction or military training,

requiring costly and complex action to comply with the *National American Graves Protection and Repatriation Act*.



Two geophysical data sets depicting the subsurface archaeological remains of the Fort Clark Trading Post in North Dakota (ca 1832-1861): magnetic susceptibility (left) and soil conductivity (right).

Transition Plan:

Key communications were directed at installation specialists through the ERDC-CERL report series and through the individual efforts of Dr. Hargrave. The transition was designed to provide the installation staff with information on the effectiveness of the systems and appropriate field implementation strategies. A similar effort focused on communicating with technical specialists in the archaeological remote sensing community. This involved providing those individuals conducting field studies with the results of the research so that they can be included in best practices. Areas of future research were identified to provide guidance to next cycle of research activities. In addition to traditional scholarly publication and meeting presentations, a key vehicle for dissemination of the results is through the *North American Database of Archaeological Geophysics* (NADAG, <http://www.cast.uark.edu/nadag/>). Where the results of the research provide a good business case, we anticipate that

instrument designers and software developers will respond and create products that can be used in future applications at installations and other locations. ESTCP has funded one such effort *Streamlined Archaeo-Geophysical Data Processing and Integration for DoD Field Use (SI-0611)* to develop the ArchaeoMapper software package.

Accomplishments:

The results of the integrated data sets clearly illustrate the very substantive subsurface site characteristics that are discoverable from the integrative methods used. Based on these results a dramatically clearer picture of the subsurface is realized, compared to traditional site evaluative methods. By more clearly imaging the totality of information about the subsurface from all sources, a better understanding of site content, structure, and organization may also be achieved. The amount of information provided from these methods dramatically improves the ability to assess the site properties consistent with eligibility evaluations. The extensive amount of information yielded by the approach also serves as important guidance should site mitigation be needed. Compared to the typical site evaluation results these methods provide orders of magnitude more information on the nature of the internal sites structures and its characteristics.

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