Space Archaeology
Abstracts of selected proposals.
(354000Z001N-SAP)

The National Aeronautics and Space Administration (NASA) solicited proposals that would utilize remote sensing data to improve our understanding of past human settlement patterns and the relationships between the natural environment and cultural adaptations as functions of time and space. This is a new program, one that uses space-age technology to understand an age-old problem, environmental change and how societies have generated and/or responded to that change with various degrees of adaptive success. The major goals of the Space Archaeology program are: (1) to accelerate archaeological discovery and understanding through access to and analysis of remotely-sensed data obtained from space borne and airborne platforms and (2) to facilitate the infusion of technological expertise and capacity in remote sensing into archaeological research by fostering multidisciplinary collaborative partnerships.

This solicitation requested proposals that use remotely sensed data in two focus areas:

- Regional landscape analysis and modeling that relate human settlement patterns and subsistence strategies to environmental factors derived from remote sensing (i.e., climate, topography, hydrology, vegetation cover, etc.) and
- Protection and preservation of cultural heritage sites and/or planning for sustainable development of cultural resources.

Proposals must incorporate use of remotely sensed data and/or derived products from NASA and/or data from other international space agencies with missions providing data types not available from NASA. This solicitation is not intended to support studies that seek to use spaceborne sensor data merely as surrogates for airborne optical data, nor is it intended to support extensive fieldwork such as excavation.

NASA received a total of 17 proposals, and 7 have been selected for funding. The total funding to be provided for these investigations is approximately $2 million over three years.

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Ronald Blom/Jet Propulsion Laboratory
Developing Analysis Protocols for Multipolarization/Multifrequency Radar Data and Digital Elevation Models for Mapping Archaeological Landscapes of The Maya Biosphere

We propose to develop archaeological protocols for analysis of the multifrequency and multipolarization radar data collected by the NASA/JPL AIRSAR instrument in 2004 via an interdisciplinary team of archaeologists and radar discipline experts. This work is timely as we can leverage on existing NSF funded archaeological investigations in the Maya Biosphere by Co-I Golden and Collaborator Scherer to cost effectively provide archaeological ground truth and evaluate and guide remote sensing products from a user's point of view. We will produce orthorectified enhanced multipolarization/multifrequency
radar images of selected areas to simultaneously inform ongoing archeological investigations and develop radar processing and analysis protocols for future use. Co-I Saatchi will aid in understanding vegetation signatures in the radar data, and their impact on extraction of archaeological signatures. In addition, Co-I Chapman will take the lead to produce, mosaic, and orthorectify a digital elevation model based on the C-Band interferometric data. Based on previous work by the PI and Collaborator Comer, we expect the DEM to be vital to regional understanding of human interaction with the landscape. This DEM, and key radar data products developed, will be made available on the SERVIR (http://servir.nsstc.nasa.gov/) web server for future use by the broader research community. We see these efforts, which directly addresses both goals of the Space Archaeology Research Opportunity, as the basis for development of broader remote sensing based archaeological protocols for this type of environment and future proposals.

Paul Buck/Desert Research Institute
Remote Sensing to Aid in the Search of Prehistoric Anasazi Agricultural Fields and Seasonal Dwellings in NW Arizona

Objectives: We propose to use remote sensing to estimate soil, vegetational, and geomorphical characteristics to determine the potential of landscape features to sustain productive prehistoric maize agriculture in the Mt Trumbull region of NW Arizona, an arid region of the Colorado Plateau. Prior archaeological research shows a high density of prehistoric Anasazi habitation sites and, as the results of limited subsurface testing, some of these sites contained ancient maize. The prehistoric Anasazi depended to a large extent on maize agriculture and it is often presumed that larger sites were located near “agricultural fields” and that many smaller “field houses” were constructed and used to tend crops during the growing season. There is little independent data to support this tautology and in most cases, we do not know what an agricultural field looks like. We have no model of the relationship between site locations and attributes of soils, suitability for maize agriculture, retention of soil moisture in the subsurface, etc.

Strategy: We have been conducting archaeological research in the Mt Trumbull area for 6 seasons. Over 400 sites have been recorded in the 4 quadrangle area (~100,000 acres) of Mt Trumbull. Site density here is up to 100 sites per square mile. Remote sensing (Landsat TM, ASTER, and digital elevation) data will be used to estimate soil type, current vegetation cover, soil moisture, surface roughness, and proximity to known habitation sites, as well as used to detect subtle linear features that may have been roads, trails, dwellings, and irrigation features. Variables we will measure include depth of soil and slope, aspect, and soil moisture content. Parent material for local soils will be mapped and the distance from parent sources, combined with the previously-mentioned soil characteristics, will be used to estimate soil depth. This data, initially focused on two intensively surveyed areas in the Mt Trumbull area, will be built into a crop/habitation model, which will be tested in nearby areas. Field investigations and image analyses will be used to refine our approach and ultimately validate our results. With this model, we will determine where in the study area optimum soils and exposures were for effective maize agriculture. We will identify optimum soil, nutritional, moisture, and drainage
conditions for prehistoric maize and modern natural species to use as indicator species of favorable prehistoric maize growing conditions.

Significance: Our model will provide some predictive capability in the region for prioritizing subsequent survey intensity. The research proposed here may also allow planners of the new Grand Canyon-Parashant National Monument (where the Mt Trumbull study area is located) to avoid particularly sensitive areas when designing recreation and other facilities for the national Monument.
**Tom Farr/Jet Propulsion Laboratory**  
**Hydrologic History of the Sahara: A Framework for Archaeological Exploration**

The goal of this project is to predict the locations of human occupation sites in the Sahara Desert. To do this we will generate new maps of the paleohydrology, topography, geomorphology, and surficial deposits of the area and develop GIS-based models which use these maps to pinpoint potential living sites. The maps we generate will constitute a unique resource for future exploration for archeological sites in N Africa. Past efforts have produced partial maps of buried paleo-drainages and have delineated ancient lakes using new topographic data. This project will produce the first complete maps. The proposed work directly addresses the goals and focus of NASA's Space Archaeology Program by developing and using new remote sensing data for archaeological exploration, with the collaboration of archaeologists working in the area. The development of models of human interaction with an environment undergoing cyclic wetter and dryer periods also addresses NASA's interest in characterizing changes in Earth's land cover and hydrology and how humans cope with those changes.

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**William Middleton/Rochester Institute of Technology**  
**Hyper- and Multi-spectral Satellite Imagery and the Ecology of State Formation and Complex Societies**

Funding is requested for the acquisition and analysis of Hyper- and Multi-spectral satellite imagery from the Hyperion and ALI imaging spectrometers aboard the Earth Observing 1 satellite and multispectral data from the Landsat satellite. These data will be used for the analysis of archaeological landscapes in the state of Oaxaca, Mexico, in order to better understand the changing, ongoing, and two-way relationship between a complex society and its environment. Oaxaca was the center of the Zapotec state, the earliest state-level society in ancient Mesoamerica, yet one that is still incompletely understood. With these data, we will be able to analyze landscape variability; identify different environments and their locations, and calculate their extent of coverage; classify landscape variation into archaeologically meaningful taxa such as arable land, natural resource areas, and their geographic relationship to archaeological settlements; dynamically model paleoecological landscape change resulting from both natural and human causes; and assess the impact of development on previously identified archaeological sites over a large portion of the state of Oaxaca. Much of the area to be imaged has been subject to extensive archaeological survey over the past three decades and therefore provides an extremely well-documented context for the modeling of a prehistoric society and its changing landscapes. This project will take place in conjunction with an ongoing archaeological survey aimed at investigating the nature of primary state formation, a paleoecological study investigating the relationship between human impacts and climate change on the ancient Mesoamerican landscape, and a methodological study developing new techniques for the classification of hyperspectral data. This interdisciplinary, interinstitutional collaboration will provide considerable leverage to the results obtained through this project, as well as a achieving a number of NASA’s research funding goals.
Miriam Stark/University of Hawai'i at Manoa  
Early Historic Landscapes Of Cambodia'S Mekong Delta

Southeast Asia’s earliest civilizations emerged during the first millennium A.D. along the region’s coasts and river valleys, including the Mekong delta. The rise of these early Southeast Asian states is conventionally explained by social and economic factors, but work is needed to build diachronic landscape histories in the region. The Lower Mekong Archaeological Project, or LOMAP, was begun in 1996 to examine the kinds of natural and human-induced landscape and environmental changes that accompanied the emergence and decline of one of the Mekong delta’s earliest trade-based polities. Interdisciplinary research is needed to locate social practice and change within its ecological setting, and ultimately to assess the association (if any) between environmental factors and the rise and decline of the Mekong delta’s early historic centers. LOMAP researchers from the University of Glasgow are now collecting and analyzing local and regional environmental histories from across the delta to underpin our interpretations of the history of these centers. Both paleoenvironmental and archaeological settlement data are needed for this research, and funding is requested from the NASA Space Archaeology program to complete the project’s archaeological component. We wish to study stability and change in settlement and land use from c. 500 BC – AD 1000, and to develop a predictive model for archaeological sites and features. To this end we request funding to acquire and use Very High Resolution remote sensing data in our GIS database. Undertaking predictive modeling will, firstly, extend the project’s geographic coverage across the entire project area in Takeo Province, including areas that are currently inaccessible. The funding would also enable LOMAP to prepare and give the completed GIS database to Cambodia’s Ministry of Culture and Fine Arts, after having trained two Cambodians in GIS techniques so that they can use the database for heritage management uses.

John Weishampel/University of Central Florida  
Remote Sensing Of Ancient Maya Land Use Features At Caracol, Belize Related To Tropical Rainforest Structure

Caracol is one of the largest Maya archaeological sites in Mesoamerica. During its heyday (ca. AD 650), it was among the most populous cities in the Pre-Columbian world. To understand the social, political, economic, and ecological implications of historic settlement/land use patterns requires broad-scale, regional surveys that extend beyond the urban epicenter. To accomplish this, we propose to use:

(1) Satellite remote sensing to detect Maya archaeological features at Caracol based on spectral signatures of the rainforest vegetation; and

(2) Airborne LiDAR to map below-canopy terrain encompassing known and newly satellite-detected features.
Through these two objectives, the spatial extent (~180 km²) and distribution of structures comprising urban and suburban settlements will be detailed. The results from the passive, remote sensing (Landsat TM and hyperspatial) will help dictate the flight coverage of the small-footprint, canopy-penetrating LiDAR. From this active, fine-resolution sensor, causeways, agricultural terraces, reservoirs, irrigation canals, plazas, and buildings around Caracol will be identified, digitized, and analyzed at a regional scale. At present, less than one-fifth of this extensive site has been surveyed. This study represents the most ambitious application of LiDAR for archaeological prospecting to date.

Although the Maya cleared ~75% of their landscape for agriculture and settlements, the rainforests rebounded to yield the most recent, vast natural reforestation event. Through combining archaeological, ecological, and remote sensing expertise using the data acquired from (1) and (2) and we will:

(3) Relate contemporary rainforest canopy structure to historic Maya land use regimes.

From the hyperspatial satellite imagery and airborne LiDAR data, we will derive aboveground biomass and habitat structure measures (i.e., canopy top height, vertical distribution of return, degree of canopy openness, crown diameter of dominant trees, canopy texture) for the landscape around Caracol. Hence, we will assess forest recovery patterns in relation to a variety of land use legacies.