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**COASTAL NPS INVENTORY AND MONITORING NASA-USGS AERIAL
SURVEYS AND GIS PRODUCT CREATION AT THE U.S. GEOLOGICAL
SURVEY'S CENTER FOR COASTAL AND WATERSHED STUDIES**

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INTRODUCTION

Since 1995, the National Park Service has been working in cooperation with the Observational Sciences Branch at NASA Wallops Flight Facility to develop NPS resource management applications of airborne LIDAR (*light detection and ranging*) very high-resolution topographic surveys. In 1997, the USGS Center for Coastal and Watershed Studies (CCWS) entered this partnership by establishing and funding a component of their *National Assessment of Coastal Change Mega-Project* entitled *Assessment of Hazards and Habitats for National Seashores and Parks*. Subsequently, this partnership has expanded through the establishment of additional NPS-USGS-NASA projects to now include NPS-USGS-NASA aerial surveys over various NPS barrier island, tropical island, and coral reef parks throughout the National Park Service's Northeast Region and Southeast Region. Although the component projects are now funded by a mix of NPS and USGS programs, interaction with the NPS Inventory and Monitoring Program has become the central theme, and as such, this partnership is herein termed the NPS-IM/USGS/NASA partnership.

BACKGROUND

In partnership with the National Park Service and the National Aeronautics and Space Administration (NASA), U.S. Geological Survey (USGS) is collecting optical remote sensing data using a variety of sensors, including the ATM and EAARL lidars, the AISA hyperspectral scanner, and downlooking digital cameras. Acquisition sites include National Park Service units ranging from the Northeast Coastal and Barrier Network parks, and Southeast Regional parks, inclusive of parks within the Southeast Coast Network, the South Florida/ Caribbean Network, and the Gulf Coast Network. The data is being collected primarily to advance research on methods for the investigation of coastal regions using these new technologies. The National Park Service recognizes that the resulting low altitude aerial survey data sets have many uses, including change detection for shorelines, mapping high resolution topography and bathymetry, and the mapping of coral reef habitats. This agreement provides additional staff at the USGS lab to assist with the analysis and interpretation of the data to provide useable products for NPS managers. This agreement allows for the federal government to more efficiently hire non-permanent staff positions through the National Park Service instead of using a staff placement agency. The cost savings have been estimated at about a 30% reduction in costs through this arrangement.

Given its proximity to NASA Wallops Flight Facility and Park interest in using the resulting data sets in ongoing resource management activities, Assateague Island National Seashore (ASIS) has been a focus of data collection and applications development activity. In addition, by developing a baseline data set for national scale investigations of coastal processes and severe storm impacts, the USGS *National Assessment of Coastal Change Mega-Project* has recently conducted one or more NASA aerial surveys of most other National Seashores along the contiguous U.S. coastline. At ASIS, pilot efforts to use NASA aerial survey data sets in resource management and monitoring have already resulted in significant practical contributions. Topographic LIDAR and aerial photography data sets acquired during NASA-USGS overflights of

ASIS are being used in the Threatened and Endangered Species Recovery (Piping Plover and Sea Beach Amaranth) Program, the Geomorphologic Monitoring Program (elevation models, topographic profiles, and beach re-nourishment), and within the Wildlife Management Program (horse grazing effects on vegetation and natural dune evolution). Aerial imagery acquired in conjunction with LIDAR surveys is also being used as a base cartographic product in a variety of park-wide activities including facility management, interpretive programs, and visitor services.

The initial NPS-USGS-NASA cooperative project sited at ASIS has clearly demonstrated the value of NASA aerial surveys in meeting "on the ground" NPS resource management needs. The project has also revealed the importance of the USGS/CCWS role in converting raw NASA remote sensing data sets into GIS-compatible information layers of high relevance to the management needs of National Seashores and Parks. Indeed, the two major issues involving the use of NASA airborne LIDAR data are 1) access to aircraft for data collection and 2) the arduous level of data processing required. LIDAR surveys result in very large data sets, which in their raw format are not compatible with most GIS software. The USGS has taken the lead role in developing methods (LaserMap, ALPS) for processing these data to a level that they can be imported into widely used GIS software packages (ESRI). As a result, Parks have been able to directly access these data for use in park natural resource management activities. Accordingly, the NPS-USGS-NASA partnership has yielded results beyond the basic topographic data initially envisioned. Using elevation data as a starting point, demonstrable progress has been made in extracting significant geomorphologic features such as dunes and shoreline. Initial work using LIDAR data coupled with ancillary images in vegetation and land cover mapping has also been promising.

STATEMENT OF WORK

The goal of this NPS-IM/USGS/NASA partnership is to create new high resolution aircraft-based remote sensing/GIS-based capabilities for natural resources management and coastal studies, and to tailor and apply these capabilities to the needs of the NPS Inventory and Monitoring Program. The NPS-IM/USGS/NASA partnership is using advanced aircraft remote sensing techniques (LIDAR, multi-spectral scanning, and aerial photography) at the lowest possible cost through a close technical collaboration with NASA/GSFC Wallops Flight Facility at Wallops Island, VA. The aerial mapping methods that have been developed within the NPS-IM/USGS/NASA partnership are resulting in digital maps and derived metrics that depict:

- Fine scale subaerial topography, key geomorphic features (shorelines, dunes) and three-dimensional topographic change
- Barrier island land cover, and seaward vegetation boundaries
- Vegetation community structure and wildlife habitats
- Fine scale submarine topography, key geomorphic features (channels, rubble deposits, seagrass "blow-outs", reefs)
- Benthic habitat maps
- Benthic topographic complexity (bottom roughness) maps

Northeast Coast and Barrier Network

Between 1999 and 2002, the NPS Northeast Region Coastal and Barrier Network conducted a series of scientific and technical workshops to identify critical environmental indicators or vital signs. These meetings identified LIDAR topographic surveys as a preferred method for the collection and extraction of certain key indicators, specifically beach micro-topography and dune elevation features. Biennial surveys were recommended as the appropriate collection interval for data acquisition and processing. LIDAR surveys have been flown at the networks four ocean parks in 1998, 2000, and 2002.

Aerial Surveys

Pre-mission planning for park specific purposes including the delineation of those geographic areas designated as desirable by park and regional staff will be conducted by the term NPS employee in St. Petersburg, in close coordination with Network NPS staff and staff from NASA and the USGS prior to all upcoming aerial surveys. In the Fall of 2002, the newly developed NASA EAARL lidar was used to survey selected portions of Assateague Island NS, Gateway NRA, Fire Island NS, and Cape Cod NS. During FY2005, this project undertook NASA EAARL surveys of NPS units designated by the Northeast Coast and Barrier Network. Given the need of the integration of this project into the regional monitoring program, it is necessary that the partners work closely with the target parks to define prioritized levels of activity and desired survey regions. Prior to performing any airborne survey, each park will be contacted and asked to participate in a pre-mission planning exercise that will give parks the opportunity to discuss, define and prioritize their areas of interest and data needs.

Aerial data acquisition surveys typically begin in late summer (August, September) and continue through the early fall (October) park survey season. We propose to use aircraft from the NASA Wallops Flight Facility and the NASA - USGS ALPS software package to perform aerial surveys at parks designated by the Northeast Coastal and Barrier Network, process data from these surveys, and extract geomorphologic features from the data. Within the LIDAR survey activity, NASA is responsible for the acquisition and initial processing of aircraft remote sensing data sets, the USGS role is to develop methods, products, and deliverables, and the NPS is expected to provide and operate a GPS base station in support of the aerial surveys.

Creation of Vital Signs Baseline Inventory and Monitoring Information Products

In FY05 the NPS term employee at the USGS in St. Petersburg will develop "bald earth" DEMs based on prior NASA EAARL LIDAR surveys of Northeast Coast and Barrier Network NPS holdings. In addition, the NPS term position at the USGS will continue to develop methods for the quantitative inventory and monitoring of landscape features, including dunes, shorelines, and the seaward barrier island edge-of-vegetation. This activity will involve the establishment of algorithms and methods of the definition of landscape features based on aerial remote sensing observations. In FY05, the NPS term employee sited at the USGS in St. Petersburg will further develop methods for the detection of change in dunes and shorelines, to create a true monitoring capability that goes beyond static mapping. In cooperation with the NPS, the USGS will develop GIS

metadata templates for the data products created within the project. Using the previously acquired NASA EAARL survey data sets, the USGS will deliver to NPS digital maps and tables that provide quantitative information on the landscape features in GIS ready format for surveyed ocean parks. The following suite of maps depicting barrier island features will be created:

- Fine scale subaerial topography, key geomorphic features (shorelines, dunes) and three-dimensional topographic change,
- Barrier island land cover, and seaward vegetation boundaries,
- Vegetation community structure and wildlife habitats.

Southeast Gulf Coast Network

During the last 5 years, airborne lidar surveys have been conducted over the sandy portions of the Gulf coast by a USGS - NASA project, and also by the Bureau of Economic Geology at the University of Texas at Austin, Texas. The USGS - NASA project acquired NASA Airborne Topographic Mapper (ATM) data over extensive portions of Gulf Islands National Seashore. The NPS term position sited at the USGS office in St. Petersburg, Florida will undertake the processing and added-value analysis of this existing lidar data set over Gulf Islands National Seashore. Optionally, the NPS may in future wish to have similar analyses performed for lidar data sets that cover other Gulf coast NPS holdings, such as Padre Island National Seashore.

Standard Processing of LIDAR Data

During FY2005, the existing Gulf Islands National Seashore NASA ATM data set will be processed and delivered to park in accordance with existing agreement with the NPS on map product deliverables. At a minimum, the suite of products generated for each survey of these NPS holdings will include:

- ASCII files containing elevation data points converted to a UTM projection and the NAVD88 vertical datum in LaserMap Level 2 format.
- Two kilometer square elevation image map tiles in the generic *geotif* file format (LaserMap Level 4) ready for insertion into a GIS.
- "Quick-look" browse maps for the elevation image maps in compact *jpeg* image format files.
- Extraction of significant geomorphologic and land cover features from LIDAR data.

Processing of the ATM data will be handled by the NPS term employee to be sited at the USGS office in St. Petersburg, Florida, who will work closely with the USGS research group headed J. Brock, and the NASA technology group headed by W. Wright at NASA Wallops Flight Facility. Custom software for the processing of voluminous lidar data sets has been developed by NASA and the USGS and this software will be applied to the processing and interpretation of the GUIS ATM data set.

Following pre-processing at NASA to geolocate all laser soundings within the ITRF99 reference system, the full data set will be filtered to separate laser soundings over land from those obtained over water. An algorithm designed to identify the benthic laser reflection on each temporal waveform will be applied, and the resulting set of range values to the seafloor will be used to obtain bathymetric spot elevations. Next, these

ellipsoid-referenced soundings will be filtered to eliminate erroneous topographic estimates due to false "early bottom" laser returns. The map positions of laser soundings that pass this test will then be converted to the UTM coordinate system. At this stage, the ellipsoid point elevations referenced to UTM will be captured as a deliverable data set.

Deliverables for the Southeast Gulf Coast Network

The data products to be delivered to the NPS based upon the recent NASA EAARL survey are as follows:

- GIS-ready metadata-documented topography data sets for GUIS. These data sets will be provided in two separate formats:
- ASCII files containing the NAVD88/NAD83 point elevation values in the UTM projection. To enable reprocessing following anticipated upgrades of the geoid model for GUIS, this point elevation data will also be provided relative to an ellipsoid datum.
- Geotiff-format image maps at the UTM projection containing gridded topography relative to the NAVD88 vertical datum and the NAD83 horizontal datum.

Funding

The NPS provides substantial involvement with the position advertisement, selection, orientation, and regular leave and payroll responsibilities through the administration at Biscayne National Park. The Northeast Coast and Barrier Network and the Southeast Gulf Coast Network will each provide one half of the annual cost salary for a GS-11 Step 2 NPS term position sited at the US Geological Survey's Center for Coastal and Watershed Studies in St. Petersburg, Florida, as well as the associated costs for OPM to advertise the vacancy of these two positions. This NPS position will have a term of 2 years, renewable for 2 more years, contingent upon the agreement of the principal NPS and USGS representatives. The initial funding will be provided in FY2004, and will cover the full 2 years of this term position, which will span FY2005 and FY2006. The USGS will provide all the anticipated office space, equipment, and training necessary to carry out the work required.

NPS Costs for a LIDAR Federal Term Analyst Position (sited at the USGS in St. Petersburg; total annual cost to split equally between the Northeast Coast and Barrier Network and the Southeast Gulf Coast Network)

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| 1) One half of an NPS term GS 11 Step 2 position with benefits to be paid for by the Southeast Gulf Coast Network to BISC (2 years @ 50%). | \$58,597 |
| 2) One half of an NPS term GS 11 Step 2 position with benefits to be paid for by the to Northeast Coast and Barrier Network to BISC (2 years @ 50%). | \$58,597 |
| 3) OPM advertising the position - \$1,000 from each Network to BISC. | \$2,000 |
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Total	\$119,194
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Total to be sent in FY04 to BISC by the Southeast Gulf Coast Network:	\$59,597
Total to be sent in FY04 to BISC by the Northeast Coast Network:	\$59,597