



Mapping Puerto Rico & U.S. Virgin Islands

—by Peter R. Briere and James L. Suggs

Color-infrared image of coastline on Isle de Vieques, Puerto Rico. Vieques lies seven miles east of Puerto Rico. In 2003 the U.S. Navy transferred eastern Vieques to the USFS as a Fish and Wildlife Reserve.

Puerto Rico is an island of physiographic and ecological diversity. The central mountains, coastal lowlands, and karst region provide settings for rainforest (up to 240 inches of rain per year at El Yunque), beaches, caves, rivers, and desert. This unique island's resources provide a magnificent environment for research and adventure, while also presenting challenges to comprehensive aerial mapping efforts.

The U.S. Army Corps of Engineers (USACE) spearheaded a collaborative effort to update the orthophotography acquired in 2004 for Puerto Rico and the

U.S. Virgin Islands (USVI) and improve upon the resolution of the existing base maps.

A host of government partners provided support to accomplish the mission, including primary partners U.S. Geological Survey (USGS), Puerto Rico Department of Natural and Environmental Resources (DNER), Department of Homeland Security (DHS), National Geospatial-Intelligence Agency (NGA), and the Lieutenant Governor's Office of the USVI. The Environmental Protection Agency (EPA), U.S. Forestry Service (USFS) and Commonwealth agencies, Municipal Revenue

Collection Center (CRIM) and Puerto Rico Electric Power Authority (PREPA) were also involved.

3001 provided geospatial services including all aerial photography and digital image processing support. Puerto Rico-based RLDA Geo-Metrica collected ground survey control for the mapping effort, while Maptech-Seasystems Corporation provided management support.

Imagery was collected over Puerto Rico and the U.S. Virgin Islands from November 2006 through December 2007, resulting in multi-spectral data capture for the entire island

of Puerto Rico and adjacent islands.

Over 85% of the project area was captured in the first five months of acquisition using two Cessna aircraft with two digital airborne sensors (Leica ADS40). During each flight, 3001 used the ADS40 sensors to collect, simultaneously, color and color-infrared imagery.

In the late spring and summer, predominant cloud cover and rainfall in Puerto Rico's mountain regions eliminated any further opportunities for image capture. When 3001 returned in August to resume and complete acquisition of the remaining 15% of the island, some areas had to be flown multiple times to achieve the best quality imagery possible—some areas were photographed as many as nine times!

The resolution, or ground sample distance, of the new photography is 0.3-meter, a significant (three-fold) improvement over the existing one-meter photography. The higher resolution imagery not only allows more ground features and conditions to be mapped; the maps are also five times more accurate.

The ground survey control effort required field crews to collect high-accuracy GPS measurements from ground locations that are visible and identifiable from the aircraft, such as sidewalk corners, medians, or painted lines in vacant parking lots. In addition, RLDA also maintained GPS base stations which provided 3001's aircraft and sensors with accurate positioning information during image acquisition. The imagery was subsequently processed by 3001 into an orthophoto (image map), using GPS, air-



Castillo de San Felipe del Morro, San Juan, Puerto Rico. El Morro is Puerto Rico's best known fortress. Spanish troops fortified this "morro" (promontory) to keep seaborne enemies out of San Juan.



Protestant Cay in the harbor at Christiansted, on the north side of Saint Croix, U.S. Virgin Islands.

borne orientation, and ground GPS measurements, as well as bare-earth surface models.

It was teamwork in the air, on the ground, and in the office

which created the final image products.

The combination of dense vegetation, mountains, and frequent rainfall creates a difficult



Buck Island Reef, north of St. Croix, U.S. Virgin Islands. The park is one of a few fully marine protected areas in the National Park System.

scenario for capturing clear imagery from 9,600 feet above ground level. But, despite persistent cloud cover and extreme elevation changes in many areas, this project produced one of the highest resolution island-wide imagery products to date.

Each pixel of the digital imagery collected during the Puerto Rico and USVI missions corresponds to one square foot of coverage on the ground. Yet, it requires just over three terabytes of storage space.

By processing only the spectral bands necessary to create the orthophotography, the final products file sizes were reduced to a total of five hundred gigabytes. These files were delivered via external hard drives to all partner agencies with corresponding project documentation and compressed versions of the files for faster downloading and viewing.

Natural and human-induced changes to the landscape can significantly alter the dynamic (rainforest) ecosystem in Puerto Rico. Assessing the scope and magnitude of these changes is critical for long-term management of Puerto Rico's valuable environmental resources, as well as implementing infrastructure updates and developments that are cost-effective.

The color and color-infrared "views from above" enable such monitoring, by capturing up-to-date information about actual conditions across a large area. The cost-effectiveness of this method is clear.

Image maps capturing changes in transportation networks, commercial or residential development, floodwater levels, damage from storm activity, and variances in vegetative health or species distribution provide information to decision makers tasked with maintaining and improving safe and healthy living conditions.

Continuing advances in airborne digital camera technologies and data processing techniques make it possible to create such information more quickly and at higher resolutions than did large aerial photography projects of past decades.

"Ortho imagery has extremely significant meaning for the U.S. Virgin Islands," said Mel Vanterpool, Director of Virgin Islands Office of Homeland Security. "With GIS technology we continue moving into the 21st century for both commercial and Homeland Security applications. This is a first for the U.S. Virgin Islands, a huge plus!!" ■

Peter R. Briere, Project Manager, 3001, Inc. 401 Dividend Drive, Suite K, Peachtree City, GA 30269. **James L. Suggs**, Project Manager, U.S. Army Corps of Engineers, 701 San Marco Blvd, Jacksonville, FL 32232.