

Virtually Preserving Sugar Plantation Structures in the Virgin Islands National Park, St. John



The principal investigators and National Park Service interns who performed this work at the Archeology Laboratory on Cinnamon Bay in the Virgin Islands National Park, St. John, March 2004

**Prepared for the National Park Service
Virgin Islands National Park
St. John**

**Edited by Karen J. Horton, P.E.
Associate Professor
Mechanical Engineering Technology**

January 20, 2005

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Three principal investigators, sixteen student and graduate interns, and three volunteers performed a project to virtually preserve several important but threatened eighteenth to nineteenth century sugar factory structures at a site on Leinster Bay in the Virgin Islands National Park, St. John. The text of this report was written by a number of the interns and principal investigators and describes the project and the work performed. It was submitted to the National Park Service as an outcome of an interdisciplinary service-learning class at the University of Maine.

**Edited by Karen J. Horton, P.E.
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Executive summary

Under the Danish Crown in the eighteenth and nineteenth centuries thousands of enslaved people erected sugar plantation buildings on the island of St. John in what is now the Virgin Islands National Park (the Park). The buildings will be reduced to ruins as the forest covers them over time. Preservation of these buildings and accessibility to the buildings is important to the historical record of St. John. Park Archeologist and Cultural Resource Manager Ken Wild hopes to be able to model the buildings with three-dimensional computer-aided design (3D CAD) software, apply visual details from digital photographs, use survey and other geographic data to model the terrain around the buildings, place the modeled buildings on the terrain model, and develop a corresponding geographic information system (GIS). This is one concept of virtual preservation.

Wild sought a relationship with faculty and students at a university with the necessary spatial information engineering and 3D CAD modeling capabilities to support the work. Constance (Connie) Holden and Karen Horton at the University of Maine (UM) responded to his request. Under this project a diverse team of investigators measured, surveyed and photographed several structures at a site and the local terrain. They developed GIS and 3D CAD techniques for the virtual preservation of the structures. The team included Holden, Horton, Wild, twelve University of Maine students, four National Park Service interns, and three volunteers. The outcomes demonstrated that this concept of virtually preserving these structures is feasible, although techniques require further development. The results of this project could initiate a long-term archeological project at the park to locate, model, and report on the plantation buildings before they are lost to plant growth and rot.

Several organizations and individuals provided funding and volunteered time. The Friends of the Virgin Islands National Park provided stipends to student interns from the University of Maine to take photographic and measurement data at the Leinster Bay plantation. The UM Faculty Research Funds Committee provided funding for Holden and Horton to travel to the site during the same time period to provide technical direction and administration. The UM Division of Lifelong Learning provided funding for Holden and Horton to teach the course MET220 Special Topics in MET: CAD Modeling of Archeological Structures in which students developed modeling techniques for the collected data and reported on the processes and results. Holden volunteered time to develop a GIS to describe the data. Horton volunteered time to develop MicroStation modeling methods, administer the project, and edit this report.

Under this project team members:

1. cleared trees and brush then took photographs, physical measurements, global positioning system (GPS) measurements, and survey data describing the structural details, the visual details, the geographic location, and the surrounding terrain for a few important and threatened sugar plantation era buildings at a site on Leinster Bay in the Virgin Islands National Park;
2. researched and applied the spatial database and computer-aided design modeling techniques required to develop a virtual preservation model of the structures on the site;

3. evaluated the application of the developed techniques to the data and the suitability of the techniques for preserving many structures located over approximately eleven square miles of park property;
4. comprehensively documented the techniques and outcomes of the project.

The results demonstrate that this concept of virtual preservation is possible. Similar techniques are being developed to preserve Greek ruins. During this project photos of a structure were applied to a simple structural model, a terrain model was created and the building model was placed on the terrain 3D CAD and GIS models. However, this is an emerging field of work with significant applied research required before adequately standardized techniques for consistent application in the field are available. A clear definition of and standards to define virtual preservation are not yet available. This includes precise definitions regarding linear and angular measurements of irregular structures. Photography methods in the field and techniques to prepare photographs for use on an orthographic model are underdeveloped. The processing of geographic data to create a terrain model of appropriate accuracy over the required distances must be further investigated and developed. The work will remain cross-disciplinary and will require the expertise of engineers until standard techniques are available to archeologists, cultural resource managers, and historical preservationists.

This report documents for the National Park Service the investigated virtual preservation techniques and the organization of the accompanying data. The report is organized as a work diary of the project. The administrative aspects and the general outcomes are described in the main body of the report. Technical details are contained in the appendices.

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The time Holden and Horton spent at the Park and the time they spent carrying out project organization, data analysis and reporting was all on a volunteer basis. Horton sought and administering funding (40 hours), developed and taught MET 220 (112 hours), worked on site in the Park (56 hours), and reported (40 hours) for a total of two hundred forty-eight hours. Holden conservatively estimated her time spent on the project as one hundred thirty hours.

When faculty members accept additional responsibilities during the summer months they receive summer salary prorated at their nine-month salary rate. The hours applied to the project total approximately two months of labor. Had the research been paid for by the Park, the salary and fringe lines for two months of faculty effort would have totaled about \$20,000.

Student interns were paid \$7.00 per hour by the Park. The work students performed in the class MET 220 was all directed toward completion of the project at the intern level. The value of the in-class efforts was equivalent to ten interns working four hours per week for fourteen weeks, or \$3920. If each class member worked an additional two hours per week outside of class, the total estimated value of the hours contributed by students is \$5880.

November 2003 – February 2004: Preparation

In November 2003 Horton and Holden solicited and reviewed student applications on behalf of the NPS for internships during March break. They recommended to Wild a group of eight applicants, six of whom were registered in MET220. The remaining two were selected based on skills in their resume that would augment the skills of the other six interns.

The course to support the project, MET 220: CAD Modeling of Archeological Structures, began on January 12, 2004. The course description and expected outcomes listed in the syllabus were as follow:

“Course Description: As a service to the Virgin Islands National Park students will document the sugar plantation on the site. Students will develop MicroStation drawing standards, computer models of plantation buildings, a Geographic Information System (GIS), and a final report.”

“Expected Outcomes:

Working as a team, students in the class should expect:

1. To develop a usable drawing standard and location database for current and future modeling and location of archeological structures in the Virgin Islands National Park, focusing on the sugar plantation.
2. For those students who so choose, during the two-week spring break, to work on site in the Virgin Islands National Park gathering modeling data and developing models.
3. To model the structures from the gathered data in accordance with the drawing standard developed.
4. To present to the Park the modeling standard for future work, the models and GIS developed, and a report describing the models and recommendations for future work.”

Coral Ash, a student in MET 220, described the first seven weeks of MET 220:

"During the first seven weeks of class we were introduced to the worlds of MicroStation and ArcView. In MicroStation we were first taught the basics of how to set up, open and manage a 3D file. We were then shown, and practiced using, tools such as snapping, fences, selection, colors, line style and widths etc. We were then shown how to create separate levels and how to attach elements to the different levels. We were shown how to retrieve reference files and raster files to be used in creating objects and how to apply materials and save them. We then moved on to using and creating complex shapes and extrusions. We created cells and worked on modifying object faces. For ArcView we first learned the basics like opening projects and activating themes and attribute tables. We were taught to join .dbf files to theme attribute tables and how to manipulate columns. We used the Query Builder to create queries and we learned how to create .dbf files in Excel. We learned to digitize from CAD files using campus buildings. We were also introduced to creating a new theme from X,Y data and 'hotlink'-ing documents and web pages."

Horton taught MicroStation skills in the first seven weeks. Wild provided electronic images of line drawings that a volunteer group of architects has made of the Leinster Bay ruins about ten years earlier and more recent photographs. He had decided that the interns would work to preserve the water mill and factory at that location. The class used the images to become familiar with the site and to practice the modeling skills introduced in the class.

Holden taught introductory geographic information system skills. The students used MicroStation files of the University of Maine campus that they imported into ArcView 3.3, and digitized. They then created a database for their GIS, and added hyperlinks to photographs and web pages. This process mimicked the skills expected that they would need for the Park project.

During this period Horton and Holden identified equipment available at UM to bring to the Park to support the project. They completed their travel arrangements and developed a basic work plan for the students' time in the Park. Horton acted as a liaison between Wild and the students.

March 1 – 12, 2004: Work in the Virgin Islands National Park

Transportation and Accommodations

Students arrived singly and in small groups on St. Thomas then took a ferry to Cruz Bay, St. John. Wild made sure the students were transported from the Cruz Bay ferry terminal to the Cinnamon Bay campground when they arrived. Wild supplied appropriate tents, cots, stoves, and other necessary camping gear for the interns. The campsites were located in the woods on the gleaming white sand of Cinnamon Bay. Interns shared several large tents on the ground with separate sleeping compartments. Except for the occasional tarantula, a couple of wet, chilly nights, and the cold open-air showers, they reported the accommodations to be comfortable.

In addition to the interns from the University of Maine, Kourtney Donohue and Susanna Fussell were already working as archeology interns. Kristine Graham arrived on March 1, 2004, and Susanna Pershern arrived on March 8, 2004. Wild assigned these four interns to work on the project on a rotating basis. In addition, three volunteers also worked with the interns. Glenn Knickerbocker and Carla R. Lesh assisted with the project for several days the first week, and

Brendan Horton assisted from March 1 – 8. Brendan is Karen Horton's son, and Knickerbocker and Lesh are her brother and sister-in-law. When these family members learned of the project they immediately volunteered to help in spite of Horton's protests regarding the cost to them.

Horton traveled to St. John on February 29 and left on March 9. Holden traveled to St. John on March 4 and left on March 11. Neither was able to stay the entire two weeks due to other professional commitments so they arranged an appropriate overlap. Both rented jeeps that they used to transport students. They stayed at a relatively inexpensive hotel in Cruz Bay complete with an open-air bar and restaurant, and one public payphone outside by the bar for resident use. The drive from Cruz Bay to Cinnamon Bay was about fifteen minutes. On St. John driving is on the left in left-hand drive vehicles, with plunging gorges, hairpin turns and no guardrails, with a posted speed limit of twenty miles per hour and an actual driving speed by native drivers of forty miles per hour. The scenery was so breathtaking as to be distracting under any other driving conditions, with bright turquoise bays, white sand beaches and mountainous islands visible from every height. However, Horton and Holden regularly reminded themselves to "keep left" and held their breaths with the passing of every taxi, a pick-up truck with a canopy over the bed covering bench seats.

Wild had originally planned to transport the team members and the equipment from Cinnamon Bay to the work site at Leinster Bay daily by boat because it was fast and required little walking. However, heavy surf conditions due to a storm the weekend prior to starting the data collection prohibited use of the dinghy to get from the moored boat to shore. Additionally, the boat planned for use was out of the water having new equipment installed. As a result, Wild, Horton, and Holden all transported students and gear the ten minutes from Cinnamon Bay to Leinster Bay to a drop point, and the team carried the equipment the last half mile or so to the work site, about a twenty minute walk over a stone beach trail. Only one day the first week did several interns bring heavy brush clearing equipment including a chain saw by boat. Walking onto the site reduced the available work time compared to using the boat. The heat and sun also reduced the amount of time the crew could perform the very physically intense activities.

Work Sites

The Archeology Laboratory at Cinnamon Bay of Fig. 1 served as the office for the interns. The Laboratory is located directly on the beach, so close to the water that it requires a rock breakwater between it and the surf, because in high surf the wooden shutters closed over the glassless window openings are the only means of preventing spray from entering the building. The walls were erected in about 1680 but a concrete floor supports the furniture and a new roof covers this ancient building. With palm trees providing some shade and a constant sea breeze in the hot climate this was a beautiful place to work. Inexperienced sailboarders who rented boards a few yards from the lab provided entertainment on the beach during breaks. Snorkeling in the crystal clear water offered a way to keep cool. The team kept the two University of Maine computers and other equipment at the lab and worked creating models and organizing and storing data. Blackouts are frequent on the island, so surge protection is a must and the lab offered the only protected circuits available to the team. The power surges were reputed to be strong enough that Horton declined to plug her computer in at the hotel without a surge protector.



Figure 1. The Archeology Laboratory at Cinnamon Bay Campground served as the project base.

The Leinster Bay plantation site was located a few hundred feet from a sand beach in a deep valley. Wild selected the windmill used to raise water from a well and the factory used to reduce the cane juice for virtual preservation subjects. In addition a number of other structures in the area including a horse driven mill to press the juice from the cane, two other wells, slave quarters, and buildings of unknown use were to be located at the site. The site was completely overgrown by trees twenty or more feet tall, undergrowth, and vines. The terrain was steep and rocky, begging the question how sugar production could ever have been profitable in such an environment, particularly at the outset of development. The obvious answer was the relatively low (financial) cost to the plantation owners of enslaving Africans. These people were then forced to work the limits of human endurance. The team viewed the work to preserve these structures as a tribute to the history of these enslaved people and their survival in spite of the cruelty of the plantation system and those who enforced it. Some team members began to view the history of the slave era and sugar production with a different perspective upon undertaking this project.

Wild considered the cylindrically shaped windmill built to raise water from a well to be an important cultural resource to preserve because it is deteriorating and has a significant hole in its side (Fig. 2). Interestingly, the structure is not deteriorating at the existing open arch built to allow access to the water, but about a quarter of the way around the structure from the arch. Benjamin Jewell investigated the structural aspects of arches that kept the arch intact, and his report is available under separate copy. [3]



Figure 2. Bowie works with data at the Leinster Bay site with the water-drawing windmill in the background.

Daily Tasks

The team members spent the morning on the first day making sure all interns and volunteers had signed appropriate paperwork to work in the Park, organizing transportation and equipment, introducing ourselves, familiarizing ourselves with the Park and its rules, and so on. The team traveled to the Annaberg Plantation sugar factory, which has been partly restored. There Wild described the importance of documenting the ruins. Team members could see the buildings, follow the basic process of making sugar from cane, and learn about the extremely harsh conditions the enslaved people were forced to endure to build and work the plantations. "It was kind of eerie to walk through the area and think about what may have happened there," intern Ben Jewell said. [2] Interns expressed their interest in using their skills to preserve the important historical structures.

Starting at Annaberg, students were tasked with self-management activities. Only minimal planning had been performed at the University of Maine because none of the team members had visited the Park, the conditions for collecting data were uncertain, and even exactly what data would be possible to collect was unclear until team members arrived and assessed the site. Each day at the beginning and ending of the day, Wild, Horton and Holden asked interns to discuss the work organization for the day and the next day. Interns worked well together under this plan, and although it was time consuming, interns were practiced at being self-directed in teams. This was key to intern success the last two days after Horton and Holden left the island.

On the first and second day, most of the intern activities revolved around planning the best course of action to take. The team determined what data needed to be taken and the best strategies for collecting the data. Once these initial decisions were made, students formed subgroups to execute the various tasks of data taking. One team focused on surveying the buildings and terrain of the area using a laser transit, a second team directed their actions towards

taking and cataloging photographs of the buildings, and a third team undertook the task of hand-measuring the buildings and their detailed features. Although most of the interns stayed with their groups, a few members rotated throughout the groups as extra help was needed, and assisted with the removal of brush from the ruins.

Team members had to clear trees and brush from the structures before they could begin surveying, photographing, or measuring. Brush removal sounds straightforward enough, but the reality was otherwise. The team had to focus energy daily on clearing the day's work area of aggressive jungle plants over very rocky and rough terrain. Only Wild was qualified to use the chain saw to cut the thick growth. A half to a full acre of jungle needed to be cleared to complete the task. Trees, vines and bushes grew around, in, and on the structures. Bugs, bees, and vines that stuck to clothes and scraped skin made the effort difficult. The team built large piles of brush to secure clear survey sights, photographs, and physical measurements.

Teams spent the remainder of the first week performing their subgroup tasks. While the surveying team continued their work throughout the second week, the rest of the interns refocused their activities, as most of the ground measurements and photographs were taken. One group began making preliminary MicroStation models, and another group began working in Photoshop to mosaic the digital photos together in order to make material files for the model. Through their work, these groups were able to create a basic MicroStation model, and in the process determined where the current data was lacking. They were able to go back to the site with a better idea of what was needed and take more photographs and measurements to fill the gaps in the data (Fig. 3). The second week also saw the creation of a new team that worked (through many technical difficulties) to take GPS points of the buildings and survey hubs throughout the site. Finally, on the last day, most of the time was spent organizing and consolidating data to make sure that all necessary information and photographs would be able to safely and successfully return to Maine.



Figure 3. Graham, George and Pershern cut brush, measure, and photograph at Leinster Bay.

Michael Morris provided a brief overview of the team activities at the Leinster Bay site from the perspective of an intern:

“On site activities:

The work done on the Leinster Bay mapping project for the Virgin Islands National Park was performed by 12 interns, over a span of two weeks. Eight of these interns were from the University of Maine, and four were already working for the National Park Service in the Virgin Islands.

Self-supervision by students:

In accordance with suggestions from faculty and Ken [Wild], the group divided itself up into a number of different task-oriented teams during daily morning planning sessions, and mid-afternoon wrap-ups. These teams were self-organized by skill and interest matching, with a couple of students acting as ‘floaters’ between the groups. These tasks, and the students primarily involved in them included:

Brush removal – all

Surveying – Alex [Stace]

Ground measurements – Warren [Peters], Greg [McKenna], Brendan [Horton]

Photography – Amy [Crosby], Suzanne [George], [Daniel Bowe]

GPS – Ben [Jewell], Mike [Morris]

Brush Removal:

Though some cleanup had been completed previously by Ken [Wild], the ruins were still mostly overgrown by thick vegetation. The initial work consisted of the entire team working to cut down the trees, vines, and other growth from around the ruins, and haul it to piles located away from the ruins. This brush removal enabled clear access to the ruins for subsequent photography and mapping activities. Throughout the two-week period, other areas were cleared as needed.

Surveying:

Surveying was done with a Nikon DTM 551 total station unit (laser transit) to obtain a series of points that detailed the positions and elevations of the buildings and terrain of the site. The surveying was performed by a crew of three workers: one operating the unit, one taking notes, and one holding a prism at the various points to be mapped. This group began by setting up a series of seven hubs, which all other points were taken in relation to. These hubs were also located with the GPS (Global Positioning System) so that the points could be properly aligned with the GIS software. After the hubs were set up, the group proceeded to map the corner points and other key features on the buildings along with a series of terrain points in order to establish an accurate topography of the site.

Ground Measurements:

A second team of three members worked with a tape measure, taking ground measurements of the site. These were taken in order to establish a basic site map and to obtain more detailed measurements of the buildings’ features for the three dimensional MicroStation

model. This team moved around the buildings, with two members operating the tape measure and the third recording horizontal distances between all key features onto a hand drawn site map. The ground measurement team successfully produced a site map containing wall lengths and widths, and the dimensions of doorways, windows, archways, holes, posts, and basins (Fig. 4).

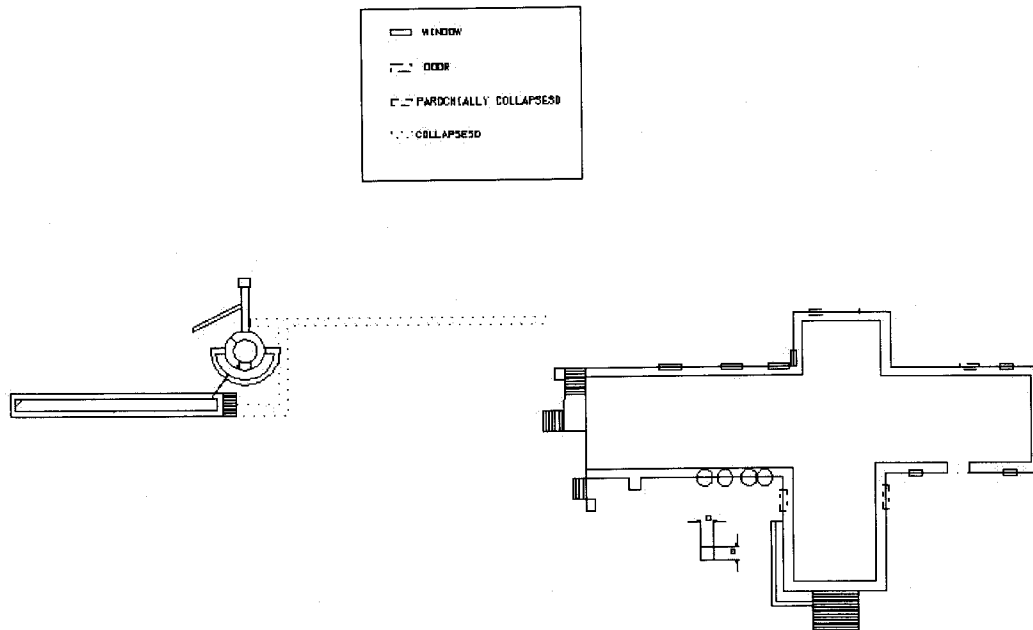


Figure 4. Students drew a simple MicroStation site map of windmill and factory at Leinster Bay.

Photography:

The camera used for on-site photography was a brand new Nikon Coolpix 5000. The method used for the majority of the photography was to stand near the center of the wall, approximately 10 feet away. The photographer's position and the camera settings were kept constant while a series of photographs were taken. Attention was paid to ensuring all parts of the wall were included and that the photographs overlapped as much as practically possible. A sketch for each wall face that was photographed was drawn onto a sheet of paper. This was of great benefit when we later organized the photo images for stitching.

GPS:

The last team used a Trimble Pro XR/XRS GPS unit equipped with TSC1 Asset Surveyor to take a series of GPS points in order to create a Geographic Information System (GIS) map of the ruins. The GPS unit was set to collect data in Universal Transverse Mercator (UTM), zone 20, using the North American Datum 1983 and the units were set to meters. They moved around the site with the GPS receiver to collect a series of coordinates of the surveying hubs, corners of many of the buildings on site, and an outline of the nearby shoreline. These points were uploaded into a computer, and using Pathfinder Office, the team was able to create and place a digital map of the Leinster Bay site onto a map of the world."

Students have further detailed each of the activities in the following appendices:

Appendix 2: Surveying

Appendix 3: Ground Measurements

Appendix 4: Photography

Appendix 5: GPS

Horton tasked several interns to take special roles during the second week to be sure the data being collected was useful, organized and available once the team returned to Maine. McKenna performed initial MicroStation modeling at the Park in order to check the round measurements. Crosby worked in PhotoShop to get photos ready to be used in the model. They were successful at displaying some of their work to local reporters on March 10, 2004, which resulted in a number of press releases. George kept the photos organized and documented. Peters managed the data collection and organization related to the modeling. Interns performed these special tasks conscientiously and the data was well organized for later use.

Team members returned to Maine ready to continue with the remaining tasks of continuing to model and documenting their work.

March 15 – April 29, 2004: MET 220 Student and Faculty Efforts

Modeling the Structures for Virtual Preservation

Stinchfield compiled a description of the activities completed by students in MET 220 following the return of the interns with the data from the Leinster Bay structures:

“Develop Three Dimensional CAD model of the Terrain

The goal of this section was to create a useful and accurate three-dimensional model of the local island terrain where buildings are located. This model was needed in order to place the buildings in their correct location. Archeologists will need to know information such as locations of buildings in case they want to perform new digs in those locations.

This model was generated with a combination of data from a contour map and surveying data. A contour map is basically a topographical map with only the lines that represent change in terrain height. This data was combined using Global information systems (GIS) software and 3d modeling software (MicroStation) to build a 3D model.

Develop Three Dimensional CAD model of the Buildings

The goal of this section was to create a useful and accurate three-dimensional model of two of the local island buildings. These models were needed to be completed before the buildings fell to the ground. Using three-dimensional modeling is a good way to preserve the history of the island.

In order for the models to be useful they needed to have enough information stored on them. This means that the models needed to basically look identical to the buildings that were on the island as they were seen at that point in time. A good approach for completing this task is to use a three-dimensional modeling program. The program of choice is called MicroStation.

Using MicroStation, it is fairly easy to make a model of each building showing what the outline of each building looks like (Fig. 5). However, it is much more difficult to draw these buildings accurately without having accurate measurements. This was one of the main reasons why the trip to the Virgin Islands was necessary. It is also very difficult to get accurate measurements from photographs for various reasons. When a camera takes a picture the lengths do not get scaled down or up linearly because the lenses are not flat, they are concave. This means that the middle of the picture will be scaled linearly but the outer edges will not be. Knowing this fact we could utilize the middle of the pictures for our models. Some parts of the pictures were imported into MicroStation and traced around to get the basic shape of the buildings for they were not regular in shape. This technique along with measurements taken on site was utilized to model the buildings.

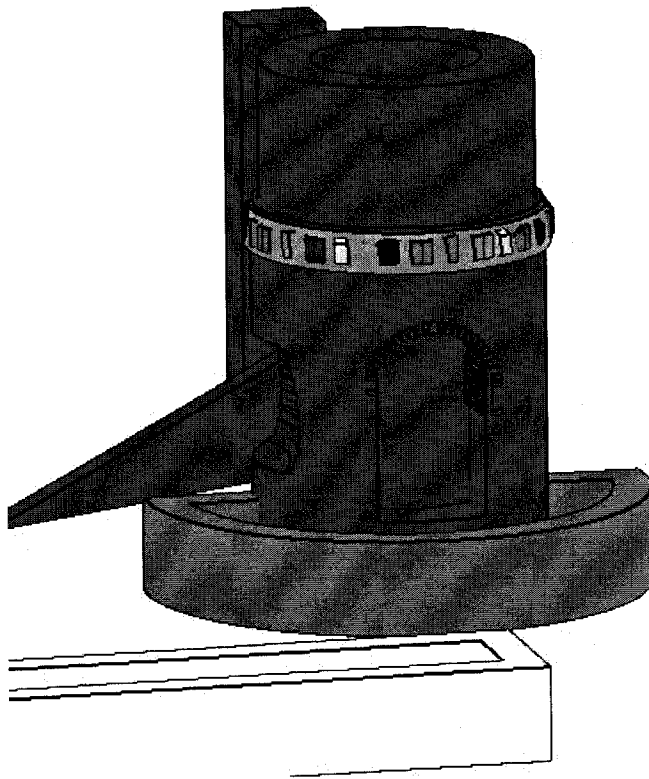


Figure 5. A filled wire-frame rendering of a model of the windmill displays structural details.

Apply Photos to Models

It is necessary, from an archeological standpoint for the buildings to show where bricks had already caved in or where partial walls are missing. In order for the drawings to look identical to the actual buildings on the island, pictures needed to be attached to the file. This process is called creating materials from photographs. The materials that get created look like the rocks or even whole walls that were used to build the buildings. These materials get applied to the models in their respective positions after the basic outline of the building is done (Fig. 6). This part of the process is necessary to make the buildings look identical to the way they look in the Virgin Islands.

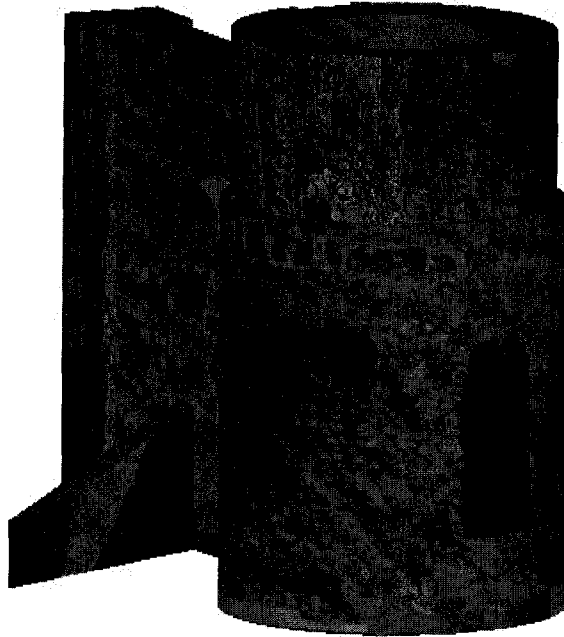


Figure 6. Photographs were stitched in PTGui and applied to the windmill model.

Deliver Model Resulting

There is a utility in MicroStation that allows users to package all of the photographs and materials used on the model, so that when the file is saved to another location or emailed to another person the model can be viewed in the way the file was originally made. What I mean by this is that the model can be viewed by anyone who opens it with MicroStation, even if the computer that they are working on doesn't have files that contain pictures taken from the island."

Detailed instructions for working with multiple users, creating specific types of structures, and using materials created from photos are described in Appendix 6: MicroStation Methodology.

The final goal of creating a three-dimensional model of the local topography of St. John and applying models of structures at their specified locations on the topography was not completely successful as not enough data points were collected. It was thought that the U.S.G.S. two-foot contour map could be used for this purpose, however it was discovered that the data was collected at twenty-foot intervals, and that the two-foot contours were computer generated. This was not adequately accurate at the scale at which we were modeling. The process of creating the topographical model required use of a topographical map. The process was documented in Appendix 7: Merging Terrain Model and Survey Data.

The Geographic Information System

While all of the students in MET220 had some introductory GIS experience, none had sufficient experience to develop the GIS required for this project, so this task fell to Holden. While the

final project was to be in ArcView 3.3, much of the development work was completed in ArcGIS 8.3. Holden used data from the United States Geological Survey and an aerial image of the island into ArcGIS 8.3. She then imported the survey and GPS data, with the MicroStation models of the structures. From this she created a basic ArcView3.3 project with metadata. Details of the GIS are included in Appendix 8: The Geographic Information System.

Challenges

As team members began to work with the data, the team members' lack of background specific to the virtual preservation task caught up with them. The project turn-around time was very short and only minimal planning could be accomplished before the researchers reached the site. Several problems with the collected data will be improved in the future now that the researchers are familiar with the area. Improving the surveying, and GPS measurements, photographic techniques will improve future outcomes. Ash documented some improvements in data taking for future teams:

“Upon returning from the trip it was discovered that certain preemptive measures would have been beneficial. An organizational plan before going to the island would have resulted in more productive work on the island. There should also have been an organizational system for data set up before the data was taken. More training in the GIS and MicroStation systems would have been productive as well. Training on how to take dimensions and how to take pictures in order to retrieve dimensions from them would have saved time after the trip. Previous practice and knowledge of the GPS equipment and software would have saved time on the trip. It may also have been beneficial to split into specific groups early on in the class, depending on interest and previous training.”

Horton arrived at St. John at the beginning of the data-taking phase without knowledge of surveying techniques, and Wild, who can survey, had encouraged Stace to start surveying. However, Wild was also active in a variety of other endeavors on site and off including using the chain saw to cut brush, interacting with other scheduled visitors, discussing the project with the Friends, and seeking appropriate publicity for the project. Stace was not adequately experienced to plan the surveying optimally. This made later data analysis difficult. The project would have been served by careful planning and supervision by a knowledgeable surveyor while acquiring the initial survey points to be sure they could be easily and accurately correlated later to GPS points. Holden arrived later, but the difficulty in using the survey data was not evident until return to Maine. Holden had to perform some corrections of the surveying data to align them with the GPS data, which required Holden and Stace to dedicate unanticipated hours to the effort to locate the structures on the topographical model.

Some initial work in PhotoShop made evident that a program more specific to stitching photos together would be required to obtain photos that could be applied to the model. At that point the investigators recognized that they required a background in applied photogrammetry to obtain appropriately taken and rectified photographs. Team members worked to stitch photos in two other software packages and finally settled on PTGui. However, photos should have been taken using an appropriate photogrammetric camera to assure that all photos were of the same scale

and camera angle. Interns should have taken photos using an appropriate camera from known distances, using a tripod and a defined camera angle, with leveling rods or similar instruments in the photos. The difficulties of using the photos in MicroStation became apparent only after many hours spent by Callahan and Crosby to perform the stitching. Holden researched photographic techniques for virtual preservation projects in Greece. That research made clear that there are still many technical issues to be resolved in this area. Holden and Horton plan to continue investigating these issues.

Team members now understand how to prepare for and plan future data collection. The data collected is useful, but future efforts are expected to be more efficient.

Reporting

In addition, as is evident from this report, students spent a good deal of time documenting their work. Horton assigned students to document areas of work they were directly involved in and therefore familiar with. Murray Callaway of the University of Maine English Department also helped Horton organize the many pieces of writing provided by students into a single report. His guidance allowed students to make efficient progress with their writing tasks. Wild, Horton, and Holden were all keenly interested in accurately documenting the project as a proof of concept to determine if the method should be pursued further. Horton had to pull the students' works together and write the body of this report, the task being too large for students to complete in the available time.

Project Achievements

Photographic Data

Having extensively photographed the structures after clearing the brush away from them is one achievement of the project. The photos were delivered to Wild immediately after the interns completed taking and organizing them. They are located on compact disks (CD's) and Appendix 4: Photography describes how they are organized on the CD's. These photographs were adequate to demonstrate the concept that photos can be applied to CAD models to implement virtual preservation. However, there are still many photographic challenges to overcome in order to develop standardized techniques.

MicroStation Model

As a proof-of-concept project, students developed a 3D CAD model of the windmill to raise water with photos applied, and the model was placed on a surface model of the area. Students also organized a method by which a number of people could efficiently work in the School of Engineering Technology computer laboratory to model structures from the data taken. This is important in cases in which several people are modeling parts of the same structure at once.

Terrain modeling relied on a topographic map of the island. It was determined that a more precise means of defining the local topography is necessary for a very accurate MicroStation model of the terrain. However, students were able to produce a 3D model of the terrain from the given data; more precise data will yield a more accurate model.

Holden and Stace were able to locate the survey points and therefore the structures on the terrain model, but the effort can be made more efficient by better planning prior to taking data.

Students were able to quickly model the overall shapes of the windmill and the factory. These rather general shapes are appropriate to place on the terrain model to visualize the site as a whole. This method was effective and repeatable.

Students developed good methods of performing detailed modeling of areas such as the hole in the side of the water mill, or irregular window openings. Their methods can be better applied in the future if the photographs can be rectified then used to make direct measurements of the structures in MicroStation.

Again, a number of technical issues must be resolved. There are limited guidelines under development regarding the accuracy of the measurements from which models are to be developed. The structures are irregular at best, and when in ruins, involve tumbles of rocks. There are no clearly applicable standards guiding preservation in terms of model dimensional accuracy, its accurate depiction of the preservation site, or even which parts of a structure must be modeled. For example, in addition to the model with photographs applied, students also developed a more complex model that depicted some of the structure of the building. The importance of accurate structural models, as opposed to photographic based models, is unexplored. There is significant development work required to develop standard techniques.

Holden is continuing to investigate the photographic techniques required. The technical field making use of photographs to measure the subject of the photographs is called photogrammetry. The team had been planning on using the photographs as a means of measuring vertical distances on the buildings, but the precision of the measurements on the photographs taken is limited. Accurate measurements from an image can only be measured if the image is orthographic; that is, directly perpendicular from the viewer and as if it were an infinite distance away so that the measurement scale of objects is uniform over the entire photo. This is never true for photographs; for example, if an item is far from the lens it appears smaller than if it is close to the lens. Using techniques from photogrammetry, photos can be rectified so that measurements can be taken from them, but the photos must be taken from a known distance, with a known camera angle, and specific control points on the photo must have known relative measurements from one another on the subject [4].

The photographs taken during this project did not meet this rigorous standard. While they are useful in and of themselves, they can only be used for imprecise measurements of irregular features.

Additionally, these photographs are difficult to apply to the models of the structures for the same reasons. Much of the time students spent working to complete a model that would "look like"

the actual windmill was spent trying to use photographs that did not meet the rigorous technical standard.

Wild envisions having realistic-looking models of the structures to preserve them for future study. Engineers require a stronger standard to use than the concept "realistic" to complete the modeling. What one person sees as "realistic" another might see as "cartoonish." In future efforts individuals applying technical skills to virtually preserve important cultural structures will need to understand the precision and accuracy that cultural preservationists require.

The MicroStation models of the windmill and of the factory have been delivered to Wild on CD.

Geographic Information System

The GIS was completed with three Views: the plantation site, the photography of the water mill and the photography of the factory build. The database design is complete, but the database is still missing a significant amount of information. It was hoped that a simple 3-dimensional scene could be built within the GIS, however, the twenty-foot contours were too widely spaced for a good representation, and the two-foot contours were not accurate enough for that task.

Conclusions and Recommendations

Project Achievements

This project demonstrated that this concept of virtually preserving the sugar plantation structures in the Virgin Islands National Park is viable. Although a number of specific techniques require further development, when those techniques have been developed and documented, much of the process will be accessible to students in technical career fields at the undergraduate level, and to students and professionals in archeology or cultural preservation who choose to learn and specialize in the methods. This method could become a cost-effective means of accurately documenting the location and structural details of many structures through 3D CAD modeling, photography, and a related GIS.

The factory area of the Leinster Bay site in the Virgin Islands National Park has been cleared and photographed. Ground measurements, survey measurements, and GPS measurements have been taken to size and locate several of the buildings. 3D CAD models and a GIS have been started. For some structures photographs have been applied to render somewhat realistic depictions of the structures. A rudimentary terrain model for the local area has been created in 3D CAD and extended in a GIS. The buildings have been located accurately on the terrain models. Other information about the measurements taken has been added to the GIS.

The photographs and models have been delivered to the Park Service. This report of the project activities is the outstanding deliverable to the Park to complete the University of Maine service-learning project under the course MET220: CAD Modeling of Archeological Structures.

Recommendations Regarding the Leinster Bay Site

Before proceeding to new sites to virtually preserve, the University of Maine Principal Investigators recommend that more work be performed at the Leinster Bay site in order to develop repeatable procedures and improved outcomes. Some recommendations include:

1. Develop photographic methods for taking and processing the photos to apply to the models.
2. Using appropriately defined methods, take new photographs at the Leinster Bay site.
3. Using appropriately defined standards, process the new photographs and apply them to the structural models.
4. Develop a definition of the measurement methods and allowable error in linear and angular measurements of irregular structures.
5. Using appropriately defined standards, if necessary measure the site again.
6. Develop standards for performing the modeling regarding level of detail, important structural details to be included.
7. Using appropriately defined standards, further develop the structural models.
8. Identify or collect adequate data to develop a detailed terrain model, minimally at the sites of interest, and define how many points are required based on terrain change or other technical factors influencing the modeling.
9. Using appropriately defined standards, apply the structural model to the terrain model.
10. Compare the outcomes of the standardized method with those of the methods used in this project.
11. Continue developing the GIS model of the Leinster Bay site to include information about the standards, the equipment, and other relevant research areas.

Long Term Recommendations

The University of Maine Principal Investigators expect that standards for virtual preservation techniques will evolve as researchers continually seek to apply the best know processes to the task [4]. The community must develop a clearer definition of virtual preservation. The definition and standardized procedures will address issues within the relevant preservation or archeological communities regarding how much information is enough, how accurate the information must be, and what techniques for analyzing, recording, and displaying the data are satisfactory. While the definition might change as new data collection techniques become available, the definition should incorporate provisions to allow cost effective virtual preservation. The technique will be useful primarily if it is less expensive and as permanent as physical preservation.

Organizations commissioning or performing virtual preservations will need to commit budget to the long-term archiving of those preservations. Any computer-generated models are at risk, because the potential for the physical media to become unreadable is great, either because hardware or software to read it is no longer available or because the media becomes corrupted. One need consider only the development of storage media in the past twenty years. For example, 5.25" floppy disks and drives standard twenty years ago are no longer available. Since then 3.5" floppy

disks have also become nearly obsolete; zip disks are now available with two different storage amounts, read-write compact disks and player/writers are widely available, as are memory sticks for the USB port. Software written for computers twenty years ago is obsolete because all forms of long-term and computational memory and speed in desktop computers has increased hundreds-fold if not thousands-fold. The storage media and software must be continually updated and the models regularly translated into newly developed software.

Final Notes

University of Maine students have repeatedly asked if the project will continue. Although the faculty members involved are committed to continuing, funding has not yet been secured for future travel or salary requirements. Both faculty members are fully committed during the academic year and are not able to accept overload assignments routinely. Securing a sizable grant to support this service-learning project will be necessary to continue the level of commitment demonstrated through this project.

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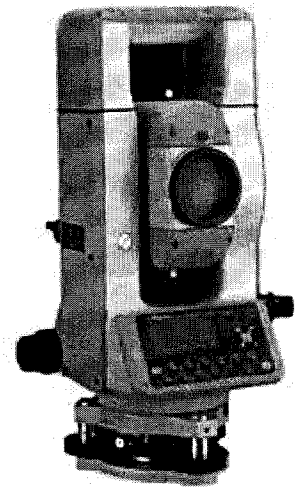
Appendix 1: Equipment List

Compiled by Benjamin Jewell

Surveying and mapping:

Total Station Unit

- Nikon DTM-550
- Used to map terrain, calculate height of structures, and map locations on site.
- Specifications can be found at http://www.georgiasurveyors.com/specs/n_dtm-500.html



Global Positioning System

- Trimble Pathfinder Pro XR backpack receiver
- Trimble TCI-21 handheld data collector
- Pathfinder Office 2.2 GPS software
- Used to map structures and surveying data points to orient site on the Earth.
- Specifications can be found at <http://www.trimble.com/pathfinderproxrs.html>



Photography:

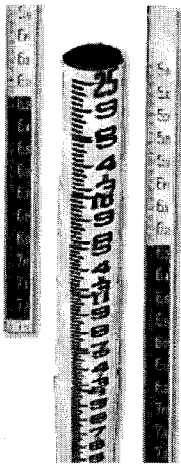
Cameras

- Two Nikon CoolPix 5400
- 64 Megabyte memory cards
- Used to photograph structures to obtain measurements. Also used photographs to 'skin' 3-D structures drawn in MicroStation.
- Specifications can be found at <http://www.nikonusa.com/fileuploads/pdfs/coolpix5400.pdf>



Leveling Rod

- 7 meter leveling rod
- Used to scale photographs
- More specifications can be found at <http://yoas.net/supplies2.htm>



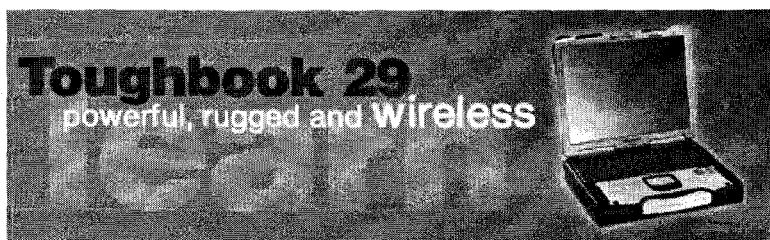
Jungle Clearing:

- Machetes
- Clippers
- Chain Saw
- Herbicide

Miscellaneous:

Computers

- IBM Thinkpads
- Windows XP operating system
- Used to produce preliminary MicroStation models, edit photographs and keep a daily activity log
- 1 Panasonic Toughbook
- Used in the field (made for the field)
- More specifications can be found at
http://www.panasonic.com/computer/toughbook/learn_more_tb29.asp



Software

- MicroStation V8
 - <http://www.bentley.com>
- ArcView GIS 3.3 & ArcGIS 8.3
 - <http://www.esri.com/software/arcview/>
- Photoshop 7
 - <http://www.adobe.com>
- PTGui
 - <http://www.PTGui.com/>

Appendix 2: Surveying

Compiled by Alex Stace

Introduction

Surveying was done with a Nikon DTM 551 total station unit (tsu), alternatively referred to as a transit or laser transit, and owned by the National Park Service. A crew of three workers performed this, with one operating the unit, one taking notes and one moving the prism.

Objectives

The objectives of the survey were to generate data for

1. elevation data to place the buildings on the terrain and in relation to each other;
2. accurately locate buildings in relation to a series of hubs, which were GPS located to allow the points to be aligned with GIS software.

Theory

Numerous points were taken, in an attempt to have enough points to accurately locate the structures on a three-dimensional model of the island topography.

Methodology

Overview:

The corners of buildings, objects and terrain features were measured while traversing the site from a number of hubs.

Equipment:

Nikon DTM 551 total station (tripod, unit, prism pole)

Deciding what to measure:

1. generally any square object can be defined with 2 or 3 points
2. Terrain points are good, run lines to help locate on terrain
3. building heights can be quickly measured
4. keep a good map of your points
5. try to measure everything needed from a point in on setup
6. terrain pts on level ground are rather pointless

Basic Setup:

The unit consists of a tripod (with cap), the Prism pole, with the prism stored, capped, in the instrument case. The instrument itself is in the case, as well as the manual, several papers on operation and setup, a plastic shield for light rain, a plum bob and the data cable. The instrument's battery is the top of it and looks like a handle. It is removed by rotating the tabs and pushing them in. (Even though it looks like a handle and can probably support the unit, do not

carry it by this. Many similar instruments only have an instrument rail that looks the same, but will be likely to break. You DO NOT want to drop something worth more than your car....)

Basic setup is the same as any instrument. Set up the tripod at a reasonable height, centered though the screw over your point (you need a small point to focus, a pen dot works well). When it is centered and visibly level, attach the instrument (DO NOT OVER TIGHTEN). Then using the screws, center the instrument over the point while looking through the centering sight. When it is centered, adjust the legs until the bull's eye level is centered. After the bull's eye is centered, center the instrument by partially loosening the mounting screw and sliding it on one axis at a time. After this check the fine level and adjust the screws until it is accurate.

Most of the following is explained in detail in the manual if you can find it. It is randomly organized:

1. turn on the power (button on either panel)
2. plunge scope
3. go to menu
4. check settings
5. go to job, and create a new one with whatever name
6. instrument will reset in new job
7. hit the STN button
8. hit known
9. input the point
10. it will prompt you for a number (call it pt 1), the instrument height (measured from the cross parallel to the scope, then ask you for the coordinates. As this will be your datum, input 0,0,0. It will then ask you for a backsight.
11. Setup a backsight hub a distance away in a sensible direction (north is good, but may not always be feasible). Tape the distance (will be your X value, so input it as a negative) then continue inputting the backsight, giving it a name (pt 2), coordinates (measured distance,0,0 though last number will be different if the ground is not level) and finally backsight on it by focusing, and hitting MSR (it will ask you for prism height).
12. There are simpler ways of setting up, such as quick station, but unless you are 100% sure you will only be working off of the datum do not use this.

You are now ready to begin measuring

By hitting the DSP button you can cycle through 4 different displays. I find 2 to be the most useful as it gives azimuth, horizontal and vertical distance.

When you wish to begin taking points, simply set up the prism, aim at it and make sure to FOCUS. Then hit measure and wait until data is returned.

This data can be written down (I recommend it). Then hit the REC button to record. It will ask you the prism height (default is previous, so it's simplest to pick a height and keep it at that. The point number will increase incrementally, depending on what you are doing and how you like to

work you may want to create gaps between points at different hubs (I do). You can also add 8 or 10 character labels to each point.

When you wish to set up additional hubs to measure from, simply create points, and save them with hub names for easy reference (make sure you WRITE IT DOWN). When you want to work from another hub, you must have created it as a point previously. When set up on it, got to STN, Known. Then input the point number and instrument height. Then choose azimuth for your backsight and MSR to the prism. Now the instrument is set up to measure and record in X,Y,Z coordinates from the datum. (You need to do this every time you setup on a hub, and it's a good idea to check if you turn off the instrument and come back to it later)

Download/conversion:

1. attach dongle to parallel port on field computer
2. hook up cable between TSU and 25 pin serial port (check pins and slots on tsu)
3. start surveylink
4. go to download, select the proper instrument and check the settings
5. Set the output file and give it a .trn extension
6. Turn on TSU, plunge and hit menu, check the setting to make sure they are the same as on the computer
7. Got to comm and get ready to transmit
8. Go back to the computer and go through the last few dialog boxes until it says waiting to received
9. Hit transmit on the TSU and the data should both be visibly being transmitted on the TSU and being received on the computer.
10. Go to convert and select the .trn file
11. Convert it to a .rw5 file
12. Open the .rw5 file (the data will open up and if you understand surveying concepts it should make sense)
13. Go to convert, select coordinates and convert the file to a .crn file
14. The new file will open
15. Now convert the .crn file to AutoCad DXF file, an ASCII 2 file, and any other formats that will be useful.
16. Make sure you keep all files and the original data together in a meaningful way

Discussion and Conclusions

Possible problems:

If it gives you coordinate errors when trying to do the first translation, you have conflicting zero points. I had this problem and rectified it after figuring out how the basic code works. You can split the traverse data into different files in notepad on the basis of the conflicting starting points. Then run it through the conversion.

Software use of survey data:

All files can be opened with a text editor.

The survey program dumps data into .dxf format. This is AutoCad format, but can easily be opened with MicroStation and ARCVIEW.

When opening a .dxf file in MicroStation it looks two-dimensional but is really three-dimensional. The file is composed of four layers, one being the point entities, one being Numbers, one the labels and one Z values. The text labels need to be selected and shrunk to a reasonable size (.2 and .3 is good). Then the labels layers need to be selected and moved closer to the points.

A raster image of the site can then be attached and applied to the background to aid use (aerial photo would be great).

Select labels and points such as terrain or hubs and create new layers for them with different colors. This lowers clutter and makes point easier to recognize.

Buildings can be formed by connecting points with lines. If this is done from an orthogonal view, the smartlines will snap to the points in 3d creating a 3d outline of the ground level of the building. This should be done in another layer.

The file then should be saved in both DGN format for placing buildings on the layout, and DXF for use in ARC.

Check your points against the sketch. They can be wrong!

Appendix 3: Ground Measurements

Compiled by Michael Morris

Introduction

Ground measurements were taken by hand with a tape measure to supplement the surveyed measurements of the buildings on the site. Although the surveyed measurements are more accurate, it was impractical to take exact survey points of all the building features due to time constraints and the complexity of the buildings mapped. Only key points such as corners and openings (holes) were surveyed on the buildings and measurements to more detailed features were made by hand. Using the hand measurements allowed for the rapid production of a basic ground map of the site.

Objectives

The team obtained the horizontal dimensions of all key features on the buildings. These features included, but were not limited to wall lengths and widths, doorway and window widths, and the dimensions of archways, holes, posts, and basins.

Methodology

Overview:

To take ground measurements one moved around the building, measuring with a tape measure the distances between all key features, while recording the measurements onto a hand drawn site map of the building.

Equipment Used:

Long, metric tape measure (50+ meters)
Graph paper

Step-by-Step Process:

1. Set an approximate scale and north arrow for the site map drawing on graph paper (ex. 2 squares = 1 meter).
2. Establish a key for drawing (doorways, windows, staircases, etc.).
3. Determine a starting point on the structure for taking measurements, and label it on drawing.
4. Starting at that corner point, measure along wall to first important feature. Where features lack definite edge due to collapse/erosion estimate the distance from whatever remains of the structure.
5. Record measurement with a drawing of its shape and estimated size onto graph paper.
6. Continue measuring from each feature to the next along the outside of the structure, recording each distance.
7. If the scaled structure exceeds the paper size, clearly label the last point and continue drawing on a new sheet of paper starting from that point.

8. If any feature requires special descriptions, label with numbers and write a description of the feature and its dimensions at the top of the page.
9. Once the measurements for the outside of the structure are complete, move to the interior wall and repeat process
10. Complete site map by taking a number of wall widths at different points throughout the building.

Results

Using the steps above, the ground measurements team produced a fairly detailed, hand drawn site map with the important dimensions of the buildings. The measurements collected were imported into MicroStation to produce an initial two-dimensional map of the site (see attached site map).

Discussion and Conclusions

The process developed to take ground measurements proved to be fast and efficient for generating a basic site map in MicroStation. Also, it provided some of the more detailed dimensions important to the three-dimensional MicroStation model.

Despite its overall effectiveness, minor problems with the process led to some inaccuracies in the distances. These problems included:

1. General inaccuracy in estimating edge points of collapsed and disintegrated features.
2. Difficulty obtaining accurate measurements in some places due to vegetation growing in and around walls
3. Difficulty ensuring the tape measure was horizontal for all measurements.
4. Lack of agreement between measurements of parallel walls that should have been very close to the same length.

Since all hand measurement data was used in conjunction with survey data, these inaccuracies were not detrimental.

Recommendations

Some recommendations to individuals making similar ground measurements in the future would be to:

1. Attempt to clear all nearby vegetation before taking measurements.
2. Establish a usable scale, key, and naming system before making the hand-drawn map on graph paper.

3. Take the maximum length measurements for each wall, and measure all features off these edges. This will avoid any compounded error created by taking measurements in succession around the structures.
4. Use a level along with tape measure to ensure only horizontal distances are taken.
5. Take as many measurements as possible the first time through to avoid returning to the site after the modeling has begun.

Appendix 3: Photography

Compiled by Stig Callahan, Amy Crosby, and Suzanne George

Introduction

Photography is an integral part of the final Leinster Bay model. The photographs are directly applied to the 3-D models as skins for a realistic image. Photographs of the modeled buildings are vital to the completed drawing because the tools of MicroStation cannot create a photorealistic image.

This report provides a detailed description of the photographic applications used on the Leinster Bay model. First, each building or ruin was systematically photographed. Each photograph was edited with Adobe Photoshop 7.0 and PTGui and stitched to several other photographs, adjusting color, contrast, brightness and cropped in to produce a two dimensional skin in .jpg format that can be used in MicroStation.

Objectives

1. Outline the photography process while on St. John
2. Provide detailed descriptions of manipulating the photographs used in the 3-Dimensional MicroStation Model
3. Describe techniques and procedures for applying photographs as materials in the MicroStation model.

Theory

Digital photographs taken on the island of St. John can be stitched together and applied to a 3-Dimensional MicroStation model of the ruins. Applying a 2-Dimensional photograph to the model in MicroStation results in a reproduction with actual images attached for photorealism and future archeological analysis. Applying photographs provides documentation of the current state of the ruins. Since the model will be used for future archeological research, this level of detail is necessary.

Methodology

On-Site Photography Challenges:

1. remembering to bring media reader
2. remembering to put both cameras in the same mode/resolution
3. consistency of distance from objects photographing
4. remembering to have scale measuring stick in all photos
5. getting directly perpendicular to object photographing
6. running out of memory
7. maintaining consistent numbering system

8. keeping track of organization of diagrams and corresponding pictures to diagrams
9. getting photos that were useful for modeling (we had a modeler go out with photographers to ensure good shots from a modeling perspective)
10. stitching photos—lots of color/contrast issues when stitching
11. starting with a clean memory card each morning
12. storing of photos
13. naming photos with consistent names with GPS/site map etc.

Joining Photos in PTGui:

1. To stitch your photos in PTGui, first place your images in a location that is convenient, but not the desktop. Working out of the desktop has caused problems in the past.
2. Launch the PTGui application. The wizard should pop up and it will guide you through the whole process. If you prefer, close the wizard and just move through the program sequence according to the task tabs (load images, panorama editor, etc.)
3. Select the type of panorama that you want to create. This should be either 'partial single row' or 'multi-row panorama'.
4. Click on the load images button. Use the provided directory to select the images that you want to stitch then click OK to load the images. If you have loaded a lot of photos, it may be beneficial to arrange them in any order that makes good sense to you. To do this, close the wizard and select the *Source Images* tab on the main screen. The program will call the images (1,2,3,4,5...) but you can choose which image will be called #1 and which will be called #2, etc... use the buttons at the bottom of the screen to rearrange the photos as you like. If you want to use the wizard again, it can be launched with CTRL+W.
5. Open panorama editor. Choose rectilinear projection. Left click to move images to around the canvas. Right click to rotate images. Buttons at the bottom of the screen may help you. You can select a single image to move/rotate. You can select all move/rotate. Once the images are all approximately lined up where they should be, close the panorama editor and start laying down control points.
6. Use control point editor to tell PTGui where to stitch your photos together. This is done by selecting a photographic feature that is common to both images, and identifying those two points with a control point. Accurate placement of these points is critical to success so take your time. Pick only those features that stand out in both photos. Fair stitching can be done with as few as 4 control points, provided that they are accurately placed. Basically, the more, the better so don't be afraid to put a dozen or so control points per pair of photos.
7. PTGui v3.3 has crashed in the past when using the scroll arrow buttons to pan through an image. I recommend dragging the scroll bars to pan and save your work often in case you forget and click one of the arrow buttons.
8. Next, run the optimizer. The run optimizer button is in the lower left hand side of the optimizer screen. This will tell you how well you did at accurately placing your control points. If it returns with poor results, you should go back and adjust your control points. When the optimizer returns good results, click OK.
9. Create a preview of the stitched image to make sure it will appear as you desire it to. If the preview looks skewed, go back to the panorama editor and re-center the images by moving them all at once. To do this, use the button called 'edit entire panorama' at the

- bottom of the screen. Re-run the preview. When the preview looks the way you want it to, save your work and then finish the stitching process by creating the panorama.
10. To create the panorama, first specify the output file in the space provided. The name must include the full path. It is easiest to use the browse button to specify the path and then type in the name you want to call the final stitched image.
 11. Once click on the create panorama! Button, it may take several minutes to complete the stitching process. If you are stitching several photos, this will take much longer. 16 photos can take upwards of a couple hours.
 12. While you are working, save your work frequently!

Problems with the program that we noticed (PTGui v3.3):

- 1) Working out of the desktop causes problems during the stitching process.
- 2) When using the control point editor, using the scroll arrow buttons (onscreen) sometimes causes program to crash.

Joining Two Photographs Together Using Photoshop:

1. Right-click on the photographs you wish to join together, and click open with -> Photoshop.
2. Use the **arrow tool** in the Photoshop tool menu, located on the left of the screen, to drag one picture onto the canvas of the other picture. It doesn't matter which, just as long as they are on the same canvas.
3. Double-click on the layer menu at the bottom right of the screen that says **background**. When the background layer dialogue box pops up, click ok, and the layer is no longer a background, but a workable layer.
4. Scroll down on the **edit (?) menu** until you find **canvas size**. Change the units to percent, and make the height 200% and the width 300%.
5. Drag both pictures apart on the screen so you can see all of both of them.
6. Select the **crop tool** from the Photoshop tool menu, and, by clicking and dragging on the photo, select a column reaching from the very top of the photograph to the very bottom, but cropping the sides off the well. Click again, and the outside edges of the photograph should appear darker.
7. Hit enter, and the part you cropped off should disappear.
8. Do this to the other photo as well. Be sure to see where the two photos overlap so you don't cut off too much from the sides.
9. On the right-hand side of the screen, there is a small part of the **layer menu** that says **opacity**. Click on it, and drag the arrow down until the opacity changes. You can view what you are doing to the photograph while you're doing this. Select an opacity that allows you to see all of the key features of rocks, but so it is still somewhat see-through, so you can line these up with the other picture.
10. Drag the opaque layer onto the non-opaque one. If the layers are not in the right order, as in the wrong one overlaps the other, go to the side layer menu and drag the bottom layer to the top of the list of layers.
11. Line up the rocks as best you can, and un-click.
12. Change the **opacity** back to 100%.

13. If things worked out well, which they usually don't, the photographs will line up and match pretty well. There are a number of things you can do to when they don't, however.
14. If the colors of the two pictures are different, scroll down on the **layer (?) menu** and find **adjust**. From here you can change the **brightness and contrast**, or the colors. Select **auto-adjust** first, and, if this does nothing, select **curves**.
15. At the top of the **curves** dialogue box, there is a pull-down tab that says "RGB," which stands for red, green, and blue. By pulling down on this, you can adjust which color is most dominant or most missing. Usually red is prominent in the picture, so, select red if this is the case.
16. In the middle of the dialogue box there is a small square with a line running diagonally across it. By putting your cursor in the very middle of this diagonal line, you can drag it up or down, or any direction you want. Observe what happens to your picture as you do this. When you are pleased with the color of your picture, hit OK.
17. If the brightness and contrast are drastically different between the two pictures, go to the **layer menu**, select **brightness and contrast**, and move the arrow for each up and down until you get the results you want.
18. If you are sure that you have placed the pictures in the right place and you don't need to move them anymore, go to the **layer menu**, scroll down, and hit the **flatten image** button. This makes both pictures one.
19. If the rocks look really, really bad where the two line up, use the **magnifying glass tool** in the Photoshop tool menu on the left-hand side of the screen and zoom in to any problem areas.
20. Select the **smudge tool** from the same menu and smear together rocks that look particularly bad. It helps to smear black into black and create lines and shapes around existing rocks with black. Keep smearing to a minimum, because it starts to look fake with too much smearage. (If you don't like what you've done, go to the **edit menu** and hit **step backward**.)
21. Be sure to save your work often! Images these sizes tend to crash the computer. A lot. Be sure to save them as jpg files, so they can be read in MicroStation.

Things That I Tried That Were a Waste of Time:

1. I tried a lot of things that, essentially, cut off precious minutes from my rapidly fleeting life. First I tried cropping all along the edges of rocks on the edge of the photograph that was to be joined to another photograph, which was difficult and took a long time. This was stupid because it would be almost impossible to duplicate this in MicroStation. So don't do this!
2. One of the most horrible mistakes I made was not saving my work every five minutes, which was how often the computer crashed and all my work was lost.

Detailed Modeling:

Applying detailed photographs to the drawings is necessary part of making the model. Without detailed photos attached to the model, it is impossible to further research the ruins once they are overgrown with vegetation. In order to apply a detailed photograph to the model, one needs a high quality .jpg file with the number of pixels per determined by the level of detail.

Once the photos are determined to be of high quality, crop each photograph with Adobe Photoshop or other photo editing software for application on the model. Each photograph can be a single material in a MicroStation Palette. When creating the material it is important to scale the image to the appropriate dimensions for application. This is done in the "Define Materials" dialog box and can be easily modified at a later date.

Once the palette is formed each material is applied by color. One color attached to one and only one photograph. An excel spreadsheet ties up the bookkeeping by listing the color and associated material in a concise spreadsheet format. It is important that the user chooses "save settings" off the file menu in addition to or instead of the "save" option on the file menu. This ensures that the material files are associated with the model and can be opened as a package at a later date or on another machine.

Organization of Photos:

Every photograph taken for use on the 3-D model was placed into the Photography folder within the Leinster Bay directory. The photography folder contains one folder for each building photographed on site. *WB* denotes well building and *FB* denotes factory building. Building 4 denotes the small fallen building between the well and the beach (Ken wasn't sure what its function was, and didn't have a name for it)

Each of the building folders has numbered folders within (i.e. FB1). For the factory building, each number is associated with an individual wall of the building (inner and outer walls separately). There is a MicroStation sketch in the FB folder that shows the corresponding number for each wall. The well building folder also has numbered folders within (i.e. WB1). These numbers denote different structures around the well and different views of the well. Each well building number has an attached MicroStation sketch describing the orientation of each photo.

In addition to MicroStation sketches, there is also a folder of hand drawings. These hand drawings have the photo numbers written with a sketch of the wall. Each drawing is labeled with the corresponding building and folder number.

Appendix 5: Global Positioning System

Compiled by Benjamin Jewell

Introduction/Objectives

Creating a Geographic Information System (GIS) of the ruins was one of the goals of the Leinster Bay project. We collected coordinates to accurately orient the digital map created for the Leinster Bay site. Global Positioning System (GPS) coordinates were necessary to correctly place the site onto a map of the island of St. John. Using the included software that came with the GPS, collected data was downloaded onto a PC and used to create a primitive overhead map of the site. This map proved valuable in helping the team visualize the entire site.

Theory

Using government satellites and a receiver purchased by the National Park Service, GPS coordinates pinpointed the position of the site and its individual structures on the Earth's surface. Implementing the theory of trilateration, the GPS receiver picks up timing signals sent out by several of the 24 satellites constantly orbiting the earth. Since the speed of the timing signal and the positions of the satellites are known, the distance between the receiver and each satellite can be calculated. In order to establish a correct location, information from a minimum of three satellites is needed, and for elevation, a minimum of four satellites is required. Once the receiver finds the radio signals from the satellites, the computer uses trilateration to determine the location of the receiver. However, the accuracy of this process is about ± 30 meters. One-meter accuracy can be obtained using differential GPS. Differential GPS makes use of a reference receiver, that is at a known (carefully surveyed) location. This reference station receives the same GPS signals as the roving receiver but instead of working like a normal GPS receiver it attacks the equations backwards.

In addition, the Trimble receiver is capable of picking up a radio signal from a ground station. The position of the ground station is precisely known. The difference between the ground location and the location predicted by GPS is a correction factor. Instead of using timing signals to calculate its position, it uses its known position to calculate timing. It figures out what the travel time of the GPS signals should be, and compares it with what they actually are. The difference is an "error correction" factor. The stationary receiver then transmits this error information to the roving receiver so it can use it to correct its measurements. The Trimble GPS regularly picked up a signal from the Continuously Operating Reference Station (CORS) in Puerto Rico, resulting in the improved accuracy.

The computer connected to the receiver displays the location in a number of different coordinate systems.

Methodology

Following is the methodology developed to use with the GPS system provided by the National Park Service during the internship. The equipment was manufactured by the Trimble Corporation. The receiver was the Pro XR/XRS, the handheld computer was the TSC1 Asset Surveyor, and the software package was Pathfinder Office 2.1.

Steps for taking GPS data points:

1. Attach batteries to GPS unit in backpack.
2. Connect handheld to GPS via serial cable.
3. Connect antenna to GPS via coaxial cable.
4. Turn on hand held (green button, lower left corner).
5. Set GPS to UTM Zone 20 and NAD 83.
 - a. From the main menu, choose configuration
 - b. Select the coordinates menu
 - c. Set to UTM Zone 20 North and NAD 83
6. Create a rover file to map structures. Select "Data Collection" file from main menu.
7. Choose "Create Rover File."
8. Choose "Point File."
9. Physically place GPS antenna on, or close to, the point on the structure desired for mapping. Ensure the radio link is established (in order to differentially correct the data in real time), and the PDOP is below 5 (this is important for accuracy).
10. For each mapped point, take at least 100 data points to ensure high precision of ground location. The number of points is counted in the lower right hand corner of the rover collection screen.
11. Map all key points (corners, main features, etc.) into a rover file. Give each point a name and clearly mark by hand onto paper site map. This will eliminate confusion when downloading and mapping GPS points.
12. Create a new rover file for each structure.

The above procedure detailed instructions for creating a point rover file. However, a line rover file is more appropriate when mapping large features easily outlined (shoreline, stream, etc.). Instead of taking data at a single point, the GPS continually maps data creating a 'line'.

1. From the Data Collection menu, choose "Create Rover File" then "Create Line File."
2. Begin taking points and walk the length of the feature.
3. Depending on the size of the feature and the amount of memory space available, the interval over which the GPS takes points may need increasing or decreasing. Generally the unit is set for one point per second or one point per five seconds.
4. Below is a diagram of the TSC1-Asset Surveyor.

Downloading GPS data to Computer:

1. Plug handheld into "DATA I/O" port on battery charger. Take female-ended serial cable that is attached to battery charger and plug into serial port on computer. Also plug in security key.
2. Turn on handheld. Press ESC on handheld to stop it from attempting to connect to GPS.
3. Open FILE MANAGER from main menu on handheld. Scroll down to FILE TRANSFER and hit enter.
4. On computer, open Pathfinder Office. Hit OK and accept default project name.
5. In the UTILITIES menu, select DATA TRANSFER.

6. Select desired files from AVAILABLE FILES menu, and click ADD. Once desired files are added, click TRANSFER. Close data transfer window.
7. In Pathfinder go the FILE menu, and scroll to OPEN. Select desired file and open it.
8. Waypoints should now be displayed on the screen, if not click on the "Map" button. In order to view the coordinates of a point click the "Position Properties" button (plus sign next to question mark) and then click on the desired point. To view information about a point, click the "Feature Properties" button (notepad with a X on it) and then click on a point.
9. To export the data to a different file select the "Export" button on the left side of the screen, or go to the UTILITIES menu and scroll to EXPORT. In the export menu you can then select the file(s) you want to export, the destination of the exported file and the format you want to export the file into, then click OK.

Exporting to ArcView:

1. Export GPS data as "Sample ArcView Shapefile Setup" in Choose an Export Setup drop down list. Choose the folder you want to export the files into from the "Output Folder" drop down menu (for our project the folder is My Computer → Local Drive (C:) → VINP_Project → Leinster_Bay → GPS).
2. The exported files will have a default name (point_gen or line_gen). Rename the three file names (there should be a .shp, .shx, and .dbf) to make them unique.
3. Open Arcview (Start → Programs → ESRI → ArcView GIS 3.3 → ArcView GIS 3.3).
4. Working with the Leinster Bay project (or any other established ArcView project) click on "Open an existing project", otherwise click on "with a new view".
5. If creating a new project, click yes to the "add data now" prompt. If using an existing project, click on the "Add Theme" button (Second button from the left on the top button bar. Icon is a big plus sign). Now browse for your file.
6. After adding the appropriate files, click on the check box in order to view the data (on the left hand side of the View window).

TSC1 - Asset Surveyor Operation

Menu Icons
(current choice is highlighted)

Battery Status

PC Card (if used)

Real-Time Status

Number of Satellites

Current PDOP

Number of Fixes in Current Feature

Softkey Menu

Corresponding Softkeys

use **NEXT** to:
cycle through all open screens
("multitasking")

use **MENU** to:
open main menu from any screen

Use **ARROW KEYS** to:
move around on screens
key will cycle through choices on text menus
key will bring up text menus when ► shows

If unit locks up, try
(in order of desperation):

- 1) Turn off, **[Ⓢ]** then on.
- 2) Hold **[Ⓢ]** key for five seconds, then turn on.
- 3) Warm boot (don't loose data):
 - a) turn unit off **[Ⓢ]**
 - b) hold backspace key
 - c) press **[Ⓢ]** key while holding **[Ⓢ]**.
 - d) unit should re-boot after a few seconds.
- 4) Cold boot (loose *all* data):
 - a) ask for directions!!

use **ESC** to:
back out of menus and screens
exit data capture (saves file)

use **ENTER** to:
select highlighted options
save changes to screens
save and end current feature

[Ⓢ] On-Off Switch (toggle)

[Fn] Secondary key functions

[Fn] [E^o] to increase contrast

[Fn] [F^o] to decrease contrast

[HELP] Useful help screen

Results

We successfully collected data points at many locations throughout the site. Our first priority was accurately locating the datum points used in the land surveying portion of the project. Mapping the datum provided the information needed to set up A Total Station used to survey the site,. Points were then taken on the individual structures on the site . Only a few points were needed to place the structures on a GIS map and any missing data could be filled in with the land surveying data. However, to create an overhead site map of the ruins, points were taken from as many corners of structures as possible in order to outline them on a 2-D map.

Problems encountered:

1. Many technical difficulties dealing with battery charging, faulty cables and other unknown problems.
2. In some cases the radio link was not established so collected points were not differentially corrected, making them inaccurate.
3. Difficulties gaining enough satellites on points taken near taller walls and in thickly wooded areas.
4. Problems lining up gathered points onto existing maps due to not being in the UTM Zone 20 and NAD 83 that the maps were referenced to.

Recommendations

1. Before going to site, ensure GPS is functional with fully charged batteries.
2. Familiarize oneself to the usage of the GPS unit by taking sample points in an open area before going to site.
3. Obtain a radio link before taking any points.

Determine the mapping coordinate system before taking any points to avoid confusion and ensure that all maps line up appropriately.

Appendix 6: MicroStation Methodology

Compiled by Suzanne George, Greg McKenna, Michael Morris, Luke Stinchfield

Introduction

The MicroStation CAD program is the backbone of this project. In addition to basic modeling there are many different skills and techniques needed in order to create the finished models. These include making materials, merging models, and advanced modeling techniques.

Objectives

This appendix will describe how to:

- create a file for multiple users
- Merge multiple models
- Import pictures to MicroStation
- Scale pictures in MicroStation
- Use pictures in a model
- create materials
- manage materials
- Apply materials
- Other specialty techniques useful for this project.

Methodology

• MULTIPLE USERS

These instructions allow multiple users to work on the same drawing at the same time.. It allows someone to assign separate tasks for each individual and then bring the work together into one common file. These instructions should be used in conjunction with the instructions for merging multiple models.

1. Create a common drive accessible to all individuals working on the model. Make sure to have enough memory available on the drive for the project.
2. Create a MicroStation base file for all of the drawings. Give the file a meaningful name such as 032504well.dgn. The 032504 correlates to the date that the file was made while the "well" part of the file name relates to the content of the drawing.
3. The base file must also contain all necessary components for all future tasks to be completed (what do you mean by components?).
4. Save that file in the group drive.
5. Assign tasks to each individual in the work group.. Each person opens the base file and resaves it under a new name, meaningful name. s Any new item is drawn in a new level named appropriately.
6. Save the new file in the same drive as the base file.

7. When all tasks are completed, the files can be combined into one file by merging multiple models.

• **MERGING MULTIPLE MODELS**

These instructions allow the user to merge multiple models into one file. These instructions should be used in conjunction with the instructions for multiple users.

1. Open the file that you want to import the models into.
2. Open the **file** menu and select **reference**
3. Open the **tools** menu and select **attach**
4. Select the file you want to import
5. The **Attach Reference Settings** dialogue box should appear.
6. Make sure that under **Orientation** that **coincident** is selected and select **Okay**
7. Copy the imported model. This will allow you to manipulate the model.(how do you copy the model? Will something popup that says copy?
8. Detach the file using **Tools- Detach** in the **reference** dialogue box after you have copied it.
9. Repeat pervious steps for as many models needed.

• **BUILDING ARCHWAYS**

These instructions create archways in conical shaped buildings. The instructions rely on quality photographs of the building being drawn are available. A file containing drawings of bricks is needed as well. The user should also have an understanding of 3-D modeling.

1. Ensure a base file exists.
2. Open the base file and save it under a meaningful, new name such as archway032504well.dgn.
3. Create a new level called archway, and make it the active level.
4. Open the file that contains a drawing of each type of brick used on the building. At least three different types of bricks are needed to make the archway. Place the largest brick at the top of the archway. Place a wedge shaped brick at the bottom of the arch on both sides. Copy the three bricks.
5. Paste the bricks into the archway file. Take measurements of these bricks and write them down as they will be needed later.
6. Using pictures of the building as a guide, rotate the rocks to the correct position in the front view. Rotate the rocks in the other views as well to get the rocks in the proper position.
7. Working in the isometric view draw an arc directly on top of the archway that is there. Use the **place arc** tool, and change the method to **edge**. Snap to the beginning of the arch, the top, and then the other end of the arc. Use the same method to copy an arc on the inside of the building. Also, draw the two lines that connect both arcs.
8. Turn off all other levels except for the archway.
9. Move the archway to a different section in the drawing.

10. Change the color of the archway so it is easy to distinguish the bricks.
11. Put a brick in the correct orientation at the top of the archway. Use the **construct array** tool to make the bricks follow the arc. Ensure the array type is **polar** and the rotate items box is checked. Count the number of bricks that are on the first row of the archway including the two wedges.
 - a. $\text{DeltaAngle} = \frac{\text{bricks} \times 2}{360}$
 - b. $\text{Items} = \frac{\text{bricks} \times 2}{2}$
12. Click on the brick at the top of the arc and use the center snap tool to find the center of the arc. Once the center is found left click to make the array.
The array will not follow the arc completely because the arc is not completely in a 2d plane. It will also only be on half the arc. You will need to do the array again only change the **DeltaAngle** to a negative value.
13. Align the bricks with the arc in the top view using the **move element** tool. Select a brick, change the values in the x and z boxes to zero, click on the **near snap point** tool, and move the brick until the arc turns violet. Click again to place the brick at that point. Do this for all of the bricks.
14. Replace the bottom bricks on either side of the archway with a wedge by snapping to their location and then deleting the square bricks. Remember to use the photos for reference. A larger brick needs to replace the top brick using the same method.
15. Record the distance between bricks on the arch.
16. Use the **modify solid** tool to change the length of the bricks on the arc to match those of the photograph.
17. Working in the top view, copy the arc and move it to the shortest length brick and then add the distance between bricks to that number. Do this for all the lengths that were used.
18. Copy the bricks from the first arc and move them forward using the copy tool and the **near snap point** tool. Change the values in the x and z boxes to zero.
19. Use the **modify solid** tool to change the length of the bricks on the arc.
20. Repeat steps 16-19 until the archway is filled with bricks.
21. use the modify solid tool to fit the bricks to the inside of the arc.
22. Use the **place fence** tool to put a fence around the archway.
23. Turn the level that contains the building on.
24. Use the **copy** tool to make a copy of the archway, make sure the **use fence** box is checked, and move the archway to its proper place. Align the archway in the isometric view.
25. Turn the level that contains the building off.
26. Delete all the arc lines and the arc that is not on the building.

• CREATING MATERIALS FROM PHOTOGRAPHS

These instructions teach users to build materials from photographs. All photos used must already be edited with Photoshop(see appendix ?) or another photograph editing program.

1. Open the **Settings – Rendering** menu. Select **Define Materials**

2. Select **File – Open pallet** if you are adding material to an existing pallet or select **New pallet** if creating a new pallet.
3. To create a new material, press the **New** button on the **Define material** dialogue box.
4. Name the material.
5. Press the **select** button to choose the photo you want to use as a material.
6. Select **Base color** and **Specular color** and set to white
7. If the material is to be tiled multiple times set **Size X:** and **Y:** to factor something less than one. That number will depend on the relative size of the material.
8. Repeat for as many materials as needed.
9. When finished, close the Dialogue box and save the pallet.

• IMPORTING PICTURES

These instructions import pictures from a file into MicroStation.

1. Open the **file** menu and select **Raster Manager**. The Raster Manager dialogue box will open.
2. Open the **file** menu in the Raster Manager dialogue box and select **attach**.
3. Select the picture to import.
4. Working in the view that you want to view the picture, pick a point and expand the box that appears to a desired size. You will be able to size it exactly later. Refer to scaling pictures for instructions.

• SCALING PICTURES

These instructions scale the pictures. The scaling of the pictures allows the user to copy lines directly from photographs and use them in MicroStation drawings.

1. Open the **file** menu and select **Raster Manager**. The Raster Manager dialogue box will open.
2. In the **Raster Manager** dialogue box open the **edit** menu and select the **Modify** (Make sure that the picture is highlighted).
3. From the **Modify** dialogue box change **Display** from **Pixel Size** to **Scale factor**.
4. If there is a known printed scale, change accordingly.
5. If the picture has unknown scale, first determine if there is something in the picture that is of a known height or length. Example (stadia rod, person, wall length, etc.)
6. Set the **scale factor** to **1: 1**.
7. Using the picture measure the known distance.
8. Calculate the scale factor by dividing known distance by distance that was just measured. This will give you the scale factor.
9. Note if the picture has not been Rectified the picture will not be scaled perpendicular. Example if you used a vertical distance the horizontal distance will not be correct.
10. To fix the perpendicular scaling factor there must be a known distance in that direction.
11. Using the scaled the photo, measure the known distance and find the scale factor
12. In the **Modify** dialogue box under **scale factor** change either the X: or Y: scale by multiplying the scale factor by the number in the field.

13. Before changing the number make sure to turn off the association lock, it looks like a Pad lock. Click on the lock so it appears to be unlocked.
14. Note that the picture will not exactly be to scale because the distortion from the lens gets worse as you move closer to the edge of the image.

• MAKING IRREGULARLY SHAPED HOLES

These instructions help users to create irregularly shaped holes in the side of buildings. the instructions are designed for a round or conical shaped building but can be used for vertical walls as well.

1. Obtain several different photographs that contain a profile view of the hole.
 2. Open a photo as a raster file in MicroStation.
 3. Use the **Place Smartline** tool to trace the general outline of the hole.
 4. Move this outline to the side, and repeat the process, using the other photos as raster files.
 5. Compare the outlines and create an "average" outline, composed of features from each individual outline.
 6. Set an origin point, and create a cell of the outline.
 7. Close the current document and open the MicroStation file containing the drawing in progress..
 8. Insert the outline cell into the front view next to the model and compare with the photograph to get the outline correctly scaled.
 9. Turn the outline into a complex shape by drawing a line between its extremities and using **Create complex shape** tool.
 10. In the 3D construct toolbar, select **Create Solid or surface of revolution**.
 11. Change type to **Surface**, set axis to **Drawing Z**, and angle to **360**.
 12. Select the outline and create revolution by dragging outward. Look at the top view to make the surface the desired size relative to the well.
- intersect the newly created surface with the model. It may take several tries to create a correctly sized surface. Once the surface and solid are aligned, subtract the surface from the model using the **Construct difference** button in the 3D Modify toolbar.

• PACKAGING THE MODEL WITH PHOTOGRAPHS APPLIED

These instructions help users package the model, materials, and photographs used to create the materials to burn to CD or copy to other media. This is necessary to be sure all the photograph files used to create the materials of the rendered model are packaged with the model itself. The package is self-extracting when copied onto the next computer from which it is to be opened.

1. Before starting, it is important to understand that the resulting package has a very specific structure. There are text files with *.mat (materials database) and *.pal (palette database) extensions that point to the correct palettes to open and photographs to attach to specific materials. Put the model (*.dgn file) in a directory of the same name from which you will wish to open it on the computer it will be transferred to. For example, if

- you want to put it in the c:\ directory on a different computer, then put the model in the c:\ directory in the computer you are working from.
2. With the model open in MicroStation, from the Utilities menu select the Packager option. Follow the instructions on the screens and step through the packaging. A *.pzip file is created.
 3. Copy the resulting file onto media.
 4. Copy the resulting file from media onto the next computer.
 5. Execute the file (double click on it from My Computer or Windows Explorer, or run it in the Run box) and it will open a self-extraction box. You will need to click on extract and follow the instructions.
 6. All the necessary files are now available to recreate the model with materials.
 7. If problems exist attaching materials, open the *.mat and *.pal files (under the Materials subdirectory) using a text editor or word processing program and check the paths of the photograph files. Edit the paths if they are different from the actual file locations.

Results

The information provided allows one to construct complete models of ruins. These models would be accurate representations of the ruins at the time of data collection and have accurate and photorealistic materials applied.

Discussion / conclusions

The data for the modeling came from three different sources; surveys, ground mapping, and photographs. The surveying data was used to locate the buildings relative to each other and in the correct place in the world. The ground mapping was used for many of the general measurements and location of major features wall length, thickness, stairs, pillars, doors, and other notable features. Also the ground modeling was used as a way to check the accuracy of the photos and to scale them. The photos were used to make materials and to model much of the detailed aspects of the model profiles of a wall, locations of small features.

Appendix 7: Merging Terrain model and Survey Data

Compiled by Alex Stace

Overview

To build a useful model locating the structures on St. John, an accurate model of the local terrain is needed. We generated this by a combination of data from a 2-foot contour map and surveying data. These data were combined using GIS software and MicroStation to build a 3D model.

Methodology

Overview:

With enough data a surface can be created and converted to a solid object.

A section of the local area was clipped out of the island's terrain map. This was then combined with the GPS points. Then the survey points were aligned using those points. Finally the main surface was created with the contour lines. The area around the structures is then modeled individually with survey points.

Procedure:

1. A section of a digitized topographic map must be clipped in ARC
2. Combine the GPS points of the hubs with this file
3. Use either ARC toolbox (may not work) or the universal translator in MapINFO to convert the file to a DGN or DXF file.
4. Open the File in MicroStation
5. For ease of use move the GPS points to a different level
6. At this point or later, align the survey points. This is done by opening the points as a reference file. Using the reference file window tools, rotate and move the points until they are line up. Then copy the file into a new layer and remove the reference file.
7. Now each contour line must be moved to the proper height (two feet).
8. Set the following in MicroStation:
 - a. Locks: Boresite On, Depth Off
 - b. Snaps: Nearest
9. Once all the lines are at their proper heights, turn snap on and to "nearest."
10. Using the Place Point Curve tool, create parallel Bezier curves crossing the curves with snaps to each curve as it is crossed, and always going from low to high.
11. Using the Construct Surface by Section tool, click on each of the parallel lines in order, from the same end. Accept.
12. Alternatively, with smoothing turned on, create a surface by network, by selecting the lines from one side to another. If not all the lines were created from the same direction, the surface will be insane.
13. Create a solid with the edge boundaries inside the surface but with volume above and below the surface.
14. Copy the entire entities or save to a new file.

15. Use the Construct Difference tool, keeping the Last original, and construct the difference between the solid and the surface.
16. The top half should remain cut by the surface
17. Boolean this solid with the other block to create the lower surface.
18. Delete the lines and surface, or send them to another level and turn it off.
19. Turn the Points back on. The area directly around the points should be Booleaned out.
20. Individual surfaces can be created by mapping beziers to the points. This technique can be used to fill in the surroundings accurately.
21. The structures can be aligned and copied from reference files as well.

Appendix 8: The Geographic Information System

Compiled by Constance Holden

Wild and Christy Loomis (Data Manager for the Virgin Islands National Park) provided several data files that would be useful in developing the GIS. Several of the files were Arc/Info coverages¹, created by the United States Geological Survey (USGS), and shapefiles², created by the National Park Service. These files included: the island boundary, 20-foot contours, 2-foot contours, roads, vegetation types and soil information for the Island of St. John. Also included was a full-color, aerial image of the island. The USGS files used the Puerto Rico, State Plane coordinate system, the North American Datum 1983 (NAD83) and the units were in feet. The coordinate system for the project was to be in the Universal Transverse Mercator (UTM), zone 20, with the units in meters. All of the GPS data was collected in this system, and downloaded as shapefiles. The first task was to convert the USGS coverages to shapefiles and convert them to UTM, zone 20, NAD83 (meters). This was accomplished using ArcToolbox, part of the ArcGIS 8.3 software suite. The Park Service data was already in the appropriate system. The next task was to be certain that all of the data collected by the students aligned with the data provided.

A bay profile was used to verify the alignment of the data. In addition to collecting GPS points of buildings and surveying hubs, the interns collected a stream of data while walking the "high-tide" line of Leinster Bay, which created a bay profile. The reprojected USGS files lined up very well with this bay profile, but the Park data was displaced. The Spatial Adjustment tool in ArcMap, which is also part of the ArcGIS 8.3 suite, was used to "rubber sheet" the vegetation file to the USGS file of the island boundary. The Georeferencing tool of ArcMap brought the aerial image into the same coordinate system as the other data.

The next task was to import the survey data and align it with the GPS data. The survey data was imported into ArcMap as a CAD file in the .dxf format. The coordinates for two points, for which GPS data existed, were obtained by zooming in to a scale of 1:1. From this information, a world file was created and attached to the survey data. Once these points were in their correct position, they were saved as a shapefile and attribute information was added to the database. The attribute information included an ID number, a description of the point; e.g., upper left corner of the trough, and the elevation. The accuracy of this process could not be verified, as there were not enough common data points collected by both the survey team and the GPS team.

The top views of the MicroStation models of the water well and the factory were imported into ArcMap, and using the same method as described above, a world file was created that brought the CAD files into their correct positions and saved as shapefiles. These shapefiles were lines files that provided an outline of each structure. However, polygons were required for the project. An attempt was made to convert the line files to polygons using the Clean and Build tools of ArcToolbox, but the result was unsatisfactory. The only other option was to digitize the structures, using the outlines as a guide. One of the editing tools available in ArcMap, is the AutoComplete Polygon tool. This tool creates a single boundary between adjacent polygons, such as the inner wall of the water mill and its interior, but its use requires that the feature be

¹ A coverage is a proprietary vector file format for storing the location, shape and attributes of a geographic feature.

² A shapefile is a non-proprietary vector file format for storing information about a geographic feature.

created in a geodatabase. An added advantage of creating a feature in a geodatabase is that its area and perimeter are calculated. A personal geodatabase was created and the water mill was built, as a stand-alone feature. Once the water mill was completed it was exported as a shapefile. A similar procedure was followed for the factory. Then duplicate shapefiles of the watermill and factory were merged into a shapefile called buildings.

Metadata for the project was also created using ArcGIS 8.3. In the case of data obtained from the National Park Service, information was added to the existing metadata, identifying the processing steps taken. Metadata for the new shapefiles were created using the Federal Geographic Data Committee format, with all of the required fields completed.

Once all of the shapefiles were completed, they were added as themes in the first View of an ArcView3.3 project. The project included the following themes: Buildings, Trails, Roads, Main Roads, Annaberg Ruins, Contours (twenty-foot), Soil Type, Vegetation Type, and Aerial Photo. A screen shot of this view is shown below.

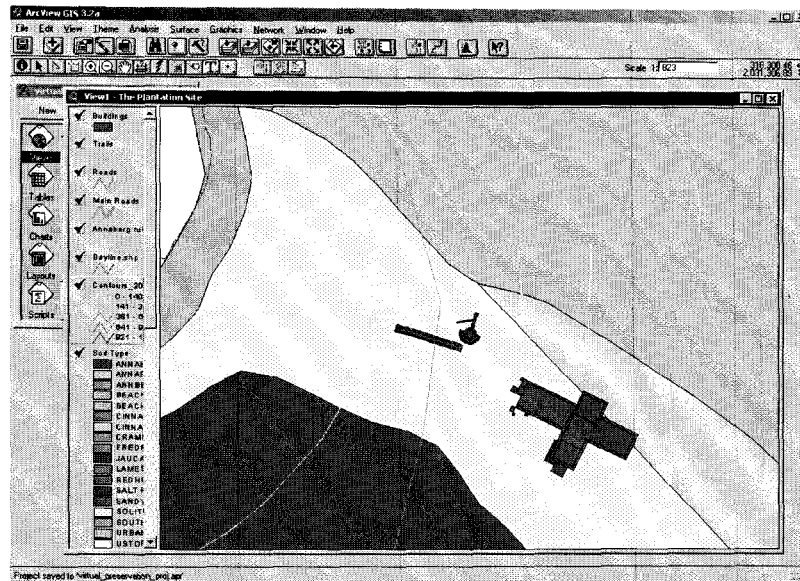


Figure 7: GIS View 1 - The Plantation Site

The second and third Views of the project were created by Bowe, and represented the position from which each of the photographs was taken. These Views were duplicated from the paper drawings mentioned previously. View 2 showed the outline of the water mill, and the location from which each photograph used in the model was taken, as well as some additional (miscellaneous) photographs. The original photograph was then hyperlinked to the theme attribute table. View 3 provided a similar layout for the factory building. Screen shots of these Views are also shown below.

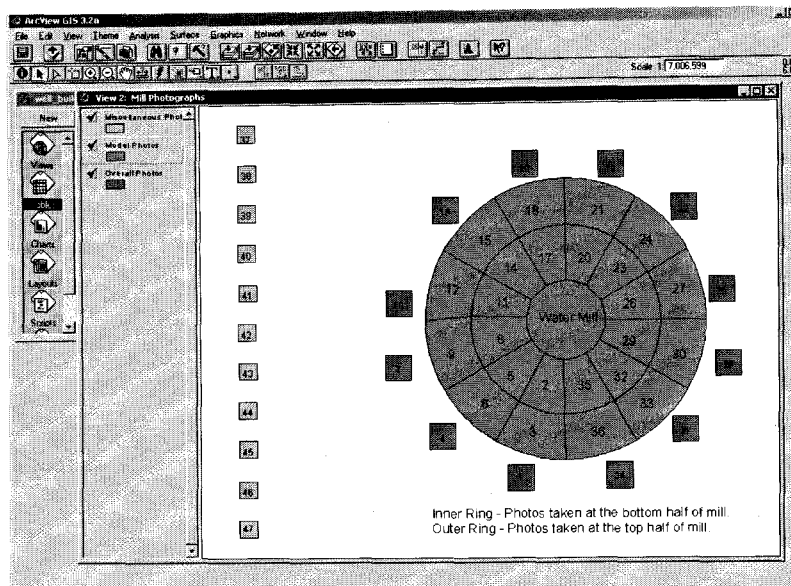


Figure 8: Record of Water Mill Photographs

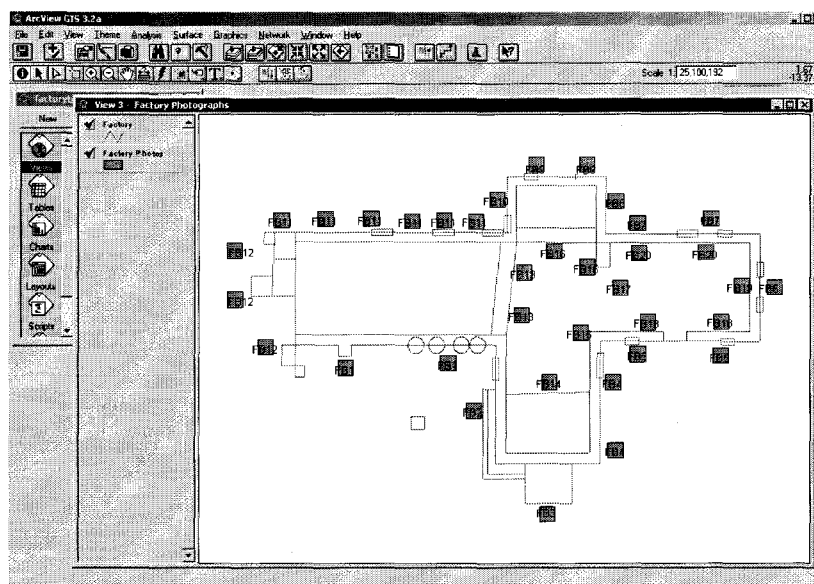
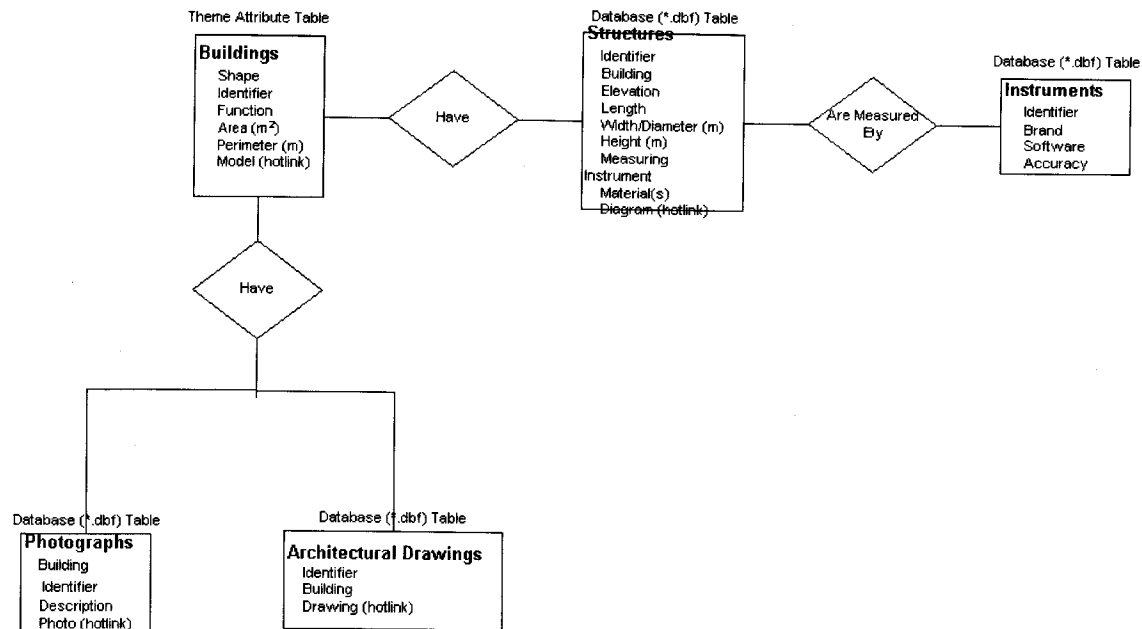


Figure 9: Record of Factory Building Photographs

The final step in the process was to create a database containing all essential information. A modified entity relationship diagram for the database is shown below. The records in the database are not all complete. This is again due to the fact that insufficient planning went into

the project prior to the data collection trip. Had the Entity relationship diagram been completed before the trip, data sheets could have been prepared and all of the necessary data collected. It is hoped that over the next year, National Park Service personnel and/or other interns can fill in the missing information.

An Entity Relationship Diagram for the GIS Database



An additional step that could be completed would be to add a script to the GIS that would run a VRML model of the site in a web browser.

