3D DATA COLLECTION FOR CHARACTERIZATION OF BAT HABITAT

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Abstract

Ground-based LIDAR (**Li**ght **D**etection **a**nd **R**anging) units currently are too costly and bulky for effective use in the cave environment. A tripod-mounted Impulse 200 laser rangefinder system allowed us to collect over 1,200 3D data points in just three days of field work. All data points were entered into the WALLS cave survey program and exported to a GIS for creation of a 3D model of the cave environment. The finished product was viewable in both Acrobat 3D PDF format as well as Google's SketchUp software. Future projects include the ability to digitally transfer data while in the cave and incorporation of traditional survey techniques for fine tuning the 3D model.

Key words: cave mapping, cartography, LIDAR, Impulse 200 laser rangefinder, Gruta de Consuelo, Mexico

Introduction

Traditional cave maps often concentrate on floor detail at the expense of other information. This technique often overlooks both existing and potential bat habitat. In early 2007 Bat Conservation International contracted Zara Environmental LLC to investigate and prototype a new laser rangefinder method for data capture and visualization to better understand bat habitat.

LIDAR (**Li**ght **D**etection **a**nd **R**anging) is a technology similar to RADAR that can be used to create high-resolution digital elevation models (DEMs) with vertical accuracy as good as 10 cm. The laser scanner transmits brief laser pulses to the ground surface, from which they are reflected or scattered back to the laser scanner. Detecting the returning pulses, the equipment records the time that it took for them to go from the laser scanner to the ground and back. The distance between the laser scanner and the ground is then calculated based on the speed of light (USGS 2008). Conventional, ground-based LIDAR is used to frame and automatically map a three-dimensional space or object. The unit we used is a simpler, rangefinder LIDAR unit. Unlike the automatic units which "paint" the scene with datapoint, the rangefinder unit must collect each data point individually.

Materials and Methods

Gruta de Consuelo, Coahuila, Mexico, was surveyed in January 2006 using traditional cave mapping techniques (Dasher 1994) and symbols. Survey stations were established and distances were measured between them with a fiberglass tape. Inclinations and azimuths were measured with Suunto clinometer and compass. A sketch of the cave was made in plan and profile views. Baseline survey data were entered into the Walls cave mapping program (free download from Texas Speleological Survey 2008). A line plot was created and sketches aligned around it as a pencil drawing. The completed map was digitized from this pencil draft using the open source drawing program Inkscape (2008) The native file format for Inkscape is Scalable Vector Graphic (SVG), which is directly exportable from Walls.

Field work conducted in January 2007 built upon the map created in 2006. Survey stations were relocated and made permanent by drilling and installing steel anchors. Some additional passages were surveyed and added to the existing cave map, as well as many more cross sections. A tripod-mounted, Impulse 200 laser rangefinder (Figure 1) with distance, azimuth and clinometer capabilities was used to manually measure an additional 1,200 stations on walls, floor and ceiling (Figure 2). The Impulse 200 laser unit was chosen for its small size, waterproof characteristics and overall extreme ruggedness (Figure 3). The laser wavelength is outside of the visible spectrum. We obtained a "point cloud" that represented the shape of the cave passage. These additional stations were added to the survey in Walls. Stations were classified as to whether they represented ceiling, walls or floor, then exported as an ESRI compatible shapefile. We experimented with a number of computer programs for developing the model, including Rhino 3D, ArcGIS, and Blender. Ultimately we used a CAD program (MicroStation) to build the polygon mesh by connecting the survey stations, which form the "skin" of the model. The model was exported from MicroStation's native DGN format to an AutoCad DWG file. Other formats were also exported, such as a 3D PDF file and Google's free SketchUp (2008) software.

Results

Two products have resulted from this project, a standard cave map of Gruta de Consuelo, and a 3D model. The cave map consists of plan, profile and cross section views. The survey stations are included in this map, as they can be used to locate roost areas by future researchers. Since the three main cave passages form a triangle shape, three different profile views were used to best depict these passages. Map files are in SVG, which can be read by a number of programs including Adobe Illustrator, Internet Explorer, Mozilla Firefox and others. However these files are best manipulated in the program which created them, Inkscape. Versions of these cave map files are also provided in PDF (two-dimensional) format.

Figure 1 Lasertech Impulse 200 laser rangefinder. Image courtesy of Lasertech (2008).

The 3D cave model is composed of a collection of joined polygons that form a low-resolution representation of the cave (Figure 4). This model can be rotated, panned and zoomed utilizing the PDF files viewed in version six or newer of Adobe Acrobat, which supports 3D viewing. The model is also provided in DWG format, a common CAD file format. Both the DWG file and Walls three-dimensional, point-cloud shapefiles can be imported to ArcGIS, as well as any

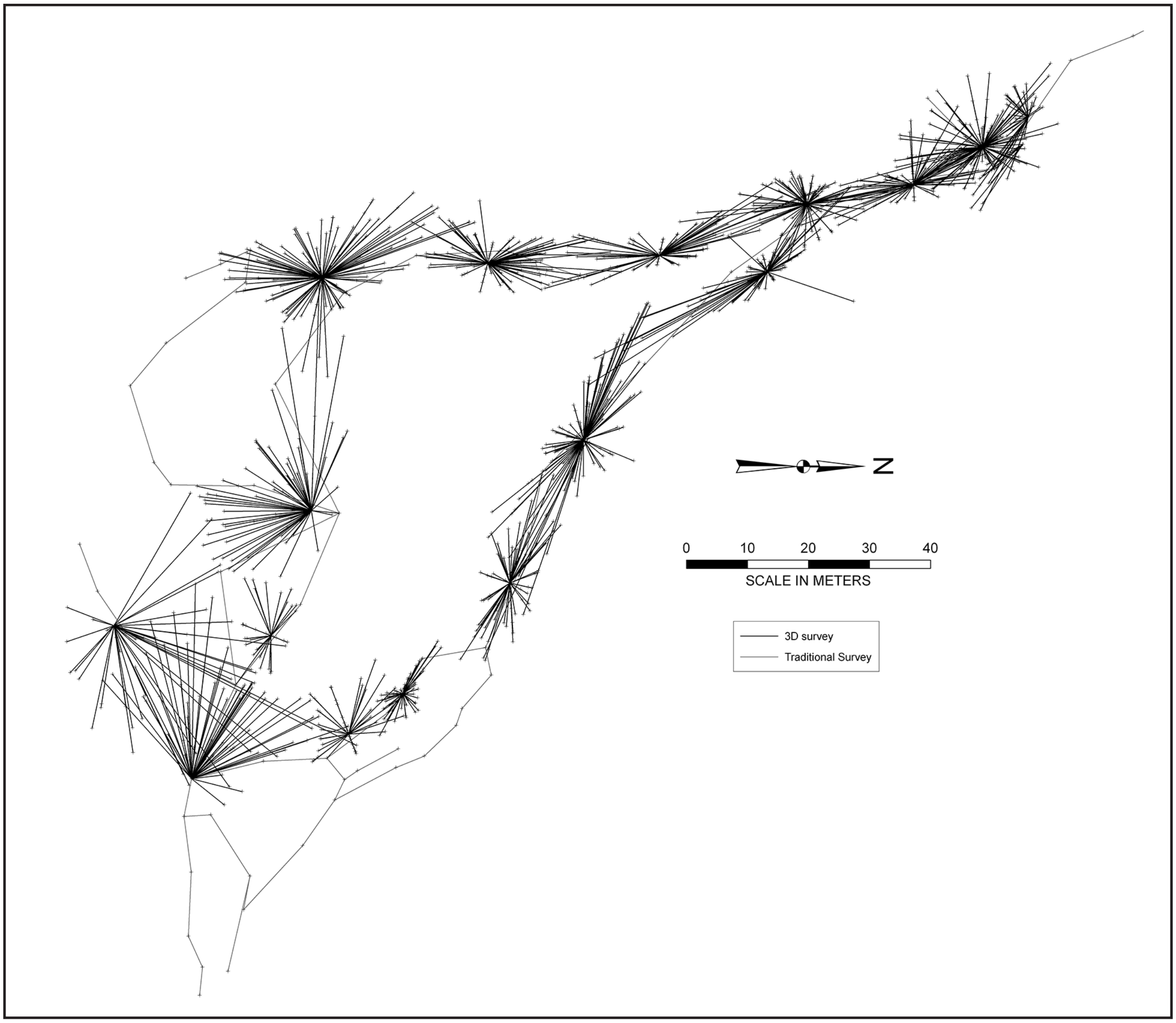

Figure 2 The laser rangefinder took 1,200 survey stations in Gruta de Consuelo, Mexico.

number of other graphics environments. A third format provided here is designed to be used in Google's SketchUp software, a free downloadable program. This user-friendly software can be used to mark bat usage on areas of the model.

Discussion

This project is an experimental one, designed to test methods for delineating bat roosts on irregular surfaces of cave walls. It is likely that the methods used here will be further developed in future projects, in which smoothing techniques could be used to create a more realistic model. While there are other methods currently available for making higher resolution 3D models of caves, such as conventional, ground-based LIDAR, which costs about $100,000, the method used here is quite economical, about $1,000. A model has been created which can now be used to mark bat roosts in an environment such as Google SketchUp.

Acknowledgments

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Figure 3 *Aaron Addison configures the Impulse 200 laser unit.*

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Figure 4 *The 3D model of Gruta de Consuelo*