Art historians have long grappled with the great monuments of medieval architecture.

The science of making measurements from photographs; its relevance then and now.

Mapping the extent of a surge that can be expected under worst case circumstances.

CAPTURING CANTERBURY IN 3D

LONG LIVE PHOTOGRAMMETRY

STORM SURGE MAPS SAVE LIVES
S
ome of the oldest traces of human history have been preserved by the constant climates underground—in the deep, cold dark of caves. Since our first ancestors began marking routes in caves with primitive tools or painting images with cinder, ash, and paint, we humans have been mapping caves such as Big Bat Cave in Breckinridge County, Kentucky. Through the collaboration between the Kentucky Karst Conservancy (KKC) and Qk4, Inc., the Big Bat Cave LiDAR project was initiated with the goal of collecting, mapping, and preserving the fifty-seventh longest cave in the United States. Instead of the cave preserving our history, it is our primary goal to digitally archive the cave to know better how to preserve its history.

For centuries, cave mapping has been conducted manually, using a compass and measuring tape and then sketching the results in a field book. While handheld electronic distance meters are now the standard devices used in cave mapping, the technology is still based on the compass-and-tape survey methods by which one data point at a time is collected. Referencing those data points can be tedious and the results provide only a small subsample of the cave footprint. Cave mapping using LiDAR scanning enhances this process by collecting millions of data points while referencing them horizontally and vertically in 3D space.

The idea of mapping the Big Bat Cave was born in late 2013 during a conversation between Ken Bailey and Ben Shinabery. Ken is an aerial LiDAR GIS analyst now retired from the Louisville and Jefferson County (Kentucky) Information Consortium (LOJIC), and
Ben is a professional land surveyor for Qk4, Inc. and the head of Qk4’s 3D Terrestrial LiDAR work. The topic of conversation was mapping high definition topography with stationary LiDAR.

During the discussion, Ken asked whether laser scanning would work in a cave setting? Ben brought to bear on the question his expertise in field topographic surveys and 3D terrestrial LiDAR: If the scanner could create high definition point clouds of bridges and roads, why not take it through the cave from one entrance to the other? Even if the effort would not produce the hoped for results, the experience and the knowledge gained from collecting LiDAR in a new manner would be worth the trip.

Ken is the president of KKC, which owns the land rights to the Mushroom Entrance of Big Bat Cave. For years, KKC has applied for grant funding to pay for the cave conservation efforts and to help supply equipment and training for college students interested in caving and GIS. The efforts to provide for the historic conservation of the cave and to promote educational initiatives in technology have been conducted on a volunteer basis. As an added benefit, therefore, this LiDAR cave mapping project has helped KKC attract student involvement by exposing them to innovative ways of exploring the world around them.

In short order, Big Bat Cave was selected as the perfect place in which to test the underground mapping ability of LiDAR technology. With the location chosen, next step was obtaining the equipment, which was provided by Qk4, a Louisville-based consulting firm of engineers, surveyors, and planners.

Qk4 uses a Faro Focus 30 terrestrial scanner, which is small, touch-screen integrated, and transportable in a
A water-tight case similar to a professional photographers pack. All that is needed to pack through the cave can be handled by one person. The internal batteries run the unit for an entire 6- to 8-hour collection day. The data is stored on a SD card, so there is no need for an external power source or a laptop controller.

January 24, 2014, on a freezing day in rural Kentucky, twenty or so cavers, students, mappers, together with an environmental team counting hibernating bats for a white nose syndrome study, entered the cave with bright expectations. David L. Black, an award-winning cave photographer, documented the trip for both the bat counting team and the LiDAR mapping team. To reach the hibernation rooms in the cave, the team climbed, crawled, and sloshed for an hour before reaching the main cave chamber where they would begin scanning. The chamber was large enough to stand and walk freely. While the environmental team counted bats, Ben and Ken began their first LiDAR collection by setting permanent reference points for future...
On that first day, the team collected 11 individual setups, which stretched over 600 linear feet of cave corridor and, at one point, 55 feet of vertical relief. It was the first time Ken had witnessed a 3D Terrestrial Scan, and the first time Ben had mapped millions of points that far underground. What came out of that first trip was the most interesting LiDAR dataset that either Ken or Ben had ever analyzed. The cave can be experienced through a Youtube flythrough of the actual 3D point cloud found by using the search Big Bat Cave LiDAR. From the first day, the Big Bat project was a success.

According to Ben, each trip brings with it new and exciting challenges. “There are some tight spaces in Big Bat with the ceiling only 12 inches above the floor. We have documented bats, crickets, spiders, fungus, geologic layering, historic cave mapping reference points, and the list goes on. While the scanner is collecting data, the team has a chance to sit and chat about life, explore new areas of the cave, or just relax in pitch black darkness.”

For almost two years, KKC and Qk4 have been mapping Big Bat Cave with LiDAR data collection. As Ben attests: “With each trip, we fine-tune our process of collecting and analyzing the geospatial data and gain valuable experience below the surface.” As an added
benefit, Ken notes: “On each trip, there is at least one team member who has never experienced the LiDAR collection process. Engineers, GIS professionals, students, speleologists, and surveyors have all gone underground to have a part in this exciting new method of archiving Big Bat Cave.”

KKC continues to offer an open invitation to students and staff at several universities and colleges around the central Kentucky area. Students from the University of Louisville, Jefferson Community College, and Southern Polytechnic State University in Georgia have also worked on the project. Students are encouraged to reference this experience on their resumes. Because the Big Bat project is self-funded, any student who participates has full access to the data set. With help from local high school geography students, KKC has plans to 3D print portions of the digital cave model.

The research possibilities in cave LiDAR mapping are just beginning to be explored. Since this project began, news of several other cave mapping projects have emerged showing the rich datasets collected around the world in places such as Devil’s Sinkhole in Texas by the Texas Cave Management Association, and the Geibihe cave system in China highlighted by the National Geographic Society. LiDAR technology is providing new insights on cave formation, connectivity, and underground topography. Caves have been a preserved record of our past history and climate conditions. This LiDAR data set may shed insights into these paleo-climates as well as help KKC preserve the story of Big Bat Cave.

The Kentucky Karst Conservancy and Qk4, Inc., hope to learn more about the Big Bat Cave by using LiDAR to archive the existing cave in a 3D point cloud. Support for the KKC is welcome through donation to this non-profit 501 (c)3 or through volunteering on any of the offered trips throughout the year. The data gathered and the opportunities for learning through this collaborative project hopefully will guide conservation of our natural resources for years to come.

Ben Shinabery is a Land Survey Manager for Qk4, Inc. specializing in Digital Terrain Modeling and Terrestrial LiDAR. His land survey experience includes high definition topography from UAS mapping, Terrestrial LiDAR, and Subsurface Utility Engineering collecting everything from above and below.

Ken Bailey is a GISP and the president of the Kentucky Karst Conservancy and a graduate of the University of Louisville. He has been caving for more than 30 years in Kentucky, Georgia, Alabama and Tennessee.

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Youtube Flythrough and Process Videos:
www.youtube.com/watch?v=S1I3rIR8WO2Q
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