

DIGITAL UNDERGROUND

Fixing bad survey loops in Lechuguilla: There's an app for that!

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Lechuguilla Cave is located within the boundaries of the Carlsbad Caverns National Park in the Guadalupe Mountains of New Mexico (USA). Its exploration started after the base of the entrance pit was excavated in 1986. The cave is now a 133-mile multilevel maze that spans less than two square miles of desert. With over 34,000 survey shots, it constitutes a formidable survey challenge.

Unsurprisingly, the labyrinthine nature of the cave favors an abundance of survey loops—almost 3,000 to this day—making it easy to determine how good the survey data are. Alas, applied survey standards have not always been on par with the complexity of the task. A quick look at the survey data—maintained by the Park as seven Compass subcaves for manageability—reveals that a large number of these loops show a large closure error, some reaching as high as 17% of the loop length. Many put the blame on the tendency of early explorers to proceed quickly so as to get to see more of the cave—Lechuguilla is often considered as the most beautiful cave on Earth. Furthermore, the exploration policy through August 1991 (the L.C.P. era) was to “not” take backshots, which would have caught some of the errors.

In recent years, several teams have undertaken fixing poorly-closed loops in various parts of the cave. In November 2011, I was invited by Peter Bosted for a second such week-long mission in the South area near the Big Sky camp. This time, with an advance knowledge of the type of problems we would be facing, I worked up to the last minute to implement special features in my Auriga cave survey freeware.

Running on a Palm OS PDA, Auriga is capable of computing and displaying the whole of Lechuguilla Cave on a small screen as shown below.

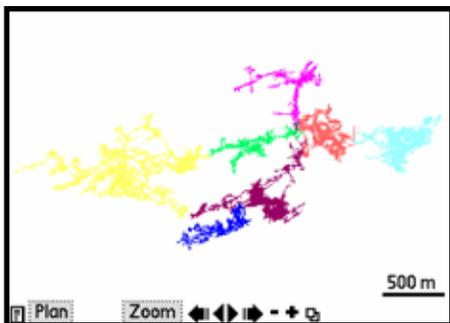


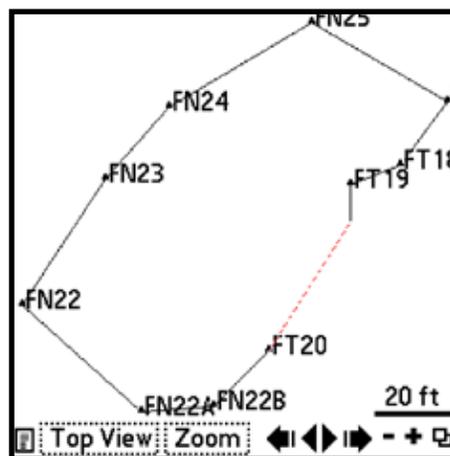
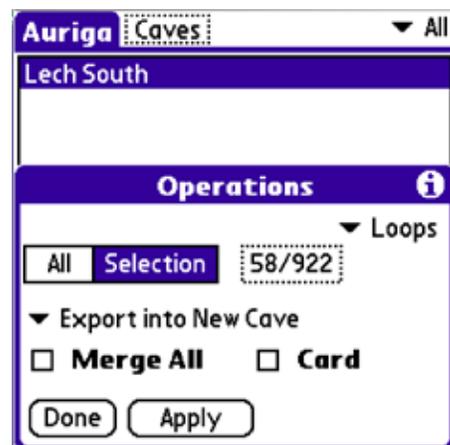
Figure 1—Lechuguilla on a PDA screen

Unfortunately, partly due to the Park requiring paper notes from surveyors as they exit the cave, the software is seldom used to survey new passages in Lechuguilla. Instead, its use has often been limited to quickly searching existing stations, connections or raw survey data, replacing a heavier and less convenient printout. However, when revising existing data, a computer (PC or PDA) becomes an invaluable asset, allowing one to readily ascertain the impact of revised survey shots on overall loop closure. Some teams chose to leave a light laptop at camp for night work; we instead chose to carry in our field survey pouch a PDA inside a protective case. Thus, when a loop that started with a 7% closure error reached 0.6% after revision, our team could consider the job done, without having to revise further survey shots, and could then immediately move on to another loop.

Using his own specialized loop analysis software at home, Peter had determined a set of “segments,” or series of survey shots that were likely blundered. On my part, I selected in Auriga the bad loops based on their quality index. This quality index, very similar to Compass’ sigma value, represents a multiple of the expected (normal) error given the current set of instruments. It takes into account the station position error (default is 5 cm) as well as random instrument error (by default, 1% for tape, and 2° for compass and clinometer.) A quality index of 1 indicates a survey work on par with the precision of instruments, while 2 is usually considered an upper limit. But with so many bad loops, we used a threshold value of 2.5. For the South subcave alone, Auriga found 58 loops with an index greater than 2.5.

While Auriga attempts to minimize unnecessary computations when a dead end survey shot is changed, modifying one that is part of a loop is sure to trigger a cave-wide re-computation. On the Aceeca PDA32 we were bringing underground, this operation took 2.5 minutes for the 8,600 survey shots of the South subcave. To avoid this delay every time we would fix a loop, we used a classic divide-and-conquer approach: before entering the cave, I performed a bulk export of all selected (bad) loops into separate cave files on the PDA, thanks to Auriga’s Operations dialog (Figure 2, right top).

Not only did this made for a very uncluttered line plot (Figure 3, right lower), but computing any of these 15 to 50 survey-shot



files was instantaneous.

Thus, instead of inputting revised survey data into the main South file, we would work with individual loops. Finding the relevant loop that corresponded to Peter’s suspicious survey shots was achieved launching a quick global survey station search among the cave files stored on the PDA.

Given the heavily interconnected nature of Lechuguilla’s survey data, a survey shot that is part of a loop is likely to be part of one or more additional loops. Thus, a last-minute feature was added to Auriga to bulk export a survey shot to all other caves on the PDA that also have this survey shot, so as to propagate the fix to all relevant loops. In some cases, fixing a loop could also fix a connecting one, thus reducing the team’s burden.

For the most part, found errors were of two kinds: swapped digits during data transcription or bad tie-ins (error on connected survey station). In these cases, fixing the single blundered survey shot brought the closure error down to 0.7% or better, indi-

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cating an otherwise adequate earlier survey process. Only a few loops showed systematic poor compass readings, requiring us to re-measure every survey shot in the loop to attain a satisfying level of closure error. A pair of 3-in-1 DistoX measuring devices allowed us to proceed quickly, yet accurately. These were checked every morning for consistency, and recalibrated if need be. When required, measurements were repeated until foresight and backsight agreed within 2°, although 1° or better was not uncommon. Measurements were taken on paper, and verified on the PDA running Auriga before moving on to another loop.

While merging a single loop file back into the main cave was already available in Auriga, this feature was expanded after the expedition to enable merging a selection of cave files (such as all modified loop files) into a single target cave (like the main South file). This is now part of version 2.03.

Overall, the field use of Auriga for checking the success of our work at fixing bad survey loops resulted in a faster process; we could often stop resurveying at mid loop, confident that we were now done with it. During our May 2010 expedition, we reduced the number of bad loops (as defined by greater than 2-sigma error in the Compass program) from about 200 to 90. This year, we reduced it even further.

Some fixes caused a 200-foot shift in parts of the cave that had previously been mislocated due to bad survey data. Of course, if future survey teams also use Auriga to check their new survey data as it is taken, or at camp at night, these kind of errors could be avoided altogether, or at least discovered before it's too late. In the meantime, we may have to go back!

The Auriga cave survey freeware can be downloaded from the Auriga website at www.speleo.qc.ca/Auriga.



Barbara Schomer

NSS 18003 FE

AUGUST 8, 1942-NOVEMBER 2, 2011

NSS Fellow and Life Member Barbara Schomer died November 2, 2011 after a year-long battle with cancer. Barbara started caving in the early 1970s with Norm Snyder and the American Youth Hostel chapter in Pittsburgh, Pennsylvania. Norm led hard, bare-bones beginner trips and was surprised when Barbara kept coming back. Her desire for more adventurous trips led her to the Explorers Club of Pittsburgh and her first vertical trip, Cass Cave, West Virginia. About this time, she also joined the Pittsburgh Grotto and by 1981 was helping with the organization of the 1982 Costa Rica Expedition. Barbara was always one to pitch in and when the expedition's operations person started sleeping late, Barbara took over organizing the day's tasks so that everyone had an assignment. On the expedition she met her future husband, Bru Randall, and the two began caving together. Barbara edited the Pittsburgh Grotto's *Netherworld News* for several years, but preferred caving to writing about it. She led beginner trips, helped organize, and teach, vertical classes, grotto open houses, and joint trips with the Explorers Club of Pittsburgh. She participated in several grotto survey projects, Askon Hollow in Pennsylvania and Twin Columns and Overholts Blowing, in West Virginia. Barbara also surveyed in the Central Kentucky Karst Coalition's Roppel Cave and transitioned to the Cave Research Foundation survey of Mammoth Cave when Roppel was connected. Barbara's American caving also included trips to TAG, the alpine karst of Wyoming, and the lava tubes of Hawaii.

In 1984, Barbara and Bru returned to Central America to deliver the final report of the 1982 Costa Rica expedition to the Costa Rican National Park Service and survey more caves there and in Honduras. In 1989 she helped out with the Earthwatch Maya Cave project in Belize.

In 1986, Barbara was selected to be an International Teaching Fellow and spent the year in Victoria, Australia. She and Bru quickly connected with the Victorian Speleological Association and were soon caving all over Australia. In fact the caving was so good that Barbara and Bru returned in the summer of 1987, driving three quarters of the way around Australia in 60 days, caving along the way and taking part in two caving expeditions. They returned again in 1994 for an expedition in the Northern Territory. In 2002 Bru had a teacher exchange to New South Wales, there they caved and surveyed with the Highlands Caving Group and Sydney Speleological Society.

Barbara loved to travel to places that didn't get a lot of tourists. She and Bru trekked in the Andes, canoed 1000 miles on the Yukon River, and spent two years as Peace Corps Volunteers in Kenya. In Kenya, they managed to cave and survey with the Cave Exploration Group of East Africa and climb Mt. Kenya.

As arthritis made cold, wet caving more difficult, Barbara continued to take her grandchildren and nephews caving. She also became interested in the study of lichens; we've all seen them but perhaps not noticed them. Her interest eventually led her to volunteer work in Everglades National Park, Florida, during the winter of 2010, helping with the lichen inventory project there. In her honor, the project leaders, Jean and Rick Seavey, named one of the newly discovered lichens, *Calopadia schomerae*, after her.

In late September of 2010, just after returning from a trip to Ireland, Barbara was diagnosed with stage 4 lung cancer. She went through all the recommended treatments of radiation and chemotherapy, all for the purpose of being able to tie up all the loose ends; it was Barbara's Last Great Adventure. Through all of this she managed to attend a VAR, go on a caving trip, and attend the Old Timers Reunion in West Virginia where she got to see so many of her friends one last time. Now she has joined Floyd Collins, Lew Bicking, Bob Lutz, Dale Ibberson, and a host of other cavers. She is at peace but she is not alone.

Bru Randall

