Cave surveying in 2017

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This report is an attempt to make a snapshot of the current status of “Cave Surveying”. I tried to collect some basic information about cave surveying practices around the world, and the report summarizes what i could gather during the past months.

The picture that comes out is still fragmented, incomplete, and sketchy, because cave surveyors are rarely interested in how their fellow surveyors do their surveys, and seldom consider the discipline of “cave surveying” in a perspective.

I first briefly review the evolution history of cave surveying practices. Then I talk about the situation in 2017.

A brief history of cave surveying

The basic ideas of cave surveying are at least as old as A. Martel: the approach to cave surveying and map drafting described in his books "Les Abimes" is still used these days. A cave map consists of a plan view, a profile view and cross-sections. A traverse through the cave is measured and it provides the skeleton around which the cave details are sketched [1].

Nevertheless, the techniques have evolved considerably, especially in the last decades, both for the data acquisition and for the data processing and map drafting. Visualization of 3D models are very popular nowadays, and Cave GIS (Geographical Information System) are not uncommon.

For many years the main instruments were compass, clinometer and tape. Other devices have been used (topofil, Abney, etc.) but as far as my experience goes I have used mostly compass, clinometer and tape [2].

With the advent of information technologies people started to think about the ways cave surveying could profit from the new computing resources, both for the processing of survey data and for the organization of cave surveys and information. Many cavers in the 70s wrote data reduction programs, but most of these programs were confined to a local, if not personal, use and never turned into "cave surveying software solutions" adopted by cavers around the world [3].

Notable exceptions were TopoRobot by M. Heller (1970), Compass by L. Fish (1979), and Ellipse by D. McKenzie (mid 70's).

TopoRobot had a thorough, very professional design from the very beginning. It requires the user to organize the survey stations in a sequence of "series". This might seem a rather rigid requirement. But it forces the surveyors into a good discipline of surveying, measuring transverse dimensions (LRUD), and leaving no dangling section. The program also provides the representation of the cave survey both in 2D and in 3D, with volume information obtained from the LRUD data. Its success was probably due to the fact that there was nothing better in Europe at that time.

The reason behind Compass' success is its design goals. The program was written to solve a very specific problem, which required handling inputs in many different forms. The main goals of the program were to show how the cave looks like in 3D and to help find good leads. It was written to be “idiot-proof”, with easy of use in mind, and above all, from the beginning it has been user-driven: the improvements are suggested by the users. Another important feature is the adaptation of the program to available computing resources: it started on PDP-11, then ported to Apple-II, then to DOS PC, and finally to the following versions of Windows.

Ellipse was used by several cave projects in southern USA and in Mexico.

It was capable of generating line plots of survey data and the associated walls. It was ported to micro-computer in the 80s. Then in 1994 the author developed the PC program Walls, from it.

Cavers can always find something wrong with the rigging of a pit made by another caver. With cave surveying it is no different. So with the diffusion of personal computers, other full-fledged programs came out: Survex by O. Bett and Wookey (1990), OnStation by T. van Ieperen (1990), WinKarst by G.Petrie (...), VisualTopo by E. David (1999), GHTopo by J.P. Cassou (2003), and many others [see Wookey 2001 review] [4]. Walls and Compass are still actively maintained. TopoRobot and VisualTopo have been discontinued, and OnStation too seems no longer being maintained. But they are still widely used.

As the PC got more powerful the cave survey programs added more features: loop closure compensation, error detection, map overlaying, better 3D viewing, statistics, etc. And they became more specialized as well.

Personally I came across more than four dozen PC programs related to cave surveying, and I guess there exist at least as many more. About half of them are written mostly for survey data post-processing (data reduction). Some are data format converters, a few are cave databases. To this one should add the plugins for (commercial) drawing programs, databases and GIS. Some programs came and went away, but a number of them [more than 20] are still in use, and a few data-reduction programs have spread in several countries.

In the late 80s cavers started using CAD and drawing programs to draft the cave maps. Even nowadays, most of the cavers still use AutoCAD or Adobe Illustrator (or other drawing programs) for their cave maps. Nowadays there are plugins for the speleological symbols helping cavers to draft nice maps. AutoCAD is used mostly by "technically" minded people, Illustrator by artist cavers [5].

In the 2000s there came programs specifically designed for cave cartography: Therion by S. Mudrak and M. Budaj (2002), Tunnel by J. Todd [2004), TopoCalc'R by J.P. Hereil (2009), GHTopoDraw by J.P. Cassou (2008), CaveRenderPro by J. Hartig (2014), and cSurvey by F. Cendron (2010). These programs are all currently maintained. Therion, in spite of its user unfriendliness, is probably the most widespread and, in my opinion, is the most comprehensive cave drawing program [7].

The next line in the evolution of cave surveying was the use of hand-held PDA devices to record survey data. The Auriga project was started by M. Meltzer to be used with his "sensor box" in 1998. Interrupted in 2000, the project was resumed in 2002 by L. Le Blanc who is currently developing it [6].

Finally the development of an integrated electronic device to measure azimuth, inclination, and distance (or just azimuth and inclination as in Meltzer's prototype). Needless to say there have been various attempts. Some never got beyond the prototype stage [EasyTopo] or were never good enough for cave surveying [Kombi]. The project DUSI by S. D'Espagner became a product, but was later retired. The SAP by Ph. Underwood, became product too, and it is now on stand-by. CaveSniper by J. Wojcicki, which is actively being maintained, is a niche product used only by a minority of cavers [8].

DistoX, by B. Heeb, is the only device that got a worldwide distribution, and revolutionized the cave surveying practices. The reasons behind this success are (1) the design choice of an integrated instrument that measures distance, azimuth, and inclination in one shot, (2) a calibration procedure that can be carried out without special equipment, and (3) PocketTopo, a Windows PDA program to work with DistoX written by Heeb himself. PocketTopo has become the de-facto program to use DistoX with a Windows PDA, and is probably the DistoX program most used in the field [9].

With the advent of smart-phones there came cave surveying apps. Measuring apps, like Aragonite by Argonga and CaveMeter by G. Meidinger, use the device sensors to measure azimuth and inclination of shots. The direction is taken looking at the target through the device camera and pictures of the shots are saved. Other apps are specific for managing survey data and making sketches: TopoDroid by myself (2010), Abris by O. Shturm (2013), CaveSurvey by SK Paldin (2014), Qave

by Svist (2014), and SexyTopo by R. Smith (2015). CaveSurvey is developed and spread in Bulgaria. Qave is used by the polish club that develops it. SexyTopo is very similar to PocketTopo, but so far has only a few installations. TopoDroid was initially designed to work with DistoX and draw sketches a` la Therion (with icons, lines, and areas). It has evolved considerably following the suggestions by the users, and it is now the cave surveying Android app most widely used in the world [10].

The latest developments concern obtaining a richer set of measured points, thus providing data for a better reconstruction of the cave passages. PMLS, by A. Gati, Z. Fekete and P. Suru, uses the DistoX with a special firmware that allows to easily record hundreds of splay shots at each station. ZEB1, produced by GeoSLAM, is a hand-held laser scan device that can be used underground. Other projects, like Caveatron, by J. Mitchell, and Hypercave, by A. Rossi, developed novel hardware specific for the acquisition of data in the cave. These are still prototypical, but something may come out soon.

Cave surveying survey

With so many tools (both hardware and software) at cave surveyors' disposal I was curious to know about how cave surveying is done in practice around the world. This analysis relies on the replies from a survey sent out to some cave surveyors in different countries. It is far from complete, both because the number of my contacts is limited, and because many of them provided a personal view of the "status of cave surveying".

The questions were aimed to make a basic picture of how caves are surveyed, the survey data processed and cave maps produced, and how the cave information are organized and managed.

Q.1 How do cavers measure the survey data in the cave ?
Q.2 How do they record the data and take sketches in the cave ?
Q.3 How do they process the data (data reduction) ?
Q.4 How do they draft the cave maps ?
Q.5 Do they make 3D cave model ?
Q.6 Do cavers manage cave data and information in GIS ?
Q.7 Are the cave data and information organized in databases ?
Q.8 If so, are these nationwide, region-wide, or by the club ?

Survey results

The survey was sent out to people in different countries: Australia, Austria, Brazil, Bulgaria, China, Czeck Republic, France, Germany, Iran, Italy, Mexico, Moldavia, New Zealand, Norway, Poland, Russia, Slovakia, Spain, Switzerland, Ukraine, United Kingdom, and U.S.A.

From some of them I got thorough replies. From others I got incomplete replies. Some of the replies reflected the strict personal view of the author, others covered the situation in his/her country.

The following tables summarize the results of the survey.
A red square means that the tool is among the most used in the country.
A light red square, used by many cavers.
A orange square, used by some cavers.
A yellow square, a rare use by a few cavers or a small group.
A gray square, used but it is not quantified how much.
A dark gray square, use that I inferred from discussion forums on the web.
Two people reported that Therion is not diffused among cavers in their country because it is too hard to use (violet square).

	Au	At	Br	Bg	Cn	Cz	Fr	De	Hu	Ir	Il	It	Mx	Mo	Nz	No	Po	Ru	Sk	Es	Ch	Ua	Uk	Us
*	28	25	20		x10		454	76	20	30	4	372		1	6	3	28				40		150	200
Suunto																								
DistoX																								
laser																								
Silva																								
CaveSniper																								
SAP																								

Table 1. Survey data acquisition. The first row (*) is an estimate of the number of caving clubs in the country.

	Au	At	Br	Bg	Cn	Cz	Fr	De	Hu	Ir	Il	It	Mx	Mo	Nz	No	Po	Ru	Sk	Es	Ch	Ua	Uk	Us
paper																								
PocketTopo																								
TopoDroid																								
Auriga																								
Qave																								
CaveSurvey																								
SexyTopo																								

Table 2. Survey data recording and sketch drawing

	Au	At	Br	Bg	Cn	Cz	Fr	De	Hu	Ir	Il	It	Mx	Mo	Nz	No	Po	Ru	Sk	Es	Ch	Ua	Uk	Us
Compass																								
Survex																								
Walls																								
VisualTopo																								
WinKarst																								
Therion																								
Excel																								
OnStation																								
TopoRobot																					1			
Grottolf																2								
GHTopo																								
Topo																								
Polygon																								

Table 3. Data reduction programs

	Au	At	Br	Bg	Cn	Cz	Fr	De	Hu	Ir	Il	It	Mx	Mo	Nz	No	Po	Ru	Sk	Es	Ch	Ua	Uk	Us
paper																								
AutoCAD																								
Therion																								
Tunnel																								
cSurvey																								
OpensTopo																								
TopoCalc'R																								
GHTopoDraw																								
Illustrator																								
CorelDraw																								
Inkscape																								
CCloud																								
Xara																								
Visio																								
CaveRender																					3			

Table 4. Cave map drafting instruments

Notes.
1 AGHplan is used for the Holloch region.
2 Report for Norway comes only from the research group that developed and use Grottolf.
3 CaveRender is also available as app for Android.

The picture that comes out is, many of the surveys are still done with tape, compass and clinometer but the trend is that the traditional instruments are being replaced by DistoX. Indeed in some countries DistoX is now used more than the traditional instruments. About 2200 DistoX units are distributed around the world. Many of them in western European countries (ch, de, at, fr, it, es, uk), scandinavia and eastern Europe. Between 100 and 200 in the us, and a few dozens in Australia and New Zealand. (B. Heeb, private comm.)

For data recording and sketch drawing, paper and pencil remain the preferred medium. However a considerable number of cavers use PockeTopo. TopoDroid and Auriga come next.

As for data reduction, Compass, Survex, and Walls are the most widespread programs. VisualTopo and TopoRobot are also widely in use although no longer maintained. Then there is a horde of other programs. Data reduction is probably a task to which programmer-cavers cannot avoid putting their personal expertise at work.

Finally cave map drafting is still done mostly with paper and ink, or a freehand drawing program (Adobe Illustrator, CorelDraw, Inkscape). In some cases CAD programs. Therion is used in many countries but it is not widespread. Other cave drawing programs seem to have a mainly national diffusion so far.

The organization of cave information and data varies from country to country. In some countries there is a national register, in some others there are only regional registers, while in the others still it is left to the local clubs.

Conclusions

This survey is very fragmented and far from complete. Nevertheless some conclusions can be drawn:

1. DistoX has come out as the winner in the process of replacing the traditional surveying instruments with digital devices. The reason for its success can be traced to it being a complete instrument (one shot takes all three data at once), its viable calibration procedure, and the affordable price.
2. there is no completely paperless solution: many cavers find the electronic devices still not comparable to sketching on a piece of paper. There is also the problem of keeping the device clean and dry in the cave environment.
3. on the side of data reduction, national borders or languages work as a barrier to limit the spread of caving programs. Few programs emerge as “international”. There remain a large number of “national” programs, and even “local” ones
4. for cave map drawing, there is no definitive cave-specific solution. Drawing programs, such as Adobe Illustrator or Inkscape, with suitable plugins, seem to be the best replacement of paper and ink for the draftman. Therion does not have a suitable user interface. Other programs are either not mature enough for drawing solutions, or still mostly confined to “their own country”.

Overall, at present, in 2017, we see that digital devices and programs have made a big progress in bringing novel practices to cave surveying and map production. These tools have not changed the approach to cave surveying, and I do not think they will. The purpose of cave surveying is to produce a geographical documentation of the cave, which, being an “interpretation” of the reality as seen through the eyes of the surveyor, is essentially a human activity. Rather they have changed the way cave surveying is carried out and the survey are presented. The digital evolution has made it possible to get better results, while making the task easier and more fun at the same time.

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