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Compass Points

BCRA

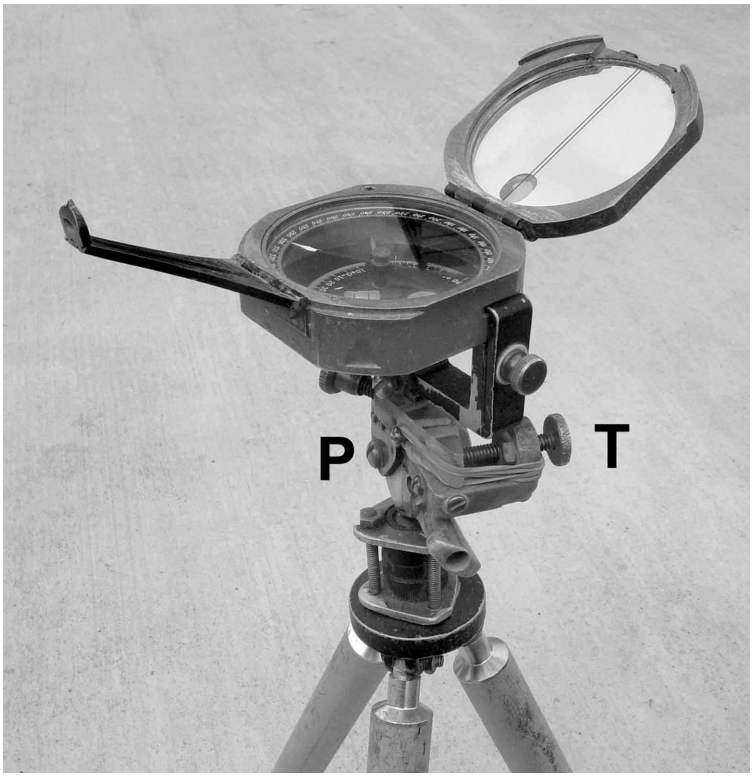

Figure 1: Brunton compass mounted on tripod and heavily modified pivot. T = tangent screw; P = pivot point for rotating compass 90 degrees to read inclination. Note dubious workmanship and rubber bands for tension. See Art Palmer's article inside.

Precision surveys with the Brunton compass

Displaying cave surveys on the internet

Summer field meet report

The Journal of the BCRA Cave Surveying Group

whether you are a member of the BCRA. Actual "membership" of the Group is only available to BCRA members, to whom it is free. You can join the BCRA for as little as £3.00 – details from BCRA administrator. Send subscriptions to the CSG secretary. Cheques should be drawn

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The journal of the BCRA Cave Surveying Group.

Editorial

Hello again from your editorial stand-in, and welcome to another issue of Compass Points. Much of the material in this issue arose from the successful Summer field meet held in Derbyshire. In addition to the surveying and other work that went on (described in loving detail in the field meet report and other articles), it was good to have the opportunity to meet other surveyors and discuss each other's projects. Indeed, it was such good fun that we're planning another one (in South Wales in October – details on page 3).

Hopefully this issue should arrive in time for the BCRA conference in Monmouth. The CSG will have a stand, and we will also be holding our AGM. The appeal for assistance in the last issue hasn't produced a rush of volunteers (to nobody's great surprise). Many hands make light work, and CSG could run much more efficiently if the work was split between more people – so if you have a bit of time to spare for CSG please make yourself known at the AGM and I'm sure we'll find something for you to do.

Anthony Day

Forthcoming Events

Hidden Earth 2002

Hidden Earth is the UK's annual caving conference, hosted by the BCRA. Hidden Earth 2002 will be held in Monmouth, South Wales on 27-29 September. The venue is Monmouth Leisure Centre & Community School. Further information can be found on the BCRA website at http://www.bcra.org.uk/hidden-earth/. The CSG will have a stand showing off surveying software and recent field meets. Other items that may be of particular interest to surveyors include:

- The Arthur Butcher Award is presented annually by the BCRA for, broadly speaking, "excellence in cave surveying". To be considered for the 2002 award, individuals or caving clubs must bring their work to the attention of the judges. This can easily be achieved by displaying your work on your club stand at the conference. If you want other work to be considered you should contact the judges in advance – see the BCRA website for details of the nomination procedure: http://www.bcra.org.uk/hidden-earth/rules.arthurbutcher.html.
- There will be a surveying competition comprising a closed loop survey course near the venue – prize awarded to the team with the smallest loop closure error.
- Wookey and Paz Vale will be presenting a workshop on lightweight expedition computing. The purpose of this workshop is to review the current technologies available for data processing and cave documentation on caving expeditions, and to compare and discuss real-world experiences. Wookey will cover his experiences of running Survex on a PDA in China, and having the complete expedition cave database available whilst surface-prospecting in Austria, and will describe current developments in this area. Paz Vale will talk about his experiences using PDA's in the field for survey production and the compilation of expedition reports and databases. There will then be an open discussion on what other people are using - what works and what doesn't.
- There is a plan hold a Survex session (though this has not been finalised) to demonstrate Survex in action, show some of the new features being developed, and discuss future plans.

CSG AGM

This will take place at Hidden Earth 2002, and is currently timetabled for 1pm on Sunday. If there is anything substantial you wish to discuss, please inform the secretary in advance. Current items on the agenda are the election of a new committee (any volunteers?), consideration of the relationship between Compass Points and the new BCRA publication “Speleology”, and a discussion on the position of CSG in light of the likely forthcoming reorganisation of British caving.

Autumn CSG Field Meet

The next CSG field meet is to be held at the headquarters of the South Wales Caving Club at Penwyllt on the weekend of 26th-27th October 2002. This field meet is open to anyone with an interest in cave surveying, from beginner to expert alike. You are encouraged to bring your own surveying gear if you wish.

The planned activities include radiolocation practice, surveying teaching/practice and a workshop for using hand-held computers for expedition surveying. As always, the programme of events is determined by the people who turn up - please contact the meet organiser if you have any ideas for things you would like to do.

Accommodation has been booked at SWCC - cost will be £3.50 per night, unless you are a member of SWCC. Camping is also available. You do not have to formally "book" a place on this meet, but it would be helpful if you could tell the meet organiser, Allan Richardson (contact details below) if you intend to turn up, your level of expertise, what you would like to do, and what equipment (if any) you intend to bring.

For more information contact Allan Richardson at:

87 Hacking Drive,
Longridge,
Preston,
PR3 3EP
Tel: 01772 783194.
email: allanr@caving.demon.co.uk
Web page: http://www.sat.dundee.ac.uk/~arb/csg/meet.html

Snippets

BCRA Cave Surveying Book

The Cave Studies series of booklets published by the BCRA aim to provide an introductory text for the sport caver who has become interested in some other aspect of speleology. Number 11 in the series is “Cave Surveying” by Anthony Day (ISBN 0 900265 25 6). This booklet was published in July of this year, and is a guide to the equipment, techniques and methodology of the BCRA system. Although quite clearly based on Bryan Ellis's *An Introduction to Cave Surveying*, (which was number 2 in the BCRA Cave Studies Series, and is now out of print), this new publication represents a careful review and thorough updating of the subject, both in the basic approach and the BCRA 'standards'.

The booklet is available in caving shops in the UK, and from the BCRA at a cost of £3.50 plus postage (see the Cave Studies series web page at http://www.bcra.org.uk/pub/studies.html for details of how to order). A full review will appear in the next issue of Compass Points.

Press Roundup

Compass and Tape VOL 15 No. 3, Issue 51

Reviewed by Wookey

Another issue of Compass and Tape (the newsletter of the Survey and Cartography Section of the National Speleological Society) arrived from our fellow US cave-surveyors in May 2002. Here is a summary of its content.

Ultrasonic Cave Mapping by W.I.Sellers and A. T Chamberlain

A paper describing the use of an ultrasonic device to capture passage profiles at the archaelogical site Kitley Shelter Cave, and set those on a conventional cave survey skeleton to produce a full

3D model of high accuracy and realism. The ultrasound device rotates and logs the reflected signals with a resolution of 10 degrees and about 5cm on an attached laptop computer. Human intervention is used later to work out the passage profile from the scan. This could be done in software but it was easier this way. Profiles were taken every 0.5m or so and the results assembled in AutoCAD. So far as I know this is the first example of a full ultrasonic profiling survey using affordable equipment. At the moment the process is time-consuming enough that it only makes sense when a highly-accurate survey is required, e.g. for archaeological study.

Canvas Map Makers Guide by Paul Burger

Paul gives a detailed tutorial on using the Canvas drawing software for drawing up cave maps. He includes suggested layer designations, scanning or digitising original drawings, and assembling them in canvas, recommended line weights, and defining built-in symbols (called macros in this program).

The Transit Survey Myth by Bill Mixon (reprinted from Compass and Tape Vol 5 No1)

Everyone knows that theodolite or transit surveys are more accurate than compass and tape right? Bill runs a simulation using typical accuracy values for these two survey types (+/-0.01 ft and +/-0.5 minutes for the transit and 0.1ft, 0.5 degrees for the compass and tape) to see how they compare. He finds that the compass and tape survey has a lower error than the transit survey after about 400 stations. This is because the transit angular errors are cumulative whereas the C&T directional errors tend to average out. He also makes the point that the very first transit shot is particularly important and difficult to do well. This analysis ignores the effects of station position error and blunders.

Letters

The Draenen Grade 5 Survey: response to an article in Compass Points 13

Andy Kendall

Sirs,

I have recently become aware of an article published in your publication (Compass Points issue 13) entitled "The Draenen Grade 5 Survey", that contains information and "rumours"

I think that these rumours and opinions should be considered as only one part of what was, in hindsight, a very stressful and busy time for many of the participants. I was not able to respond at the time to the comments in that article at the time, some of which I feel contain implied criticism of myself. I therefore would request that the following is offered to your readers as a clarification of events from my personal recollection and as a "lessons learned" that may aid anyone involved in or starting on a similar project.

Recollection

At the time that Ogof Draenen was discovered I and others began a survey. This information was for a Grade 5 survey rather than the Grade 3 survey being made by the explorers.

Given my inexperience in large surveying projects I contacted a number of experienced surveyors from other clubs for advice. Some of the people with whom this was discussed were the CSS surveying group who requested the opportunity to be part of the team. As a result of this they were eagerly invited to join the project. We agreed to do the data analysis and drawing with the CSS group managing the surveying trips.

One agreement I understood had been made was that data entry and centre-line plotting would be performed by both groups as rapidly as possible after each trip. This was, in my view, particularly important as the survey was being hand drawn at that time (plotters being a lot more expensive than they are now). In hindsight there was an expectation of more than a centre-line as discussed below.

As stated in CP13, a major talking point started to be when a "drawn up" survey would appear. This stemmed from a difference of opinion about a survey error. After the first few trips it had become clear that there was a significant problem in the data as there was an over 4 metre error in the first loop (from the Breakthrough around Big Bang Pitch and back up Pitch Bypass). My concern was when this major data issue would be resolved. The surveyors felt that they had to concentrate on other areas of the cave during fine weather. This became a significant discussion point as the amount of work that was waiting for drawing was building up.

Also about that time there began to be problems regarding the invitation to "any MCC members who wished to help to either telephone or turn up on a Saturday morning". It would turn out that for one reason or another the team had been delayed or had the number of people they wanted for the trip. I was asked to take it up with the CSS group. In hindsight this is where I think some of the personal problems between the CSS people and myself began, but the main effect was that interest dropped off rapidly.

Eventually the data error was corrected. This brought the closure down to the expected level and serious drawing could start, but by then the amount of work required to catch up was large. Over the next couple of months drawing went ahead at a significant rate with many hours being spent each evening drawing. The CSS team asked for a copy, but when we looked into the cost of photocopying the now more than 20 A0 sheets this would be prohibitive (£100 plus I think I remember).

Arthur said in his article that "Rumours started circulating about the amount of paperwork arriving through the letter boxes in Cardiff, and with the towel being thrown into the ring". This was indeed being considered, but not because of the amount of paperwork, but because of differences in opinions and priorities. These needed to be sorted out, but getting a face to face meeting proved hard to achieve given the different priorities.

We did eventually meet, and the "air was cleared" and a number of minor amendments to the drawings were agreed (clarification of junctions, positions of boulders etc). We agreed to push ahead to make sure that the drawing was up to date for the BCRA conference that September.

It must have been about this time that John "started some drawing", but as we were unaware of this, the hand drawing work (at least 200 man hours work) was brought up to date for the BCRA conference where it had been agreed to have the two club stands next to each other and have the fully drawn up survey available for people to see. However on arriving we were amazed to see a computer plotted survey that included sections of the cave for which data had not been sent to us.

Things were tense and some "straight talking" took place. We decided that we would immediately withdraw from the project. The hand drawn sheets were put back in the boot of the car and we immediately broke off from being part of the project. On getting home the drawings went into the attic where they remain to this day.

So the lessons I learned from being involved.

1. Bringing on-board people who had worked on major surveying projects and understood the scale of work that needed to be done was the right thing to do.
2. The way of working and priorities was not made clear enough on both sides at the outset so expectations were missed and this lead to breakdown in communications on both sides.
3. ALL aspects of a major survey are hard work. Don't get involved with a major survey project unless you are prepared to deal with it all. The people issues can be harder than the actual work.
4. Double data entry is a must, This was extremely useful as "data entry errors" made by both myself and John Stevens were identified and rapidly corrected.
5. If you want people to help you on your trips you have to work hard to make them feel wanted. If not you will find that you are reliant on a number of extremely dedicated individuals.
6. In hindsight we should have taken an approach of doing "rough" drawings and returning these to the surveyors to sort out the data entry/recording issues rather than moving straight to the much more time consuming final copy standard. This would have given greater visibility to the large amount of work that was going on. Trust that things will be done needs to be built, even though every set of survey pages received was in the computer and calculated the day it arrived (this often resulting in working well past midnight).
7. Computer and plotting technologies are now affordable to many. For a project of this size they should be considered a must. Email was just becoming available and affordable and would have helped significantly. Plotters would have meant that things we could not afford to do were possible, but if you take on the drawing up then make sure you consider the cost implications of providing frequent copies to surveyors (paper, ink, copying, postage etc).
8. The decision to ask explorers to survey to a different grade to the proposed final version sped up exploration, but meant that people are still working to different standards and causes sections to have to be done again. In some ways maybe this is one reason that data is still not being shared. I think that setting the aim of Grade 5 from day one would have made this much more of a team effort.
9. I didn't understand the difference in opinions regarding who would own the Grade 5 data for this system (the closed vs. open source model) and the implications of such opinions. This dispute continues today, and in my opinion the only model that makes sense is the open source model (with appropriate safeguards if needed to help make sure that people reap some benefits from their hard work). Without this being put in place a survey becomes an untestable "pretty piece of paper" rather than a scientifically valid document (maybe this is something that needs to be considered in any future revision of the BCRA survey grades). I don't know whether the complete G5 survey of Ogof Draenen will ever be published, and with so much hard work having gone in this would be a major loss to all cavers.
10. A project of this scale is a multi-year project and you need to consider the things that can change over that time and make sure that things are put in place to safeguard the project from key people dropping out (especially if they are the keepers of key information).

Conclusion

There are obviously differences of opinions on a project of this size, but when they are put into writing (as per the article in CP13) it is important that all opinions are shared rather than "rumours" being left as the only version for the historical record. I hope that readers find some of this informative, and in particular that MY lessons learned (others may have others to share) may prove useful.

Field Meet Report, Summer 2002

The Summer field meet in Derbyshire was well attended. Those present got the chance to try their hand at scale drawing underground, experiment with digital surveying instruments, and were treated to demonstrations and discussion of surveying software.

Wookey, Andrew Atkinson, Olly Betts and Anthony Day

The Summer CSG field meet was held at the headquarters of Orpheus Caving Club in Derbyshire on the weekend of 29th-30th June. A total of twelve people attended, including some honoured guests who had travelled rather further than is usual on these occasions. Martin Sluka and Martin Budaj had come all the way from The Czech republic and Germany respectively. MartinB is actually a Slovak but he is currently studying at university in Germany. MartinS decided that having got as far as Germany to pick him up he might as well carry on to Derbyshire. This is dedication to surveying. He also failed to find the rather obscure track to the Orpheus hut (due to email failure in the days before he travelled meaning he never got the detailed map and instructions) so the pair got to spend the night in the car. This wouldn't have been too bad except that: a) it was bloody freezing; and b) poor old MartinB had come with the clothes on he stood up in, his laptop and nothing else, so he didn't have a pit.

We were very pleased to finally meet Martin Sluka after occasional correspondence over many years. It was also fascinating to meet half of the Therion team in the form of MartinB. We hope they enjoyed themselves before the long drive home. Overall, our first international field meet was a great success - if any of our other foreign members wish to make the effort to come and visit us sometimes we'd be pleased to have you.

The full list of attendees is as follows:

Andrew Atkinson, Olly Betts, Julia Bradshaw, Martin Budaj, Anthony Day, Chris Franklin, David Herbert, Mehmet Karatay, Allan Richardson, Mark Shinwell, Martin Sluka and Wookey.

Activities

Saturday morning saw everyone heading underground (except Julia who had gone down with the flu and thus spent most of the day in bed). The two Martins had brought some toys with them, specifically MartinS's digital instruments and a pile of “Therion Protractors”, which are used to aid surveying to scale. Two teams were despatched to Jug Holes and one to Hillocks Mine to play with this gear. We also had some newcomers to surveying present,

and they too went to Hillocks Mine for some training. Everyone was back on the surface by late afternoon, and the evening was set aside for playing with/talking about surveying software. We were treated to a demonstration of the capabilities of Therion, and Olly gave us an outline of the likely path that future development of the Survex suite will take. There was also some discussion of the possibilities for integration between Survex and Therion. Sunday was spent drawing up the results of the previous day's surveying efforts, while the two Martins were taken on a tourist trip down P8.

Drawing to Scale with the Therion Protractor

A popular technique amongst surveyors (used at least by Germans, Americans, Slovaks and Czechs) is drawing to scale in the cave. The main advantage of the technique is that the finished drawings are basically correctly sized and oriented, devoid of the spurious bends and fish-eye distortions in large passage that British surveyors are used to finding when it comes to drawing-up time. The main disadvantage is that it is a bit slower (you can't start drawing until you have all the readings for a leg.)

One of the problems with this technique is that for legs with more than a few degrees of vertical tilt it is difficult to know how long to draw the line in plan because it is foreshortened. The Therion team have designed a device (the Therion protractor – see Figure 2) to save the surveyor from having to estimate this and turn the drawing method into a set of simple steps which can be performed even by a tired brain.

We went to Jug Holes and Hillocks Mine to try out the method and protractors - there's nothing like some real cave surveying to get the hang of things. In Jug Holes, one team (MartinS, Andy, Olly) also used MartinS's electronic instruments (see the next section), whilst the other team (Wookey, MartinB, Allan) used old fashioned compass, clino and tape. The similarly low-tech Hillocks team comprised Mark and Anthony.

To use the Therion protractor (TP) in the plan view, you first decide which bearing is up the page - preferably north, but another cardinal may be better to help keep the passage on the page. The method of use is described here and illustrated in Figure 2.

1. Place the centre of the TP on the "from" station (point O in Figure 2).
2. Align the line on the TP corresponding to the compass reading with North on the page.
3. Find the point on the protractor edge corresponding to the tape measurement (point A).
4. Follow the curved line up from here until it intersects with the radial line matching the clino reading (point B).
5. Follow the straight lines back down to the edge (point C) and mark the leg along the TP edge (using it as a ruler) from here to the centre.

Now that sounds pretty complicated, and it is not totally simple, but in fact it is fairly straightforward and quick once you get the hang of it, and means you don't actually have to think much about directions and angles. One thing we noticed almost immediately is that it saves you from in-cave gross reading errors. In Jug Holes, on plotting leg 3 it was obvious that the angle on the page didn't match the real world - something was badly wrong. A quick check of the first two readings found the error - a classic incorrect compass reading due to a steep leg. Using normal UK surveying technique the picture would have been drawn correctly and few cavers would notice that the data didn't match up until they processed it back home. This is a major gain.

The Jug Holes team also quickly noticed was that their paper was too small! Each TP is made for a particular scale (e.g. 1:200, 1:250. 1:400, 1:500) so you have to draw at the scale of the TP you have. Ours was 1:250 and for the reasonably large Jug Holes with about A5-A6 sized paper this meant everything was off the edge as soon as you started. After a couple of legs they started using it at half-scale (1:500), which was a lot more sensible, but involved some dividing-by-two, making it less of a no-brainer. The Slovaks use relatively large sheets of paper for this technique - either A4 or A5 according to the conditions. An A5 wallet that folds out to A4 for drawing is a good size. Squared paper with squares that correspond to one metre is best as it makes it easy to draw walls the right distances from the centreline. So a 1:500 TP works very well with 2mm squared paper and a 1:250 TP works best with 4mm squared paper. MartinS favours polystyrene-impregnated graph paper as it is cheap and effective (see Martin's letter to Compass Points issue 25, September 1999).

The Hillocks team started surveying in a relatively large chamber with a number of ways out, and had some difficulty orienting themselves at first as a result. However, once in a simple passage they found the TP much easier to work with. Given that the passage was close to horizontal, and the survey legs generally had shallow slopes, they quickly got a feel for the combinations of length and slope for which the foreshortening effect was negligible at the scale in use, thus considerably speeding up the rate of progress. They also didn't encounter the same problems of constantly hitting the edge of the page to the same degree in the generally smaller passage at the bottom of Hillocks Mine, emphasising the point that the scale of protractor and size of notebook should be tailored to suit each other.

Anyone can print their own TP - images are available on the Therion website (http://www.therion.sk/protractor/) for both grad and degree versions - but you do need to laminate them otherwise all the numbers will rub off in one trip (as they did with some we made before the meet). MartinS kindly offered to make CUCC a pile of protractors at our favourite sizes (1:500, 1:250) so some people will try this out in Austria this year.

Overall we were generally impressed with this technique, but it is clear that it needs a bit of practice to get up to full speed with it, and you need matching book, paper and TP for high efficiency. Allan was rather less complementary about it and is unlikely to adopt it anytime soon. If you want to be able to scan in your in-cave pictures for computer-aided drawing up, then consider having a go with drawing-to-scale. In this case, it may still be advantageous to draw an intermediate neat copy before scanning if your original notes are disjointed owing to the "edge of the page" problem or are covered in mud. However, where the in-cave pictures are drawn to scale, this task is very much less onerous than when they are not. We found that redrawing the Hillocks notes effectively became a tracing exercise, which was very fast (and could have been faster had we had a light table rather than having to hold everything up to the window.)

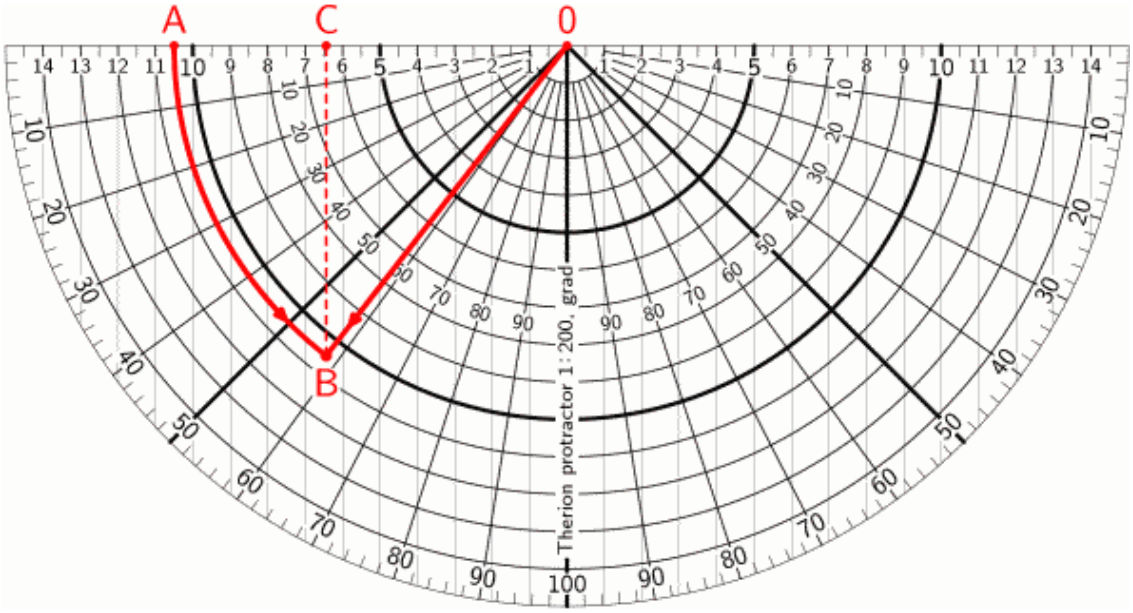


Figure 2: The Therion protractor (see text for significance of annotations).

Surveying with Digital Instruments

One of the Jug Holes teams got to try out MartinS's digital instruments, which were described in detail in Compass Points issues 22 and 23. Martin uses a Leica Disto, a small laser tape that claims to be accurate to +/-3mm over distances of 100m, with a digital level – the "incliTronic" – fastened to it. These devices are arranged with a small vertical spirit level, used to ensure that the incliTronic is correctly aligned when reading the inclination. He also uses a geological compass with a laser pointer mounted on the side on a brass bush so that it can rotate vertically. This arrangement allows the compass to be levelled whilst the laser pointer is aligned with the leg, thus improving accuracy on steep legs. These instruments are shown in Figure 3.

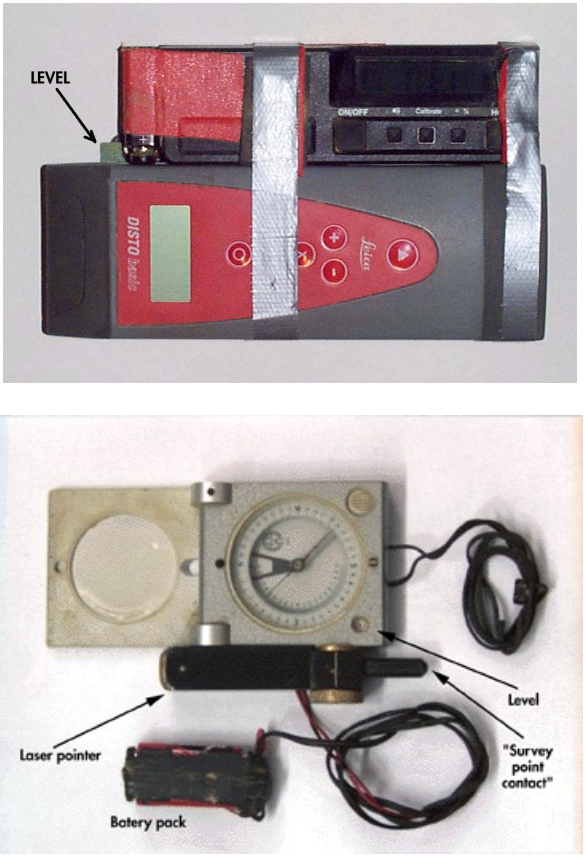


Figure 3: Leico Disto with incliTronic and spirit level (top), compass with attached laser pointer (bottom)

The combination of the Disto and electronic clino is quite bulky and it took a while to get used to the sequence of buttons that needed pressing. After activating the instrument you have 10 seconds to align the laser, with a 5 second beeping countdown. Unfortunately the last beep means one second to go, rather than indicating that the reading has been completed. Andy kept forgetting this and moving it after the last beep, therefore having to do it again (this seemed to get on Martin's nerves no end.) However, once everyone got used to this (after about 5 goes) progress rapidly improved. The feeling was that, in the long term, this kit would make for longer quicker surveying, especially if the button sequence could be reduced to a single press. The other main use of the Disto is to measure passages dimensions; no need to move or guess, but without thought this could lead to a user measuring a specific point that is unrepresentative of the overall feel of the passage.

The compass, again, is very bulky and, due to the laser arm and levelling bubble, requires three levelling movements that team Brit had great difficulty with. We did not have the opportunity to practice enough to see if this was a skill that could easily be developed. Although the compass dial was large Andy found it very hard to read. This was not helped by the graduation lines slowly increasing in length, meaning it is not possible to use these through the magnifying glass as an aid to reducing parallax error.

Overall, our conclusions based on this limited test were that the clino and Disto were excellent, but the compass was very fiddly and as such offered no clear advantage over the more usual look-through varieties, except for the steepest legs. Attaching a laser to a sighting compass could be the ideal combination.

Training

In common with many previous CSG meets, we offered the opportunity to learn how to survey. We had two absolute beginners (Chris and Mehmet) and one who hadn't surveyed for a while (David) who wanted some practice. Following some instruction in how to read the instruments and take notes at the hut, it was off to Hillocks for some practice underground. After half an hour spent wandering around looking for the entrance, surveying got underway under the watchful gaze of "expert" surveyors Anthony and Mark for a few legs until they got the hang of it. In the end they surveyed as far as the bottom of the first pitch before calling it a day, with all three getting the opportunity to try their hands at all the jobs.

In the evening, the data was entered into Survex and centre-lines for a plan and elevation prepared. Chris and Mehmet then spent Sunday experiencing the joys of drawing up, especially drawing projected elevations where passages refuse to line up conveniently. The end result was pretty good for a first attempt, and everyone learned something about all the stages of producing a survey.

Software Demonstration and Discussion

Martin Budaj, one of the two authors of Therion, demonstrated some of its features to us. Rather than reinventing the wheel, Therion works alongside Survex, and makes use of TeX and MetaPost to render 2D maps, which means Martin and Stacho Mudrak are able to direct their efforts on some innovative features.

ThEdit takes scanned survey sketches and allows you to draw them up on the computer. It has special symbols for all the things you might find in a cave survey - for example, it knows how to draw a "ticked" line that is commonly used to mark an abrupt drop, and if you zoom in or out, it will adjust the number and length of the ticks appropriately. The symbols are described as MetaPost scripts, so more can easily be added.

The finished survey can be rendered to give an EPS file, or using thPDF you can produce a PDF. PDFs can be multi-page atlases, with different levels of the cave split off and split over several pages. You can navigate the atlas by clicking on links on thumbnail overview maps.

There is also xtherion. This is a "smart" text editor that understands the format of Therion data files, and also Survex .svx files. Since the demo at the field meet, the ability to edit the 2D map files has been added, though we haven't tried out this facility.

Overall, Therion looks very promising. It is not finished, but is now very close to being usable. If you're interested, you can download the test version from their website (http://www.therion.sk/). The authors would welcome any feedback on what you think.

In the evening, Olly gave a talk on the path of future developments in Survex – these are expounded in a separate article in this issue.

Summary

Overall, the Summer field meet was a great success, with some useful insights gained into each others projects and surveying techniques. Thanks go to Allan Richardson for organising it, to the Orpheus Caving Club for allowing us the use of their hut for the weekend, and to everyone who attended.

Survex - Past, Present, and Future

Olly Betts

Olly offers his thoughts on future developments to the Survex surveying software suite, as presented at the Summer field meet.

I am not going to cover ancient history here - if you're curious, there's a brief history of how and why the project started on the web at http://www.survex.com/history.html.

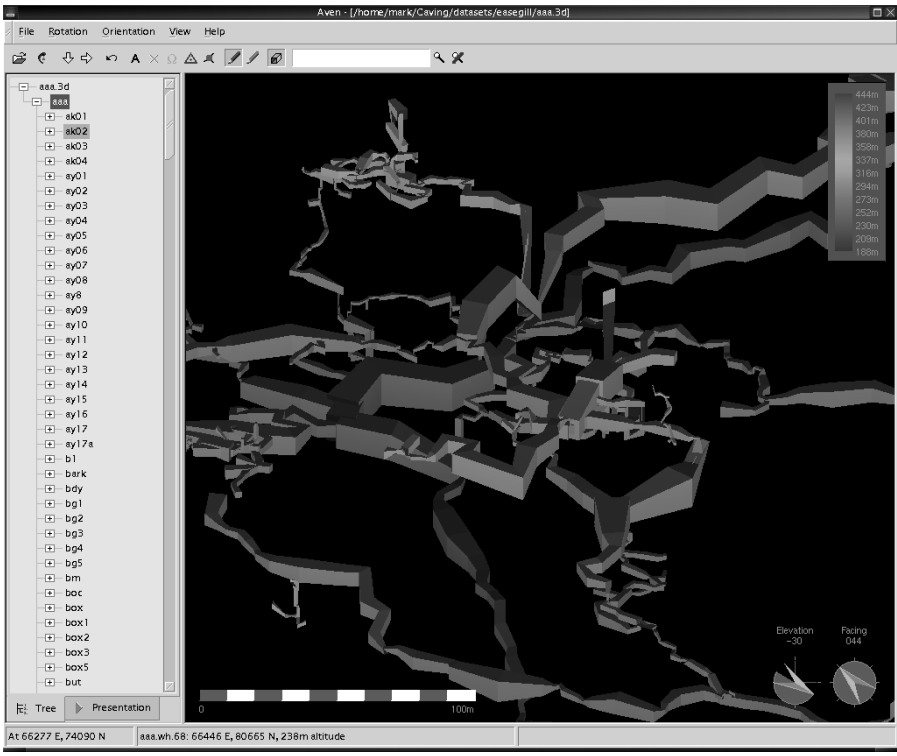
We built Survex to be powerful, flexible, and efficient - for example it doesn't pre-suppose a particular way of surveying or measuring units, it is translated into 8 different languages (plus 4 variants), it doesn't impose arbitrary limits, and it is capable of running on different computing platforms. It was open source years before the term was coined, and is probably the only cave surveying package written by a group of people - more than a dozen people have made major contributions.

For a long time, you had to be willing to use the command line to use Survex. This is no longer the case, but the reputation seems to have clung - probably because people tried it a few years ago and assume it hasn't changed. Increasingly it is undeserved.

Except on MSDOS and RISC OS caverot/xcaverot have now been supplanted by aven. Aven is a GUI survey viewer with a native look-and-feel – unlike Java programs, it actually looks and behaves like a Windows program on Windows, like a Gnome program on Unix, and like a Mac program on Mac OS X.

The most recent Survex release (1.0.14) sees the addition of svxedit - a survey data entry editor that understands the format of Survex data files. It is currently labelled as experimental - we're actively seeking feedback from users as to how it should evolve.

Over the past year, we've also been experimenting with sophisticated 3d visualisation code - for example, rendering of terrain data, draping scanned maps and aerial photos over terrain data, and tube surveys using passage dimension information (see Figure 4). You may have seen some of this in action in the CUCC presentation at last year's BCRA conference. These features should be available in an experimental release shortly.



At present, you could say the 3d file is the heart of Survex. The user types survey data into text files with the extension svx, then cavern processes this to produce a 3d file (and also an err file with loop closure statistics, and optionally a log file with any warnings and errors and some statistics about the survey).

Nearly all the other Survex programs then process the 3d file (the one exception is sorterr which re-sorts the err file in a choice of ways). A neat feature is that all these programs can also load a Survex pos file, a Compass PLT or PLF file, or a CMAP XYZ file instead of a 3d file.

This design generally works well, though there are a few niggles with the current 3d format:

- The survey data entered by the user stays in the svx files - it isn't copied into the 3d file, and there is no easy way to refer back - so you can't click on a leg in aven and look at the raw survey measurements.
- The statistics in the err and log files are also not available to the user in aven. An obvious question to ask is "How long is my new survey?" At the moment you have to process it with cavern separately and look at the output/log file.
- Data such as survey dates, personnel, and instruments aren't copied or referenced in the 3d file.
- The ends of legs are identified by co-ordinates rather than station names (in retrospect this is a poor design) and there is no explicit listing of equated stations.

The above list can all be addressed with a revised 3d format.

An alternative approach we've been discussing is to use a relational database in place of the 3d format. The main advantage is that a lot of operations become easier to implement. The main downside is that there is no longer a single file that you can give to people who want to view the survey, though it is possible that the database could be dumped and reloaded to achieve this.

There are also aspects of the current design that cannot be addressed by a new 3d format/database. These are:

- The printing system comes from an era of when DOS programs were the norm and each had to include support for printing. Nowadays operating systems include this as a centralised service. Phil Underwood wrote a printer driver this uses the MS Windows printing system, which at least means that, if Windows can drive your printer, so can Survex. It removes the need for Survex-specific printing configuration. However, because printing is performed by an entirely separate program, there is no preview facility - at best you can print out postscript and look at it with a separate program. That doesn't help much if your printer isn't postscript, as the page size won't be quite the same.
- Both printing and export (as DXF, etc) would benefit from being able to graphically select subsections of the whole survey, whether legs, stations, names, etc are shown, and viewing angles and scales. At present you have to select the view in aven, then write the numbers down and type them back into a separate program. You also have to tell it what to plot, rather than just clicking on toolbar buttons in aven.
- Whilst it is great to be able to view a Compass PLT file, it still means I need to have Compass installed to process the survey data - unhelpful if I'm on Unix or a Mac (Survex is very close to working on Mac OS X). Similarly for Toporobot if I'm not on a Mac (Survex doesn't yet read Toporobot files, but it could do - I'm just pointing out that this is also of concern to MS Windows users). It also doesn't help in the case when someone connects a cave surveyed using Survex to one surveyed with another package. In this case Survex needs to be able to read the raw survey data (the .dat file in the case of Compass), unless someone comes up with a convincing survey data exchange format, and many attempts have failed so far.

  Note that simply reading and understanding "alien" data is much easier than converting it to another format with its own restrictions. Also Survex has the advantage of not imposing arbitrary limits on such things as station name length or the ordering of survey legs (some packages do).
- The loop closing routines are designed for a "one shot" approach. It is not easy to use them in an iterative or interactive way - e.g. if a potential blunder is identified, then it would be ideal to (automatically or manually) break the survey there and reclose, but that is hard at present.

Figure 4: Example tube survey, drawn with a development version of aven.

So with that in mind, I'll sketch out a roadmap to give you all an idea of where Survex is heading in the short to medium term.

We're intending to develop Survex in two parallel tracks - one will be intended for general use, with a conservative view on making major changes. The other will be verging on experimental - it's made available to allow a larger audience to comment on the software, suggest new ideas, tell us what they like and what they don't, and so on.

We're adopting a convention used successfully by a number of other projects. The stable versions will have an even middle number (e.g. 1.0.14, 1.2.0); development versions an odd middle number (e.g. 1.1.0).

Once 1.1.something has all the features we want and we've fixed all the known bugs, we'll call it 1.2.0, and this will be the new stable version. Shortly afterwards we'll start would on 1.3.something, heading for a stable 1.4.0, meanwhile releasing 1.2.1, 1.2.2, etc as needed to fix problems reported in 1.2.0. We plan to keep each development cycle to a manageable size so new features get into a stable version reasonably quickly.

The 1.0 branch is pretty much feature complete now. The ability to specify repeat readings is currently mostly implemented, but disabled. Hopefully this will be finished for 1.0, but it may be retargeted for 1.2. We also hope to release a Mac version of 1.0, and get aven to work on MSDOS.

For 1.2, our current hopes are approximately these:

- Passage dimensions (LRUD), and drawing of "solid" cave models using them.
- LRUD requires a revision of the 3d format, so while it's changing we'll add slots for survey title/date/team/etc, which you can currently specify in the .svx files but are pretty much ignored. Also details of the original survey legs and closure errors will probably go in.
- Printing from aven (probably using the wxWindows printing facilities) with page preview so the user can adjust where page breaks occur relative to the survey and select which pages to print.
- Export as DXF/Sketch/PNG/for hand plotting etc hooked into aven.
- Import of terrain data for aven.
- Finish off and enable presentation code in aven.
- Colouring by date/error/survey etc rather than just depth.
- Make Survex more usable on palmtop devices such as the Psion 5 and Compaq's iPAQ.

After 1.2, plans are rather more vague, but will probably include:

- Extend Survex to allow it to be used to help produce and automatically update web sites for survey projects. For example, when a new survey is added, and the cave gets longer and deeper, all references to the length can automatically be updated.
- Look at using a relational database.
- Rework loop closure routines to be more flexible.
- Restructure svx parser so it's a self-contained module which can be used for parsing svx data elsewhere - for example, the data entry editor could use it to parse and colour the file as you type it in, and indicate errors at the point of data entry. It could even draw the survey as the data is being entered.
- Interactive extended elevation editor.

We plan to hold a Survex session at the BCRA conference, so if you're able, please come along and we'll demonstrate Survex in action, show some of the new features being developed, and discuss future plans.

If you can't make the conference, the Survex mailing list is a good place for questions and comments. You can find details of how to join on the Survex website: http://www.survex.com/.

Precision Surveys with the Brunton Compass

Art Palmer

When Art Palmer declared to the Cavers' Digest web site that he regularly obtains loop closure errors of the order of 0.05% using a Brunton compass for cave surveying, his claim was met with a certain amount of incredulity. In this article he outlines the methods he employs to attain this remarkable level of accuracy.

A year or two ago there was a brief flurry of correspondence on the Cavers' Digest Web site (USA) about the relative merits of Suunto versus Brunton compasses for cave surveying. The Brunton "pocket transit", for those not familiar with it, is one of the standard tools of the field geologist. It is hinged, with folding prongs in front and back for sighting (- front cover). A rear mirror provides an alternate way of sighting. Nearly everyone uses it hand-held, but unless it is mounted on a tripod its high cost and precision design are wasted. The discussion on Cavers' Digest quickly established that Suuntos were for real cavers and Bruntons were for effete snobs, or for mossbacks who refuse to change with the times.

But the Suunto has problems. It must be held close to the eye, so there is considerable chance for deflection by magnetically susceptible objects, such as parts of helmets and lamps, and even the pins in one's eyeglasses. It is difficult to ensure that the compass is situated directly over the survey point (or at the proper elevation during vertical shots). It is very difficult to sight at high angles. Finally, on the traditional model the numbers increase to the left, so inexperienced readers make frequent blunders. Still, they are ideal for the average cave survey.

I weighed in with a comment that Bruntons were superior to Suuntos if they were used correctly, and that I routinely get closure errors of about 0.05% in cave surveys - and the battle was on!

Several respondents found my claim to be incredible. Surely these results were a few lucky examples selected from many. How is it possible to obtain such low closure errors consistently, and under real cave conditions?

Like most passionately argued topics, this one is something of a non-issue. A good cave map shows what the cave is like and how to find where you are. Accuracy is usually a secondary issue. Besides, if you really want accuracy, use a theodolite. But we're concerned with fairly rapid surveying under typical cave conditions.

The following comments are an expansion of my final Cavers' Digest entry on the subject. Although they are specifically aimed at the Brunton compass, some apply to cave surveys of all kinds.

First, there are two general guidelines:

A. Minimise blunders by entrusting the compass readings only to those with extensive practice with the instrument. Each reading (even taped distances) should be made at least twice. Take your time, because the slowest person will usually be the sketcher. Avoid distractions - don't survey with people who are addicted to idle chatter!

B. The compass must be carefully calibrated. This is crucial for large projects where many different instruments are used, and/or when the survey extends over several years. Don't trust the magnetic declination specified on maps, because it is almost always out of date. Even such trusted sources as geological surveys usually rely on interpolation models that are only roughly accurate for any given site. Besides, most compasses have inherent internal errors, so it is necessary to calibrate each compass to true north individually. Establish a compass calibration course over the cave in question, and make sightings between fixed points in the calibration course before every survey trip. (It is also wise to re-check the readings afterward, to ensure that the compass has not become misaligned during the trip, and that there has been no short-term magnetic storm.) A reliable way to find the direction of true north is to make a star sighting with a theodolite and adjust for time and latitude. An adequate but less reliable method is to sight between two known points that are widely spaced on a topographic map. Subtract your compass reading from the actual direction on the map. This gives you a correction factor that must be added to each reading in your survey.

Beyond these obvious points, a few simple steps can reduce errors to about 0.05% with the Brunton. Except by chance, it is impossible to get the error much lower - 0.043% is my average over several dozen survey loops (0.011% standard deviation), and it is not going to improve, except once in a while due to dumb luck. The point is to prevent substantially higher errors.

To get this accuracy in a single shot, you would have to read the compass accurately to the nearest 0.03º. Good luck! Even measuring the distance to within 0.05% is difficult. But if the errors are random (i.e. not caused by systematic problems), they tend to cancel thanks to the "random walk" phenomenon. In each dimension (length, azimuth, and inclination) the readings ideally have a random scatter, and the error in each reading is just as likely to be too high as too low. Significant cancelling of errors will work only if there are many segments in a survey. A loop of only a few shots isn't enough. A dozen will usually do. The longer the loop, the better the chance for a small closure error (error / loop distance), but also the greater the chance for a blunder.

Below are some hints on how to minimise survey error with the Brunton compass. Some are obvious, others are not. They will not guarantee the small loop-closure errors described here, but they will at least get you close.

1. Mount the compass on a tripod. This allows the needle to settle down to give stable readings, and also helps to keep the compass a safe distance from magnetic objects. With hand-held instruments, most people consistently position them off-centre relative to the station. This error is often systematic (non-random) and tends to accumulate rather than cancel. The tripod gets the compass reader up out of the mud, too, and requires fewer contortions. Brunton sells a non-magnetic tripod and a pivot for mounting the compass on it (see http://www.brunton.com). However the pivot has been recently re-designed so that it will not work. Trust me on this one. Mine fell apart after an attempt to make it work, so I modified it by adding a gizmo of acrylic plastic and aluminium (Figure 1). This includes a tangent screw, which allows smooth and easy sighting just by turning the screw (Figure 1). Of course, some passages just aren't suited to Bruntons on tripods - river passages come to mind. However the tripod legs are retractable and can be adjusted to any angle up to 90 degrees, so it is possible to use this technique in a surprising variety of passage types.

2. Use a small flashlight as a target for sighting. I have mounted mine on a second tripod, held in place with a swivelling head

(Figure 5). This sounds like a lot of gear to carry into the cave, but the ease and precision of the resulting compass readings is well worth it. An additional benefit is that the person at the end of the tape is free to walk around and make measurements, rather than staying rooted to one spot while holding the light. Because all stations are “floating” above the floor, it is necessary to set permanent stations beneath the tripods by measuring downward with the tape. The permanent station on the floor needs a different name from the station at the tripod head.

Figure 5: Target light mounted on tripod with swiveling head. The filament stays in the same position regardless of tilt or swivel.

3. Read the angles to the nearest 0.1º with a hand lens. Sharpening and extending the compass needle helps. Actual accuracy is probably no better than 0.2º, but it is surprising how consistently an experienced reader can read to 0.1º. Older Brunton models are better. The design has deteriorated in recent decades, and much of the original precision is gone. For example, induction damping makes the needle settle down faster, but the newly designed needle can't be read so accurately without being modified.

4. Sighting with the Brunton can be a problem, because it is necessary to focus simultaneously on near objects (the compass sights) as well as on the distant target. Therefore, sight with the shadow method or some variant thereof. The simplest method is to align the shadow of the forward prong (cast by the target light) with the line on the mirror of the Brunton. This method, combined with the smooth action of the tangent screw, eliminates the stress of sighting the compass. For greater precision, I prefer to use the compass fully extended, and to sight between the two upraised end prongs. By holding the magnifying glass close enough that the rear sight is in focus, the image of the target light appears as a bright, moon-like disk with a virtual image of the forward sight imposed on it. I can't begin to explain the optics, but the result is that the images of the two sights can be brought together in a very clear and positive way. This method is also ideal for the vertical reading.

5. Alternate between foresights and backsights, shooting back to station 1 from station 2, forward from 2 to 3, back from 4 to 3, forward to 5, etc. This helps to cancel any calibration problems in the instrument. My two tripod mounts are the same size, so the target light and compass can be switched in case foresights and backsights are desired within the same survey leg. I rarely bother, and instead just repeat the basic readings from scratch and make sure they agree to the nearest 0.1º and 0.05 foot. I've never had any closure problems with this method, even in caves with commercial lighting and metal stairs. The tripod helps keep the compass at a safe distance.

6. Keep the shots short – preferably less than 15 m. Otherwise tape sag and stretch are problems. Also, compass-related errors can be substantial on long shots.

7. Carefully sharpen the pivot on the Brunton so that the needle dances wildly when hand-held. On a tripod it should take about half a minute to come to rest. A sticky pivot is a big source of error, and it can be systematic if you tend to make the final rotation of the compass in the same direction each time. Tapping the tripod leg with a pencil helps prevent sticking needles, but this should not be necessary with a properly sharpened pivot.

8. Be careful to avoid parallax errors when reading the compass or inclinometer.

9. Check the calibration of your inclinometer. Sight between two points, both forward and backward, and take the average. To correct for maladjustments, subtract the forward reading from the average of the two readings, and add this correction factor to every reading. It's easier than trying to adjust your inclinometer to be perfect. Fussy people may want to repeat this calibration at a variety of angles, in case the inclinometer is off-centre. Thus the calibration factor may vary with the angle.

10. Correct for eccentricity (in the compass, that is). The pivots on most compasses are not perfectly centred, so foresights and backsights do not agree. My own Brunton has a maximum eccentricity error of 0.5º. Even the compasses on professional surveyors' transits are not immune.

    If both foresight and backsight are made between each set of stations, and the two are averaged, the eccentricity errors cancel. But most people try to make the backsight match the foresight, unintentionally weighting the results in favour of the foresight. The two readings should be made independently and then averaged. If the compass is mounted on a tripod, it is very difficult to get reliable backsights unless two tripods are used (see item 2). Even with two tripods, it takes a great deal of patience to switch the compass and target lights to allow backsights. The added time and fatigue tend to counteract the benefits of using the tripod in the first place. It is easier to check for accuracy by making repeated measurements, rather than with combined fore/backsights between each pair of stations (see item 5), but if you do, it is critical to adjust for eccentricity.

    To determine compass eccentricity, design a calibration course with radiating lines every 15º or so from a central point, using a theodolite. From the central point, shoot to each outer point with the compass and determine the discrepancy between the actual readings and the correct values. Corrections can be made from a simple graph of the results, or they can be made by fitting the discrepancies to a sine function. This and other calibrations can be made with a simple computer routine, and with a bit of luck it can be inserted into your favourite survey software.

Below are two examples of closure error using this method. Each used the two-tripod technique, leapfrogging between stations with alternate foresights and backsights. No reverse shots were made between any given pair of stations.

A few years ago I was asked to run a base-line survey through Virgin Cave, New Mexico, by the U.S. Forest Service. The route was highly irregular, involving lots of steep angles, hanging out over deep space, etc. It included a complex loop of 550 m that took three days to complete. Total X-Y-Z closure error (with eccentricity correction) was 0.71 ft, or 0.04%. This is a typical result.

The Compass course at the National Speleological Society convention of 1998 offered more comfortable conditions. My wife and I ran a tripod-mounted Brunton survey with an uncorrected closure error of 0.137% - the overall winner for that and any other year. This included the total X-Y-Z error. (We also required the least time of any party.) However, to level the playing field, we purposely did not account for eccentricity. Corrected for eccentricity, the closure error dropped to 0.017%! A bit of luck there.

I mention these two examples specifically because they were computed under supervision. Computing the Virgin Cave survey was a bit sweaty because there were Park Service and Forest Service staff looking over my shoulder as I entered the data. You can't count on luck when you have a single chance to get it right.

Many cave surveyors will scoff at this list of suggestions. They are welcome to, because cave-survey accuracy is not a burning issue. But for the base-line surveys through major passages, this method is quite accurate, fast, and comfortable. Still, when the mud and water start to rise, I'll reach for my Suunto.

Art Palmer is professor of hydrology, geophysics, and geochemistry at the State University of New York at Oneonta. He is an honorary member of the National Speleological Society (USA) and is also a member of BCRA and the Cave Research Foundation. Although his main interest is cave geology, he and his

wife Peg have surveyed more than 90 km in and around caves using various techniques, including those described here. Among the caves they have helped to survey are Mammoth Cave and Lechuguilla Cave, nearly all 33 km of Blue Spring Cave (Indiana), alpine caves in Utah, Montana, and Colorado, and a variety of caves throughout the eastern U.S. and surrounding countries.

Cave Surveys on the Web

David Herbert

This article describes the work David has undertaken to create a website (www.cavesurveys.com) where cave surveyors can display their handiwork, and the problems he encountered in the process.

Around the millennium I started to realise that although most, if not all, caves in the UK had been surveyed I had not been able to view most of the surveys. Although there are supposedly a large number of surveys in the BCRA library in Matlock, this would certainly not be an easy way to view them, as you are supposed to request the information before visiting. It does not seem to be possible to visit to find out if the information you are looking for is there in the first place.

I considered this problem for quite a while, before feeling that the internet must be able to provide some sort of convenient medium for the browsing of this information, and providing a "shop window" for those wishing to sell their surveys. But a scanned image would just be too large to download, so another solution was required. Other considerations to bear in mind were that many people are "possessive" about their surveys, and others are sold commercially, so any image on the web would have to be displayed in a manner such that it could not easily be used by someone instead of obtaining an "original" copy.

Vectorising the survey seemed the obvious way to reduce the data, but programs that perform this function are very expensive to purchase. I did manage to trial a software product called WinTopo, but it took over 24 hours to produce the vectors for an averagely complex survey. For this trial I used the Cerberus SS survey of Fairy Cave (thankyou to Graham Price for the permission), and a 1GHz processor with 1GB of memory.

The viewing of the survey on a web browser would require an applet to convert the vector information for viewing. This was relatively easy to program in Java. In order to make it difficult to "steal" the image the vector information is only shown in a small window, with scrolling and zooming functions. An example screenshot is shown in Figure 6. I also decided that as this information was being passed in full view of internet "snoopers" I would encode it. Consequently the viewer also has to perform the decoding task.

As I now had a way (albeit inefficient) to produce and view the survey data, I proceeded to trial a website for its location and viewing. I had to use a server in the USA as most UK based servers are either too expensive or do not allow CGI scripting. The site runs from a database with Perl scripts creating the viewable pages. Survey information can be burrowed down to from a global level, through continents, countries and area, in a graphical or textual nature. There are also facilities to select a specific survey where more than one exists for a specific cave. I decided to start at a global level, as the internet is global and it was not much extra effort to add the extra layers of complexity. Each survey has a link to the creator's web site, if known, in order that the viewer can easily contact them to arrange to obtain an "original" paper copy. A facility for directly linking from club web sites to a particular survey has recently been added.

Now that the site was working, it required refining. First to be tackled was the vectorising, as it was taking far too long. I spent most of the Autumn and Winter of last year writing my own vector program. This now takes 25 seconds to vectorise the trial survey, but it makes a bit of a mess of text (the problem is the thinning process on the corners of thick text). The trial survey downloads as 22K of data, which is fast enough on all but the slowest of links.

My trial has proved that it is technically possible to produce such a system, but now comes the acid test as I ask you how it could be improved, or, even more fundamentally, if it is useful at all. http://www.cavesurveys.com has a number of surveys in the Mendip area, and by the time you read this, my surveys of the caves of Gozo should also be on there. Your comments would be greatly appreciated by email to david@cavesurveys.com.

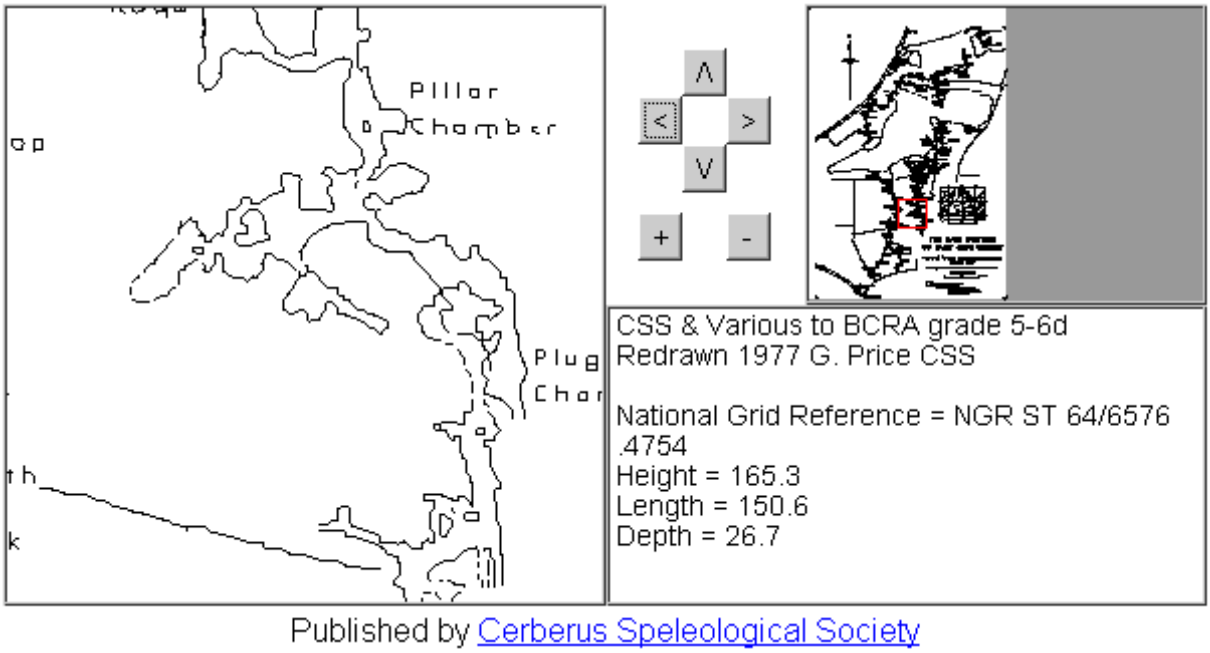


Figure 6: Fairy Cave Quarry Survey viewed using CaveSurveys.com (with thanks to Graham Price for permission to use the survey). The box in the upper right hand corner displays the whole survey, with a red box within indicating the extent of the image viewed in the zoom box to the left of the

display. The buttons in the centre, allow panning and zooming of the left hand image. The box in the lower right provides some details of the survey (the length and depth are currently erroneously displayed for area maps such as this). A link to the publishers website is displayed below, if known.