Cave Technology Symposium 2010

The BCRA held its 4th Cave Technology Symposium in the Yorkshire Dales. ***Mike Bedford*** *summarises the presentations.*

The Cave Technology Symposium is now in its fourth year and an increasingly important element in the BCRA's calendar. The 2010 event was held in the village hall at Horton-in-Ribblesdale in the Yorkshire Dales on Saturday 17th April 2010. The Cave Surveying Group had chosen to co-locate their field meeting which took place on the Sunday. This provided the opportunity for various technology demonstrations. With around 35 people attending, the Cave Technology Symposium continues to grow in popularity.

Again we were privileged to enjoy a varied programme of very interesting and informative presentations. Here those talks are summarised. If you want to know more, several of the talks will also form the basis of articles in the *CREG Journal* in this and future issues.

Nicola Mk3 Digital Cave Radio – a Users' Perspective

Graham Naylor

Graham introduced the System Nicola Mk 3 digital cave radio. He showed a prototype model, for which the circuit boards had, unfortunately, only been assembled the previous week, so the device was not yet in a state to demonstrate (the supplier had originally promised Christmas 2009, but delivered 4 months late!). The aims of this totally digital design were to address the following issues that concerned the current cave radios, namely the Nicola Mk 2 and the HeyPhone:

- Rapid obsolescence of high performance components should be avoided.
- Components should be easily available.
- The device should be more compact.
- The device should be able to receive with a compact aerial.
- It should be cheaper.
- The device should be able to send and receive text.
- The device should be waterproof and avoid unnecessary leads.
- It should be easily upgradeable.
- The frequency should be selectable.
- An ability should be provided for filtering undesirable burst noise pulses.

The new device minimises connectors that compromise the waterproofing of the box by using a Bluetooth link to a microphone earpiece. It is hoped that the prototypes will be operational towards the end of the year.

Nicola Mk3 Digital Cave Radio – the Hardware

Graham Naylor

Graham followed up the morning's talk on the Nicola Mk 3 digital cave radio (often referred to as a software-defined radio or SDR) with a more technical description of the operation of the System Nicola.

Initially the advances in modern digital circuitry were outlined with the potential offered by current analogue-to-digital convertors and field programmable gate arrays (FPGA). The whole architecture of a radio transmitter and receiver can be implemented in logic on a single FPGA.

The receiver part was described: it performs the action of a finite impulse response (FIR) filter as well as providing a demodulation step (transposing the single side band to base band).

The transmitter section was then described. It was shown how a voice input could be decomposed as an instantaneous amplitude and frequency which is then transposed digitally to any frequency. The single side band is implemented in a direct digital synthesiser (DDS) with pulse width modulation (PWM). This drives a class-D output stage and harmonic suppression using a tuned antenna network.

New Technology & Old Surveys, or How to Avoid Surveying

Andy Powell

Andy introduced his presentation with a clip from *The Hitchhikers Guide to the Galaxy* and the idea that cheap, portable access to 'The standard repository of all knowledge and wisdom' is now possible through the Web and Web-enabled mobile phones.

He suggested that cavers still have some work to do. Knowledge of our caves, particularly in the form of cave surveys, is still often hidden away in club libraries, not easy to find or access, and some cave maps are in danger of being lost forever as the ink fades and the paper yellows.

The **CaveMaps.org** Web project 'rescues' cave surveys of the Yorkshire Dales caving area and makes them easily accessible through the Web. It also enhances their value by combining them with online maps and satellite images. The remainder of the talk provided insights into the techniques and technologies used on the project.

Andy demonstrated how to digitally restore faded cave surveys with simple image processing techniques, using freely downloadable PC software. He suggested various 'best practices' for digitising and storing surveys.

He showed different approaches for making transparent backgrounds for cave overlays, and illustrated the problems with some common methods. In the process, he explained anti-aliasing and alpha transparency, then showed how to get perfect

results using the 'Colour to Alpha' feature of the 'GIMP' image processing software.

Next up were tips and tricks for overlaying cave maps on Google Earth, including a quick technique for geo-locating single-entrance caves using the scale bar and the north arrow from the survey and the measure tool in Google Earth.

Finally, he explained how, for the **CaveMaps.org** Website, custom software is used to batch convert multiple Google Earth overlays into a single set of overlay tiles for online publishing using Google Maps and Microsoft Bing Maps.

Along the way, he showed how DeepZoom technology makes it possible to put even the largest surveys online at high resolution. This was illustrated with a 200 megapixel image of the West Kingsdale cave system. He also touched on some experiments with the iPhone and Windows phones for viewing cave maps both online and offline in the field.

In his conclusion, he commended the current shift in attitudes in many caving clubs towards a more open approach to copyright protection, without which *The Hitchhiker's Guide to the Caves of the Galaxy* will never be possible.

Autonomous Cave Rescue Robots

Louise Hunter, University of Leeds

Louise spoke about the future uses for robotics in cave rescue. She highlighted how every year possibly hundreds of people are trapped in collapsed caves, mines and buildings (usually caused by natural disasters). She also commented on how recent breakthroughs in technology have allowed scientists to develop highly sophisticated robots to venture into unknown places. One such robot is the Mars Rover, which is required to scan its surrounding and collect data then send this information back to earth; it achieves this without human interference. From this, Louise proposed the research design and testing of an autonomous robot to aid rescue workers and remove any unnecessary risk of endangering a person. One of the project's aims would be to physically test the robot in a harsh environment to obtain accurate feedback on the design.

She highlighted the different methods for data capture such as a camera which could send feedback to an outside user. This would also allow for some image processing to be done, again to relieve the tasks placed on a single user. One area she emphasised was the large variation of sensors commercially available.

The different types of robot were described, from swarm and collaborative robots to modular robots. Swarm robots are usually a very simple design and cost very little to manufacture. The data they collect is also limited but the fact that usually a large number of them is used means the data returned can usually be quite detailed. Collaborative robots are more complex than swarm but in fewer numbers. They can aid each other in traversing difficult terrain, however, if a few fail, this can prove disastrous for the remaining robots. She described how modular robots have become more popular and many variations exist. They generally involve the design of one generic 'module' comprising of a simple actuator. When many modules are connected the robot is capable of creating complex structures and motions in order to navigate different obstacles.

The possibility of the robot being able to navigate various terrains such as rock, mud and even water was discussed. This would cause issues with corrosion and the robot would need to be designed to withstand various elements and also to be able to function after a short fall.

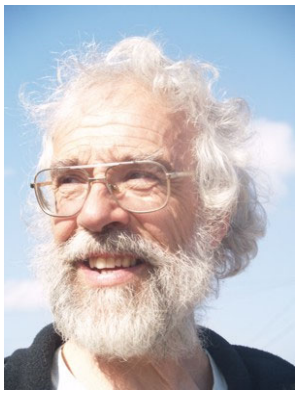
Because one of the requirements would be to include a human interface, a method of communication would be developed. The autonomous mode would allow the robot to independently roam the area, without the need for the user to control each aspect of data retrieval, whilst returning information to the user. One other possibility she spoke of would be to allow the user to have the option of full control over the robot, in case of emergencies or difficulties.

Finally issues with power were highlighted. Using an umbilical cord would provide constant power for the robot but would most likely snag, and cause a large amount of friction. If a battery is developed this would give each search a limited time, and create the possibility of losing robots which do not have enough power to return.

In the question and answer session that followed, it was suggested that one development that would be of interest to the cave rescue community would be a robot for searching sumps. The possibility of a snake-like robot was also raised.

Before Batteries – Items from the Arc which Still Have a Use

Jim Davis



Jim Davis introduced his talk by showing and describing a scaling pole made in the '70s. The design criteria of the pole were that it had to be easily transportable down constricted passages and that it should not exhibit the excessive bending seen in poles made from scaffolding tube. Sections of pole 4ft 6in long of 3in and 3.25in diameter were connected using male/female joints and securely pinned together. The whole item was able to be lifted in use when scaling an aven, for example, so that continuous progress up the aven could be achieved by leaning the pole against the opposite wall. A special hanger was used to support the base of the pole. The pole was successfully used first in Bull Pot of the Witches, in Burnetts Great Aven, and then in the Rowten sumps to scale the Jingling Avens. It was also used in PSM and Matienzo.

Now, with the advent of very efficient rock drills, this pole is rarely used except as a means of access in old mines when doing bat surveys. Extra sections of the pole were produced in 2002, but the tolerance of the joint dimensions specified was misinterpreted, resulting in excessive movement in the joints making the pole significantly less strong. For more information, the original article can be found in BCRA Transactions.

The next pieces of equipment shown were some rock drills. The first was a very small hand ratchet drill six inches long designed for use in very narrow rifts. It had a self-jacking mechanism using a slipping clutch which increased the length of the drill when the pressure between the head and foot of the drill decreased. A six inches long by 1.125 inch diameter hole could be drilled one handed and was used as a shot hole for

exploration. A second larger drill using the same principles was also shown. This drill could be used to produce shot holes or as a core drill.

Originally, the 4 inch diameter core drill was made to drill a hole in the 'Road to Certain Death' sump in Cueva del Agua, Treviso, Northern Spain. The sump, still a remarkable freak of nature, was held back by a limestone wall only 18 inches thick and the plan was to drill a hole through it and lower the water level by 9m. However, the drill was not used because it was dived instead by Terry Whitaker who reported that visibility was near perfect and no bottom could be seen. Subsequent dives by Rod Palmer and Gavin Newman revealed the sump to be 66m deep. The project still has merit because of the decompression problems of the dive, but the conservation aspect of such a fine formation also needs to be respected.

The last items of equipment shown were some plugs and feathers used for splitting rock. Originally used by quarrymen, they were large pieces of steel, the diameter of a 1.125 inch shot hole, but they have been since miniaturised to be 13mm in diameter and 6 inches long, made of plastic for the plugs and steel for the feather. These have become important as rescue equipment for use where 'clinical' removal of rock without explosives is necessary. Most recently, they were used to release a trapped climber on 'Gimmer' in the Lake District when a climber got a knee stuck in a vertical jamb.

Jim finished his talk with a request for ideas on how to detect odours in caves. Joss sticks and burning neoprene are among the smelly items that have been used to confirm draught connections in caves and it seemed that a logical next step would be to use detectors in the same way that dye detectors are used. Some good suggestions were contributed by the audience.

Super-bright LED Lights for Photography and Video

Footleg

Footleg's talk on using super bright LED lights for cave photography and video discussed why LEDs should be used, and went on to look at how to build low cost lights. Some example photographs and video clips were also presented.

Footleg discussed the use of LED lighting for long exposure photography illustrated with examples of photographs showing blurred water effects. Examples of commercially available lights were given, but their high cost and limited brightness makes them less suitable to photographic applications where several light sources are required. Brightness is limited to extend battery life for lights designed for caving.

Footleg then talked the audience through the design process and problems of heat management with his home made lights based on SSC P7 LEDs. These were compared with a commercial light using the same LED which is available from China for a comparable cost to the home made lights.

The talk was rounded off with some example photographs and discussion of the pros and cons of this technique compared to using flashguns for photography. Finally a couple of example video clips where shown to illustrate the quality and limitations of these lights in walking size passages versus larger chambers.

LORAN-C – Friend or Foe?

Mike Bedford

Many users of cave radios will be familiar with LORAN-C as a cause of interference that can make communication difficult. However, Mike introduced his talk by suggesting that, rather than just being a source of annoyance, LORAN-C might be actually be of use to cavers and not just a source of annoyance.

LORAN-C is a navigational system that was deployed before the satellite-based GPS and was intended primarily for nautical and aeronautical use. Mike described, in simple terms, how it works and went on to show which stations can be received in Europe and, accordingly, in which areas the system is useable. In the light of the recent discontinuation of LORAN-C in North America, Mike discussed its future in Europe and concluded that it will probably continue, as a backup to GPS, for the foreseeable future.

The reason that LORAN-C interferes with cave radios is that it operates in same the low-frequency area of the radio spectrum. Since this frequency band was chosen for cave radio because it can penetrate the earth to some depth, LORAN-C signals are also capable of being received underground. It follows that whereas GPS cannot be used in a cave, there is a possibility that LORAN-C could be used for navigational purposes. With this in mind Mike discussed the ways in which accuracy underground might be inferior to that on the surface and concluded that while it will be much poorer than that provided by GPS, there could be some potential caving applications.

Mike concluded by discussing a couple of possible applications. First it could permit a newly-found cave, perhaps on expedition, to be surveyed, albeit at low accuracy, very rapidly. Second, while not necessarily suggesting that such an application was necessary or even desirable, it might permit an underground 'TomTom' navigation system, of the type used in cars, to be implemented.

Using Resistivity Surveys to Search for Caves

Bill Buxton

Bill started by defining resistivity, then showing the resistivities of various rocks. He explained that because air had an infinite value, this enabled us to detect caves.

The method involves passing an electrical current between two electrodes inserted into the ground, creating a voltage gradient between them. If two more electrodes are inserted between first pair then a voltage drop can be measured. If a void exists then the voltage drop measured will be affected.

He then showed various types of array, the only types suitable for cave detection being the pole-dipole and dipole-dipole arrays.

Moving on to types of resistivity meter, he then showed a simple manual meter that could be built for about £50 and a more advanced meter controlled from a laptop costing £200 or a bit more to construct.

The second part of the talk covered results obtained in resistivity, firstly over known sites, and then over prospective sites. Known sites included SWCC's Babysitters dig (a large surface shaft), Top entrance OFD (a very large passage near the surface), Chadwell spring, and Cwm Dwr3 cave (another large passage near the surface).

Prospective sites were a possible extension to Cwm Dwr3 (possibly more large passage), SWCC's Porth Pwll Ddu dig (a possible cave passage), a site near Llygad Llwchwr (an old surface collapse), and the old railway cutting at Penwyllt (a cave intersected during construction).

He concluded by stating that resistivity surveying had proved its worth, and that digging teams could only benefit by using resistivity equipment to survey potential digs.

Design of a Laser Scanner for 3D Data Capture

Paul Mann

Inspired by ideas from the 2009 Cave Technology Symposium, Paul presented his ideas for constructing a low cost laser scanner suitable for surveying cave passages, currently the theme of his university dissertation.

Various photogrammetric techniques exist for collecting three dimensional spatial data using photographic cameras in conjunction with structured light (i.e. light projected in a specific pattern, typically spots, lines, stripes or colour bands). Caver's will be familiar with a crude variant arising in underground photographs, the lighting is often arranged to emphasis the passage shape with bands of light, this in turn creates a sense of depth.

By understanding the optical properties of the camera and the mathematical shape of the light projection it is possible to determine the co-ordinates of the illuminated subject.

Paul demonstrated the equipment he will use, a planar laser (one that creates a single sheet of light) and a cheap consumer digital camera mounted with a panoramic lens (one that views 360 degrees in one shot). This should capture a full profile of the cave passage. By introducing controlled motion into the system a sequence of profiles can be captured, facilitating full three dimensional survey of a passage.

Short range triangulation-based methods are already well established for fast and accurate remote measurement of short distances from close range (e.g. 1/100mm precision from 100mm). Paul is trying to take the techniques outside their normal range, and although he estimates a 3mm precision for a 2m diameter passage, this would drop off markedly as distances increases.

Intrinsic to scanning techniques are the huge data sets produced. Each profile could contain 3,000 measured points, Paul's methodology allows for up to four profiles per photograph at a frame rate determined by the camera but typically several per second. Storing, processing and presenting such a cave survey will present its own challenges, with design of suitable software still in its infancy.

Although the aims of his dissertation are limited to demonstrating the viability of the concept by creating and testing a crude prototype (and are unlikely to trigger a wholesale resurvey of our caves), Paul advises that other computer vision developments will soon bring many tools to automate, enhance and enrich our cave surveys.

Suppression of LORAN-C Signals in Digital Cave Radios

Antonio Muñoz Fumanal

Antonio's travel plans had been disrupted because of the restrictions on flights due to ash from an Icelandic volcano. Accordingly, Mike Bedford and Graham Naylor presented this talk on Antonio's behalf.

The presentation described a simple algorithm to suppress interference to cave radio from the LORAN-C signal. This was backed up with some experimental results obtained from its implementation in a digital cave radio.

To start, he briefly described the LORAN-C radio-navigation system together with the negative effects it had on cave radio and the reasons to get rid of it. He continued with a description of those aspects of the LORAN-C signal structure and waveform that are needed to understand the effects seen in cave radios and implement a useable LORAN-C suppression algorithm. He then analysed the LORAN-C band occupation mathematically in terms of instant and averaged lost information in order to determine what could be expected as a result of the suppression algorithm. As there is a need to place the suppression algorithm within the digital signal chain, he briefly described the SSB receiver structure used (Weaver) in the TEDRA digital cave radio. This was illustrated with a couple of real signals at different points in the chain, showing the pros and cons of implementing the algorithm at each stage with many other questions that arose in the algorithm design stage.

In the last part of the presentation, he proposed a basic algorithm implementation, describing the signal processing steps required, along with real signals involved in the algorithm. He then discussed the implementation resources needed by the algorithm and the experimental results it delivered, which were presented to the audience as a couple of audio samples with and without the algorithm. Finally he pointed out some conclusions about the algorithm and the LORAN-C band which could enhance the digital cave radios communication.

A Wireless Cave Telemetry System

Knut Brenndörfer

Due to the ash-related flight chaos, Knut could not give his presentation about wireless cave telemetry. Nevertheless, four members of the Caving Club Blaubeuren made the 1,500km journey by car to the Yorkshire Dales and Lothar presented the slides.