European Cave Rescue Association

Technical Commission
Underground Communications

Contents

Introduction

At the ECRA conference in Rudice (Czech Republic) in 2022 and in discussion with Giuseppe Conte and Dinko Novosel, it was thought that a comprehensive list of communication devices available to cave rescue teams should be provided. In the end it was decided that Pete Allwright (ECRA Honorary Member) would be tasked with producing the first issue of such a document.

Format of document

The document is in two sections.

The first section is a number of tables identifying the available communications devices.

The second section provides a detailed description of several devices, expanding on the content of the tables in the first section.

This will be a live document and will be liable to updates on a regular basis.

Thank You

A big thank you to all who have responded to allow this catalogue to be built.

As we say, this is a live document so if you have any additional contributions or changes, please contact communications@caverescue.eu with the details.

Version History

Version	Date	Description	Author
0.1		Draft	Pete Allwright
0.2	Jan 2023	Changes	PA
0.3	Mar2023	Updates from member organisations	PA
0.4	Mar 2023	Updates from Germany	PA
1.0	3rd April 2023	First publication	PA

Known Obsolete Devices

Name	Country of Origin	Date	Outline	Description	Costs	Status
Molephone	Britain	1980s	Developed in the late 1970s and 80s by Bob Machin at Lancaster University. Served CRO well for over 20 years	Used loop aerials. Max depth 300 metres. Could radio locate. External batteries.	-	Obsolete
HEYPhone	Britain	1990s	Developed by John Hey for the BCRC.	Used linear aerials; best performance was 1 kilometer in Peak Cavern. Capable of home build – 1980s technology. External batteries.	-	Obsolete – parts not available.
Nicola 2	France	1990/2000	Development lead by Graham Naylor with the SSF in the Vercors.	Used linear aerials. Capable of 1 kilometer – also tested in Peak Cavern. External batteries.	-	Obsolete. Still used by some organisations. Might be difficult to repair.
TEDRA	SPAIN	2007	SIEMENS / Hostile Environments Technologies Group of the Zaragoza University	Used linear aerials. Capable of 1 Km External batteries	Was €2.000	Obsolete
Transistor Intercom 2-way	Germany	2003		Twisted pair wired device. Based on a door intercom system from apartment building with modifications. Adapter to Fernsig plug (howl-call telephone) is available.	Was intercom system bought on ebay	Obsolete – out of production

Name	Country of Origin	Date	Outline	Description	Costs	Status
					(40€) and modified.	

Wired Communications Devices

Name	Country of Origin	Date	Outline	Description	Costs	Status
CAVE-SYS	Poland	2014	CAVE-SYS system designed to provide voice communication in confined spaces.	Leaky Feeder Cable technology. Special coaxial cable (thin and flexible, diameter 9mm, weight 5kg/500m) works as distributed antenna and provides radio coverage on VHF band (e.g. 139MHz) to handheld radios in range of LFC radiation (depend of underground structure, a few dozen meters.	€6000 – 2017 price	can be ordered from manufacturer
Cavelink2	Switzerland	2003	Ingenieurbüro Ziegler GmbH Developed by Felix Ziegler.	Embedded together with wireless operation. See below for wireless devices. Operates over single wire or twisted pair.		
Cavelink4	Switzerland	2024	Ingenieurbüro Ziegler GmbH Developed by Felix and Simon Ziegler.	Embedded together with wireless operation. See below for wireless devices. Operates over single wire or twisted pair.		
Ex-Heulruf-Telefon (howl-call telephone)	Germany		Manufacturer Funke+Huster Fernsig	Developed for mining No power supply (sound-powered telephone system with dynamic transmitter and receiver capsules)	Prices range from 30-125€	Maybe available on eBay

Wireless Radio Devices

Devices still used by rescue teams. Some are out of production.

Name	Country of Origin	Date	Outline	Description	Costs	Status
Cavelink V2	Switzerland	2003	Ingenieurbüro Ziegler GmbH Developed by Felix Ziegler.	Initially developed for work in the Holloch and extended to use in cave rescue.	ca. Euro 1000 with battery & antenna	Problems getting replacement parts.
Cavelink V4	Switzerland	Planned 2024	Ingenieurbüro Ziegler GmbH Developed by Felix and Simon Ziegler.	The next generation of Cave-Link. In addition to all the functions of Cave-Link V2, see description below.	ca. Euro 1100 / pc with battery & antenna	In development; planned availability 2024
Nicola 3	Britain	2000/2010	Development lead by Graham Naylor. Long development period.	Used linear aerials; best performance was 1 kilometer in Peak Cavern. Design requires commercial build.	Greater than £1000 per end estimate.	Some parts may be obsolete. Cost relates to small build quantities.
Nicola 4	Britain	2021/2023	Development lead by Graham Naylor.	Aims to support audio and text communications. See description below.	See below.	In development.
µHeyPhone	Britain	2017	This is the HEYPhone re-worked.	Re-worked for 2010s technology and aimed at 'home' construction. Designed by Ian Cooper and published in the CREG Journal **103**, p12. September 2018. (PDF 278KB)	n/a	Home build. Some parts may be obsolete.
Pimprenelle {Pimpernel)	France		Developed in France	See below.		

Name	Country of Origin	Date	Outline	Description	Costs	Status
Drummond Transverter	Canada	1992	Developed by Ian Drummond of the Alberta Speleological Society to reduce the time of construction.	Device is obsolete but still in use in several locations. The maker is still able to repair units. Contact via the Alberta Speleological Society	Not applicable in 2023.	Obsolete – out of production; But still in use
xFerra	Russia	2020		To be determined http://www.xferra.com/products/ Need to contact for pricing.	tbd	Commercial offering.

Detailed Descriptions - Wired

CAVE-SYS

CAVE-SYS system designed to provide voice communication in confined spaces. CAVE – SYS is a light version of MCA-1000 system to underground communication in mining industry.

See: https://tranztel.com.pl/our-solutions/mca-1000digi/?lang=en .

Leaky Feeder Cable technology. Special coaxial cable (thin and flexible, diameter 9mm, weight 5kg/500m) works as distributed antenna and provides radio coverage on VHF band (e.g. 139MHz) to handheld radios in range of LFC radiation (depend of underground structure, a few dozen meters. On surface (or another supervisor place) base station is located, one LFC segment (without any active device) can be length up to 400-500m. To expand length of LFC can be use special RF bi-directional amplifiers).

In addition, can enable a video streaming service to surface from special WiFi module at the end of LFC (tested only with one 300m segment of LCF).

Leaky Feder Cable to CAVE-SYS has been specially designed and manufactured by Bitner Cable Manufacturer.

Base station internal 12V rechargeable battery (to 3-4 hours lifetime). External power supply 230VAC/12VDC. Handheld radios battery (to 12-14 hours lifetime).

2015-2017 the cost of the system was approx.: 6000 EUR (basic configuration: base station (voice only), 4 pcs of handheld radios, LFC 300m length).

Ex-Heulruf-Telefon (howl-call telephone)

Developed for mining.

Twisted pair wired device without amplification.

No power supply (sound-powered telephone system with dynamic transmitter and receiver capsules)

Call signal is generated by turning the rotary knob with an audio frequency dynamo generating a 2000Hz signal.

direct connection to base and other call stations

Max Distance: theoretical 10km, we use up to 200m without problems, gets very quiet over greater distances (no amplification)

Call station can attach to any point of the cable with Pricker-pliers.

May be available here: https://www.satcomglobal.com/fhf-ex-howl-call-solund-powered-mining-telephone or on EBay.

Transistor Intercom 2-way

Twisted pair wired device. Based on a door intercom system from apartment building with modifications. Adapter to Fernsig plug (howl-call telephone) is available.

Obsolete – out of production. Open source

Twisted pair wired device. Based on a door intercom system from apartment building with modifications. Adapter to Fernsig plug (howl-call telephone) is available.

Based an old (1960-70s) intercom system. Was bought and modified in 2003 by Hartmut Simmert. Was developed for smaller, dry caves <100m in Saxony. Used by caving club “Höhlen- und Karstforschung Dresden e.V” and Cave Rescue Saxony until now.

- 1 base station and 3 call stations.
- Call stations: call button and speaker (=microphone)
- Base station: can change between 3 channels, call button, speak button, volume adjustable
- The call stations cannot call/talk to each other directly!
- Power supply: 6x1,5V AA Batteries
- Max. Distance: >200m (more was not tested)

Call stations are robust and resistant to cold and humidity but not suitable for permanent installation in a cave.

Contact manufacturer Hartmut Simmert via Höhlenrettung Sachsen:

- Lisa Hoffmann at hoffmann01@t-online.de

Detailed Descriptions - Wireless

Pimprenelle {Pimpernel)

https://www.speleo-secours.fr/?p=2507 (in French).

CaveLink

Cave-Link V2

Refer www.cavelink.com. Cavelink 2 is now out of production.

Can be used in three configurations:

- Single wire device

- Twisted pair wired device.
- through the earth device

An Interface for GSM SMS at the surface is available.

Communicates via text messages only.

Like all through the earth devices the maximum transmission distance for Cavelink is also dependent on antenna length, weather (thunderstorms), and the time of day. Cavelink repeats the data until it arrives correctly. Bad conditions prolong the transmission, but there are no errors. In the Hölloch cave we have several links with about 1000m distance, over which data is transmitted every 4 hours.

Cavelink was developed in 2003 and the first devices were used for data transmission from a cave for monitoring measurements during tunnel construction near the cave.

The devices with interface for GSM SMS were also used for text messages at rescue operations. Each device can also serve as a repeater and forward messages. Thus, very large distances can be overcome.

In 2010 the device was completely revised (Cavelink V3).

The focus was always set on minimum power consumption, so the device with the internal battery can be in operation for several days (continuous operation) to months (depending on the interval of transmissions).

There are many additional devices like GSM interface, loudspeaker, printer, measuring boxes for water level, temperature, CO2 etc.

Until 2019, about 200 devices have been built and are standard in many rescue organizations.

Cavelink 2 is not open source, but if someone is interested in the schemes or the source codes, they can get in touch with the manufacturers.

Cave-Link V4

Refer www.cavelink.com. Cavelink 4 is in development.

Can be used in three configurations:

- Single wire device
- Twisted pair wired device.
- through the earth device

An Interface for GSM SMS at the surface is available.

The next generation of Cave-Link. In addition to all the functions of Cave-Link V2, new functions will also be added:

- Speech transmission with wired connections (single wire and twisted pair wire).
- Interaction with Nicola devices. (Receiving Nicola communication already works).
- Transmission of digitised speech via data communication through the earth. Forwarding via multiple stations to bridge long distances.

- Bluetooth and Wi-Fi for integration of mobile phones. For example, to transmit forms or pictures.

Both transmitter and receiver are completely redesigned for these new functions. The housing and the battery have also been revised.

The new Cave-Link V4 is operated via a 4.3 inch resistive touch screen. A stylus is integrated directly into the case. The device will be compatible with older Cave-Links and their additional gear.

The device is in a first prototype status. It is planned to have the first finished Cave-Link V4s at the beginning of 2024.

Cavelink 4 is not open source, but if someone is interested in the schemes or the source codes, they can get in touch with the manufacturers.

Nicola Radios

Nicola 3

With the HEYPhone and Nicola 2 coming to the end of their life span, Nicola 3 development began in 2007 by Graham Naylor in the UK and supported by the British Cave Rescue Council.

Initial development used a Spartan 3 FPGA (https://www.xilinx.com/products/silicon-devices/fpga/spartan-3.html) to offer more functionality that previous discrete radios. Later in the design process, this changed to a Zynq FPGA but this still had limited onboard memory and no ethernet connection making the development process difficult.

In the end, the development took much longer than planned and the end product required a professional build. This put the cost too high for most organisations, The BCRC was able to run a batch of 80 radios for which it negotiated a good price and these as in use by some teams.

Nicola 3 used a speaker/microphone wired in through a connector and had internal batteries. It supported Bluetooth meaning a BT headset could be used in place of the handset.

Being programmed meant the frequency could be changed. The default was set to 87 kHz for the UK and to 86.5 for France. A menu system allowed this to be changed in the field.

Some information can be found at https://www.caverescue.org.uk/nicolaradio/ .

Nicola 4

Nicola 4 is the progression from Nicola 3 where many lessons were learnt. This radio uses a Cora Z7 (https://www.xilinx.com/products/boards-and-kits/1-1qlaz7n.html) which offers a considerable step up in capability compared to the Zynq used in Nicola 3.

The much increased RAM memory together with an onboard ethernet connection allows an embedded Linux system to be used. This has made the development process much easier.

The radio offers:

- Audio communication with an internal microphone and speaker or a Bluetooth headset/speaker
- Text messaging similar to that on a mobile phone. Multi language support is included (but remains to be fully tested).
- A touch screen is used for control and for text messaging.
- Testing is using earthed aerials to give a communications range of up to 1 km
- Uses external batteries of 12 to 36 volts (in development we are using 4 by 18650s giving 14.4 volts)

One of the main aims in the development is for easy manufacture of the radios. During development, the circuit boards have been produced by a professional company and these have been populated by Graham using a hot-plate soldering mechanism. The packing in suitable casing is then done by the developers.

The construction does require moderate skills, meaning not everyone will be able to do the builds. But it is expected rescue organisations would be able to find appropriate personnel to carry out the work and thus keep the costs under control.

The design and software will be in the public domain at an appropriate point. With the Bluetooth interface, the device could then be connected to other BT devices for example use in data collection. This is a futuristic option.

Updates available at https://www.facebook.com/AssociationNicola .

At the end of 2022, the cost estimates for the parts was some £350 – say €400. But since the electronics market is difficult at the time of writing, this estimate will vary.

The cost of manufacture will depend on the method used. 'Home' manufacture requires sufficient skills to build the proprietary circuit board and some dexterity to put the radio together.

January 2023 in development.

We have been testing audio now for over 6 months and whilst we have the signal strength the quality is not yet up to standard. Fixes for the problem require testing.

The prime developer – Graham Naylor – is now working on the texting mechanics. This is progressing steadily and we will soon be testing in the field. 9 March 2023 – some test messages have been exchanged but the mechanism is not yet 100% reliable – fixes actively being persued.

Detailed Descriptions for Obsolete Devices - Wireless

Molephone

Developed in the 1980s, this proved to be amongst the first effective underground communication devices not needing a wire to be run into the cave. It operated by a modulated magnetic signal using loop aerials. This meant the range was limited. Hearsay reports that a depth of 300 metres has been achieved in Spain. A more typical depth was some 100 to 150 metres.

The radio was robust enclosed in a diecast box and using a handheld microphone speaker. The device was powered by external batteries that could easily be changed under operational conditions.

The radio was capable of locating underground survey stations and this was used by the Cave Rescue Organisation (CRO – www.cro.org.uk . Finding these locations in the fog on a wide flat moor and on a cold winter's night required precise navigation!

The device was used by the British cave rescue teams up to the early 2000s when the HEYPhone became available. The lack of depth was not an issue.

Nicola 2

Nicola radio development began in the 1990s with the experimental Nicola 1 and led to the production of Nicola 2, used initially by teams in the Spéléo Secours Français (SSF) and later by a wider audience. This device used linear earthed aerials (compare with the loop aerials of the Molephone) and could communicate over distance s of 1 kilometer.

The device used a handheld microphone/speaker and used external batteries. The radio was enclosed in a robust diecast box. It operated on a frequency of 86.5 kHz and whilst it would communicate with the HEYPhone there was a "Mickey Mouse" effect on the voice.

TEDRA

In 1998 the University of Zaragoza started a research project to design a radio-location system that later evolved into a communications system. Once the foundations were laid, Siemens bought the patent and developed the system. It was launched on the market in 2007. As a result of low profitability and a small market, Siemens itself abandons the product.

A device that enables wireless communications to be established between underground and above ground environments. Tedra devices (Through Earth Digital Radio Appliance) do not require a wire connection between the points to be communicated and also have different benefits derived from their short installation time, light weight and mobility.

Each Tedra device integrates a pair of electrodes that are inserted into the ground and which are connected, in turn, to the electronic transmitter-receiver equipment. In the underground environment, it will be enough to correctly distribute the contact stakes or meshes to be able to put this new communication system into operation.

Now out of production.

Drummond Transverter

The transverter is driven by a commercial CB radio (usually SSB).

1m square loop antennas at 185 kHz are most common, range usually 4-500m. Range up to 700m using asymmetric loop antennas (see attached documentation). Power is usually 12V, 7AH gelled lead-acid battery which was adequate for 15 hours service as the surface unit during one rescue. Device is voice (SSB) and can provide pulsed tone for location work.

Device is very flexible, it can change frequency, change mode of operation (SSB, FM, AM). The standard 50 Ohm output allows use of many different antenna types and sizes. An important feature is the ease of use of the CB radio interface. A few minutes instruction and anyone can reliably use it.

Device is open source.

Initially published in Speleonics No.19 in 1993.

References:

1) Converting CB radios for use as low-frequency cave radios, Ian Drummond, Speleonics, 19, May 1993, p3-8
2) Further developments with the CB Transverters, Ian Drummond, Speleonics, 19, May 1993, p9
3) Update on CB transverters for cave-radio use, Ian Drummond, Speleonics 20, Feb 1994, p2
4) CB transverter goes FM, Ian Drummond, CREG J,21, Sep 1995, p7.
5) Going Deeper – two ways to improve performance. Ian Drummond and Bill Putnam, CREG J,34, Dec 1998, p24-25.
6) An Improved Version of Ian Drummond's CB to 185kHz Transverters Brian Pease, W1IR https://radiolocation.weebly.com/uploads/2/7/5/2/27523347/improvedcb_transverter.pdf