RAYNET TOMORROW

To conclude the trilogy of articles marking the 50th Anniversary of RAYNET and coinciding with the RSGB Emergency Communications Convention in Birmingham, Steve Richards, G4HPE, looks at recent advances that could enhance the role of the Amateur Service in disaster relief.

There is a dangerously superficial viewpoint that voluntary emergency communications are no longer needed. After all, the Internet has brought high-bandwidth access to an infinite database and mobile phones allow everyone to communicate anywhere, anytime. Indeed, under normal circumstances these are great tools for the Emergency Services too.

Now take these essentials of modern life to a large public event, say an outdoor pop festival. Anyone who has tried to do this will know that their mobile soon becomes useless under the pressure of users; even simple text messaging fails and Internet access via WAP or 3G technologies cannot connect. This is regularly the case at such events, even if the network providers have erected temporary cells to maximise their income! How surprisingly unnerving to be without the comforts that civilisation places so much reliance upon.

Consider now a major emergency in an unpopulated or isolated part of the UK. There are few public communications facilities – provision was deemed uneconomic. Internet, FAX, telephones and similar circuits using the cabled infrastructure are, in fact, bunched together over one multiplex route and this has failed. What limited radio circuits exist quickly become overloaded. Fixed transmission installations with large or high antenna systems are quick to lose power supply or collapse in adverse conditions. For the Emergency Services and Rescue Organisations there remain, even to this day, significant problems with inter-agency command and control at a remote incident because radio systems are not integrated.

In this and many other situations, RAYNET has the potential to help and has several attributes that increase this capability. Primarily it is the option to call on large numbers of volunteers, who give their time willingly and bring their own equipment and skills to the operation. Such people have the ability to innovate and adapt to the prevailing situation. Facilities can be established or re-established quickly through improvisation, even without mains power.

DIVERSITY

Until recently, the typical RAYNET response to a request for help would be to establish speech networks, probably at VHF/UHF. However, a key factor in successful operations is 'diversity', the ability to use more than one method to pass the information. In this respect, Radio Amateurs have an enviable arsenal of choices at their disposal - frequency bands, speech and data modes – but not all of these have been easy to deploy in the field. In recent times, though, there have been some remarkable advances in communications technology that have given rise to some exciting new possibilities in the field of emergency communications, further diversifying the RAYNET response. And Radio Amateurs are perfectly placed to offer both the time and enthusiasm to exhaustively explore the possibilities of these new options.

A FRESH LOOK AT HF

The use of HF for amateur emergency communications in the UK has thus far been underdeveloped. Several factors have recently come into play that could renew interest.

A quick scan of any communications publication will instantly demonstrate that equipment is getting smaller and more easily portable, being suitably robust and stable for use in the field. This is particularly true of HF transceivers. Alongside this, output powers across the board are increasing and receivers now boast many facilities to combat noise, man-made and natural interference. Battery life in hand-held equipment has also improved dramatically.

As recently announced, former Class B licensees now have full access to the HF bands, bringing with them a wealth of emergency communication experience from VHF and UHF operations. At the same time, important changes to Article 25 of the ITU *Radio Regulations*, which has moved to encourage the establishment of international amateur communications for disaster relief, has given a tremendous new impetus to explore afresh the potential of HF for such purposes.

Running alongside this, UK Amateurs currently have the privilege of access to frequencies at 60m (5MHz), a part of the spectrum that can offer excellent UK-wide coverage for much of each day and lends itself to NVIS (Near Vertical Incidence Skywave) effects. RAYNET is already actively experimenting with these techniques (see Figure 1.) If 60m is intelligently used alongside 80m and the expanding 40m band, a true national service is achievable. Indeed, an exclusive 5MHz allocation for RAYNET would be of immense value for national disaster relief.

Figure 1. The NVIS mobile installation used for the Longmynd Hike by M5WJF/M. Note the deliberately horizontal whip designed to optimise F2-layer near-vertical reflection back down into neighbouring valleys.

To determine whether a path exists at a given frequency at any given moment, commercial ALE (Automatic Link Establishment) software has already been adapted for amateurs by Charles Brain, G4GUO. This technique automatically tests whether a particular path is 'open' for communication and permits text transfer at the same time. Charles has also experimented with various military specifications such as STANAG 4285, designed for extremely robust data performance at HF, and digital speech techniques. If you look at his website [1] you begin to realise the expertise that Radio Amateurs can offer.

Hardware and software already exists to link HF and VHF nets together – another area to explore. Seamless transition of voice and data between the two means that the integrity of the information is assured, a vital factor for emergency communications.

It is to be hoped that these changes to the Amateur Service will galvanise a renewed interest in HF and some of the concepts that follow will demonstrate why.

NEW TECHNOLOGIES, NEW IDEAS

A significant change in most people's lives has been the arrival of affordable, powerful computers in the home and on the move. The innovators of the amateur world have been quick to see the possibilities. The advent of Digital Signal Processing (DSP) within the home computer has enabled great advances in the control of the sound spectrum. Principally, the techniques of audio signal manipulation and filtering have moved from external mechanical devices to software control directly within the computer, using the standard sound card to interconnect with radio equipment.

In the digital environment, accuracies that were previously impossible to realise in practical terms are now easily attainable. For example, minute differences in frequency/phase relationships are detectable and band-pass filtering of extremely high 'Q' can be exploited. Highly efficient data communications techniques, that occupy very small bandwidths, are a reality. This is a boon on the busy amateur bands.

Such advances have led to the development of several new data modes for Radio Amateurs, many of which use very complex DSP techniques to optimise performance over the wild vagaries of HF radio links while keeping the use of valuable spectrum bandwidth to a minimum. Much of the new software is easily obtainable, simple to operate on modest computers and free to non-commercial users.

It would seem clear that these modern data modes could find an application in amateur emergency communications. As previously described, consideration of HF for such purposes is only just beginning in the UK. Today, this part of the radio spectrum has become much more viable and offers significant attractions. For example, it may be possible to provide national coverage from just a few well-appointed amateur stations. Because of the comparative ease and speed with which an HF data receiving facility can be established within a problem zone, national access to information using this method (few transmitters, many receivers) might be an achievable goal for the Amateur Service.

NEW DATA MODES

Initially, amateur emergency communications at both HF and VHF used Radio Teletype (RTTY), which encodes the information into two audio tones switched to a predetermined pattern. This mode is termed 'unconnected' or 'broadcast' in that there is no electronic interaction between the transmitting and receiving ends of the radio link. No error-correction techniques are applied. To minimise errors in reception (caused by fading, man-made or natural interference) it is necessary to create the best possible path between stations and it may be necessary to repeat doubtful portions of the information. This mode is also quite slow, which could lead to a backlog of data. Being a somewhat blunt tool, though, RTTY was often remarkably effective in RAYNET use.

When hardware moved from dedicated mechanical units to modern computers, the use of the AX25 'Packet' protocol and derivatives began to dominate the field and in many RAYNET operations still does. Radio Amateurs who were unable to accommodate the heavy and mechanically cumbersome Teleprinter found that they could now achieve data communications at home and on location with much more compact facilities. With

this mode, small ‘packets’ of data are transmitted from the sender to the recipient. These modes are often described as ‘connected’, meaning that information is fed back from the recipient to the sender that verifies whether the data has been correctly received. The more accurate term for such modes is ‘ARQ’ (Automatic Request Repeat). Using ARQ, only data that is completely accurate is displayed at the receiving end.

Connected modes also lend themselves to routing across networks of stations, where paths to the intended recipient may exist by several simultaneous routes and the routing software is capable of automatically testing and allotting a quality to each route on a continuous basis. Packet modes tend to be used via VHF/UHF FM transmissions where audio bandwidths can be higher (leading to a greater data transfer rate) and where propagation and interference effects are not really a factor. Packet at HF is far less successful because of these issues and in order to succeed within a practical bandwidth it is necessary to dramatically reduce data rates.

The advent of the computer has allowed the introduction of very powerful, multiple error-correction systems, meaning that non-ARQ methods can now offer remarkably high accuracies over HF paths.

Some of the newer modes that are freely available and which could have benefits for emergency communications over HF radio paths are:

Non-ARQ or ‘Broadcast’ modes

BPSK31 and **QPSK31**: modes that use very low bandwidth and encode data by changing the phase relationship of audio frequencies. Sophisticated error correction systems are used. More than twenty separate PSK31 transmissions can occupy the same space as one HF SSB speech channel! (See Figure 2.) Furthermore, because the full audio spectrum can be saved as a .WAV file, the waveform can be played back into the receiving software over and over again at will, decoding a different data stream each time.

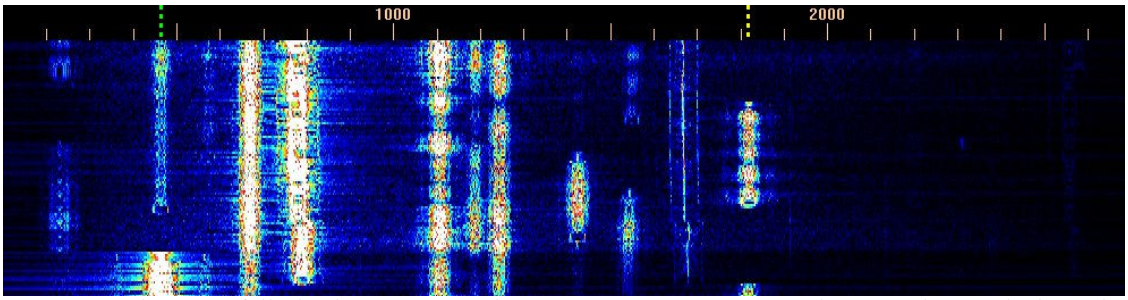

Figure 2. The ‘waterfall’ display at G4ATX showing many PSK31 QSOs within a single speech channel.

MFSK16: a mode that uses sixteen audio tones to encode the data. There are versions of this method that use a greater or lesser number of audio tones, with the relative effect on bandwidth and data rate. Forward Error Correction (FEC) and Interleaving techniques are employed and it is extremely effective under very poor HF band conditions. Figure 3. shows a typical MFSK generator.

MT63: a mode that encodes the data using 63 audio tones, usually across an audio bandwidth of 1000Hz. This mode utilises both spectral and time-based interleaving as well as FEC to provide more than one opportunity for the data to be received. Versions using higher or lower audio bandwidth, together with variable interleaving parameters, are available. MT63 is thought by some to be a bit antisocial on a crowded amateur band due to the bandwidth employed, but it is worth noting that this mode is extremely robust against both man-made and atmospheric effects. If 2000Hz of bandwidth is available, the data rate can reach an amazing 20 characters per second.

ARQ modes

AMTOR: developed for amateur use from a long-range commercial system, now generally replaced by

PACTOR: a packet radio system specifically designed for HF use. It employs similar forward error correction techniques to VHF packet.

Q15X25: an upgraded HF packet system not unlike MT63 described above.

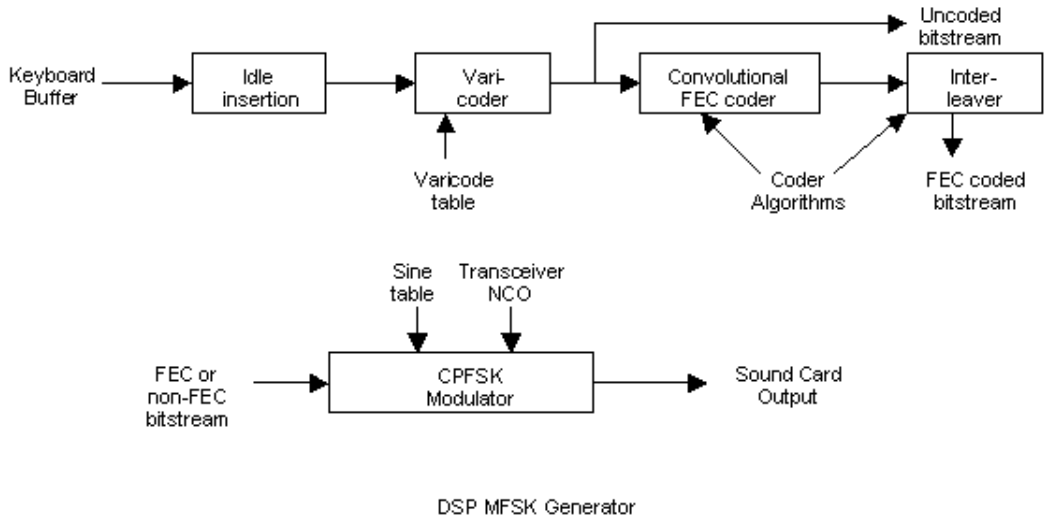

Figure 3. The complex error-correction systems employed in MFSK

Part of the consideration of the most suitable data transmission system must be to decide what value is placed on the various merits of each mode. In no particular order: data rate, accuracy (error correction), tolerance to interference, ease of operation, radio-frequency bandwidth, robustness, reliability, adaptability, availability and even legality, must all be assessed. A specialist group of 5MHz NOV-holders are looking at just these issues now and have already reached some preliminary recommendations for choice of data mode under different propagation conditions.

It is worth noting that most of the newer modes will continue to work quite satisfactorily right at the noise floor – check the higher HF bands when they are

considered to be ‘closed’ for speech traffic and you will find data communication carrying on regardless!

For an excellent guide to data modes both old and new, I highly recommend the RSGB publication “Digital Modes For All Occasions” [2]. Via the Internet, there are several software packages, many of them freeware, which can be downloaded for use. For example, DIGIPAN and HAMSCOPE are popular choices. In particular, the suite of programs by IZ8BLY [3] and the excellent MIXW [4] are multi-mode and therefore offer many protocols to try within the one program.

From an emergency communications perspective, it is unfortunate that the message handling interface presented with much of the software is rather basic. RAYNET will need to go beyond simple typing of text ‘live’ at the keyboard – the data rate is too fast for this to be efficient and, in any case, the User Services will probably present large amounts of data already in the electronic domain. Ideally, what is needed is a standardised interface for email and attachments which would be suitable for RAYNET use in the field with all of the popular communications programs. So, there is an interesting challenge for the software gurus!

PICTURES

Thus far, we have concentrated on new means of sending textual information. As the saying has it, though, ‘A picture is worth a thousand words’. Just as data modes have taken full advantage of the power of the personal computer, so too have the visual modes. Several RAYNET groups have experimented with sending computer-based Slow-Scan (SSTV) pictures on behalf of their users. Also, using the emergent data compression techniques, Digital Narrow Band Television (NBTV) offers greatly improved picture quality [5]. Software is already under development meaning that it should soon be possible to send high definition Fast-Scan, or real-time, digital pictures from incident sites via amateur radio links.

APRS, UiVIEW and WLAN

APRS (Automatic Packet Reporting System) and its UK equivalent, UiView, utilise the existing packet radio network to provide continually updated positional information from GPS receivers. This is being used for tracking the progress of widely-spread events, such as for long-distance walks and rides. This software also provides the facility to disseminate mass data, for example weather bulletins, as well as direct screen-to-screen text conversations.

WLAN is an interesting development that allows for wideband data links within suitable parts of the amateur spectrum, such as 2.4GHz. For localised co-ordination at incident sites, this concept could find many applications. See WebSearch for a link to G0TWN’s very interesting Amprnet experiments.

SOME NON-TECHNICAL NEEDS FOR THE FUTURE

As can be seen, a good number of technological advances are upon the voluntary emergency communicator. Almost too many perhaps, because clear guidance from the User Services is going to be needed to define the future role of RAYNET and to create a development strategy that focuses on the facilities most required from us. The RCVS National Co-ordinator role will be important in this, harmonising groups and individuals towards a common goal.

By making known the potential new technologies we can offer, interest and support from the User Services will be perpetuated. Closer working relationships at national level will allow RAYNET to integrate more effectively at an electronic level with the Users' existing systems.

It will be important not to oversell what we can practically achieve and there is much hard graft in training and project work ahead if we are to take full advantage of the greater flexibility that new tools are bringing us.

REFERENCES

[1] G4GUO's website lays out many of his interesting ideas that are currently under development. Go to http://www.chbrain.dircon.co.uk/.

[2] 'Digital Modes For All Occasions' by Murray Greenman, ZL1BPU. RSGB Publications ISBN 1 872309 82 8.

[3] Nino Porcino, IZ8BLY, has produced a series of programs that concentrate on many specific modes. All of his software can be downloaded from his website http://iz8bly.sysonline.it/.

[4] MIXW is a shareware program offering all of the popular data modes. The program can be downloaded from http://www.mixw.net/ and can be used for a free trial period prior to registering for a modest fee.

[5] For more background about Narrow Band TV, see http://www.qsl.net/hb9tlk/.

WEBSEARCH

RSGB Emergency Communications pages	http://www.rsgb.org/emergency/index.htm
RAYNET HF Team	http://www.raynet-hf.net/

Data mode reference site	http://www.qsl.net/zl1bpu/
WLAN	http://www.taurus2.plus.com/gb7imk/wlan_diary.htm