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The attached document is a draft of a short overview discussion of how to do digital message transmission via amateur radio for ETECS and general emergency management use. It covers various technologies.

In past exercises, ETECS has demonstrated emergency response via its wide area voice networks, via packet Winlink with our extensive VHF/UHF packet network, and via the packet network dispatched via the voice network to relieve packet congestion issues.

In the upcoming exercise, we want to demonstrate high-speed text transmission via the voice network, interspersing voice check-ins and commands with text transmissions.

To that end, the sections of the document covering NBEMS and sound-card interconnection are most important.

The document mentions specific radio brands and models, and specific soundcard devices and brands. This does not imply ETECS endorsement of these products, but it does indicate that several ETECS members have found this equipment useful and effective in the task of radio message transmission.

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Formatted Message Transmission via Amateur Radio

I. Introduction.

Whether Radiograms, or ICS message forms, the accurate transmission of written messages has been an important part of the Amateur Radio Service since its inception. The American Radio Relay League, the first national organization for our hobby, was started over 100 years ago by the need to relay written messages via radio telegraphy, and later, voice.

Today, the internet and cellular phone networks have made high-speed text messaging a given in modern life. Yet Amateur Radio still fills the gap “when all else fails.” Modern society expects a faster pace than the 13 to 25 words per minute of Morse code.

Modern digital signal processing has brought speeds to communication that were beyond our reach just a few years ago. With a contemporary personal computer or smartphone connected to a quality radio, very respectable off-grid message transmission speeds can be realized. In particular, over a quality VHF or UHF FM path, 8PSK1000R can achieve a remarkable 3300 words per minute – 50 times the speed of teletype, and 150 times the speed of Morse code!

It is relatively simple today to participate in this world. You only need to make the computer-to-radio connection, and install messaging software. The connection step, though reasonably easy, offers the widest variety, so we start with it first.

II. Computer to Radio Connection.

Our radios today are usually equipped to transmit and receive audio signals. Computers store messages as binary numbers. To bridge the gap, two devices are needed: A modulator-demodulator (modem), and a sound card connected to the computer.

A. Software (Soundcard based) Modems

Because of the processing power of modern personal computers, a modem realized as a software program can have considerably higher performance than hardware designs. We will discuss three broad families of software modems.

1. FLDigi modems

The FLDigi program, which we will discuss in greater detail later, has a wide range of modem types built in. Each of the large number of modems is designed to perform best with different kinds of radio channel degradation, such as gaussian noise, doppler shift, and selective fading.

2. Packet modems: Direwolf and Soundmodem

There are two programs designed to emulate the early Bell Telephone system data protocols for data connection over the public switched telephone network. These 1200 baud protocols were ubiquitous in telephone modems several years ago, and were quickly adapted to radio transmission. Text data is formed into “packets” to facilitate error detection and retransmission.

Soundmodem was originally written by Thomas Sailer, but has been updated and improved by Andrei from Ukraine, UZ7HO. It interfaces well with the Winlink program. It can do some higher-speed modes also, some of which require an advanced radio connection.

Direwolf is a high-performance, feature rich packet modem by wb2osz. It has no graphical user interface – it is set up by a configuration file. But many users find its power and performance make up for the configuration effort.

3. The VARA family

The VARA family of modems is the development of José Alberto Nieto Ros, EA5HVK. Unlike the software discussed so far, the VARA programs are not open source. They are protected by copyright and/or patent, and a small license payment is required to unlock full performance and silence “nag” dialog boxes. Because these modems are not fully documented publicly, they occupy a grey area in the rules of the Amateur Radio Service. Nevertheless, they have excellent performance, are widely used, and the FCC has so far raised no objection to the implicit rules violation.

VARA-FM is designed for use with VHF/UHF FM radios. VARA HF is designed for HF SSB use. Both of these programs are designed to work with Winlink, and are downloadable from the official Winlink site.

4. External Soundcard devices

A number of external soundcard devices have been developed to facilitate the use of these software modems. These devices solve certain problems encountered when using the computer’s built-in soundcard, including rf isolation and ptt signal generation.

a. TigerTronics SignaLink USB

The SignaLink device has been available for many years. It connects to the computer via USB and has an RJ-45 style jack to connect to the radio. TigerTronics sells cables to connect to many radios, and the RJ-45 jack means that a custom cable is easy to build.

The device is transformer isolated from the radio, and has a built-in vox circuit for ptt signal generation. There are controls for input and output volume, and for vox delay. There is a pass through jack for speaker audio. A unique feature of this device is that the input and output signals are connected to the RJ-45 connector internally via a 16 pin dip socket. This allows the same cable to be used for different radios by using a jumper block to change the connections.

This device is well suited for use with older radios which do not have a specific connector for data usage. One drawback of the device is that the transfomers used in many production runs do not support the wider audio frequency range needed for 9600 baud packet or VARA wide usage.

b. Digirig devices

The digirig devices are newer, and well suited to newer radios. They are very small, and about half the price of the SignaLink device. Signal levels are adjusted with radio and computer controls.

The digirig mobile device has a usb-c connector on one end, and two 3.5 mm trrs phone jacks on the other. One jacks has both audio signals and a ptt signal. The other has serial control signals. The control signas can be either ttl (5 v) level or RS-232 levels. The choice is made by bridging solder pads. The device can be ordered in either configuration at the same price, but can be modified in the field with soldering equipment. Molded cable sets for a variety of common radios are available from digirig. The device will handle the wideband signals required for 9600 baud packet or VARA-FM wide.

The digirig lite device is even smaller, and only handles the audio and ptt signals. It is the least-expensive full-featured soundcard interface, and is the ideal solution for radios with 6-pin data connectors and for handie-talkies

B. TNC Devices

Before personal computers were widely available, hardware modems for the Bell protocols were packaged with a small micro controller in a device called a TNC (Terminal Node Controller) These devices incorporated the packet protocols and were connected to the host computer with an RS-232 Serial cable.

TNCs exist in 300, 1200, and 9600 baud versions. Not many are in current manufacture, but at least one, the Mobilinkd TNC-4 is. It does 1200 and 9600 baud speeds, and connects to the host computer via serial Bluetooth. In addition, both the Kenwood TH-D75 and Btech UV-Pro handheld radios contain an internal TNC which is exposed by Bluetooth serial.

C. Specific Radio Configurations and Connections:

All of the modems discussed above, except for the 9600 baud TNCs and VARA-FM in wide mode, connect to the radio with standard audio input and output connections. The 9600 baud TNCs, and VARA-FM in wide mode, are only suitable for VHF/UHF FM use, and must bypass the FM receiver's de-emphasis network and connect directly to the FM discriminator circuit. As we shall later see, several radios provide access to this connection point.

1. Radios with internal sound card

Many modern amateur radios have a USB-connected sound card built in to the radio. In addition, they usually have a USB serial controller for radio function control. For these radios, it is only necessary to connect a USB cable between the radio and computer. Everything else is done with configuration settings in the radio and computer. Examples include the Elecraft K3s and K4, the Icom 7300 and 705, and the Yaesu 991A. See appendix C for examples of specific settings. This internal sound card is usually not suitable for 9600 baud packet or VARA-FM Wide,

2. Radios w/ 6-pin mini-din Data Connector

a. VHF and UHF with 6-pin

Quite a number of high-end VHF/UHF FM radios are equipped with a 6-pin mini-din connector on the rear which is marked "Data." Examples include the Yaesu FTM-300D, FTM-400D, Alinco 735, and others. The connector pin-out is shown in Appendix 2.

These radios require connection to a sound card, either the computer's internal card, or an external such as the SignaLink or Digirig devices. The least expensive and simplest external soundcard is the newly introduced Digirig Lite. The 6-pin Data connector usually has the wideband output required for 9600 baud TNCs and VARA-FM Wide.

b. Radios with both 6-pin data and 8-pin control mini-din connector.

These radios are usually HF or HF-VHF-UHF radios, such as the Yaesu 857 and Icom 7100. The 8-pin connector is used for a serial connection for control of the radio. Icom calls this control CI-V; Yaesu calls it CAT (Computer Aided Transceiver). This connection allows the computer to set the radio frequency, which is very useful when using VARA-HF with Winlink,

If the SignaLink device is used, a separate computer serial port or USB to serial cable must also be used.

The Digirig Mobile device has both a sound card and USB serial device in one small inexpensive package.

3. Other radios

Both Tigertronics (SignaLink) and Digirig offer cables for a variety of radios which can be used in place of the radio microphone and headphones/speaker. From a software point of view, they work like any other radio with an external soundcard.

Finally, the Kenwood TH-D75A and the BTech UV-Pro radios have internal TNCs which are exposed via a Bluetooth serial interface. The Kenwood radio offers both 1200 baud and 9600 baud speeds.

III. Message formatting and transmission software

Having the computer and radio interconnected, we now must select software to compose, transmit, receive and forward messages. This software divides itself into two groups or families.

In the first group, messages are transmitted in their entirety or in blocks without interruption. There is usually no Automatic Repeat Request, and so messages may be copied by multiple receiving stations simultaneously. The modems used often employ sophisticated forward error correction so that error-free reception is possible without repeats. The FLDigi suite, known collectively as NBEMS (Narrow Band Emergency Messaging Suite) is the exemplar of this group, but there are many others.

In the second, messages are sent to a single receiver. This software uses a connection-oriented protocol between one sender and one receiver. This does not mean that other stations cannot intercept the message, but that only the designated receiving station can be certain that the message is error-free. The Winlink suite is the exemplar of this style, and it is well-suited to store-and-forward transmission, in which the sender transfers the message to a mailbox system, and the receiving station retrieves the message from the mailbox. It can also be used in a peer-to-peer mode, but is poorly adapted to the transmission of bulletin messages to multiple receivers.

The VARA and Packet modems used in Winlink connect over the air to a single receiving station and use an automatic back-and-forth conversation, in which clients periodically report success or failure of accurate transmission of message blocks, and request retransmission as needed. Obviously, this connection protocol is not suitable for use with multiple simultaneous receiving stations.

A. NBEMS – The FLDigi Suite by W1HKJ and friends

The NBEMS system contains several programs that work tightly together to handle all parts of the messaging task. These programs are all open source, and run on most desktop and laptop computers, including Windows, Linux, and Macintosh. The “FL” in the name comes from the “Fast Light Toolkit” which is the cross-platform GUI toolkit used to build the programs:

FLDigi is the “Swiss Army Knife” program which is the central control of the suite. If can be used stand-alone for keyboard to keyboard messaging, contesting, and file transmission. This is also the program which handles all of the many modems and modes that the system can use. When using VHF and UHF transceivers, we have found the MT-63 modes to be most robust, and the 8PSK1000F modes to be fastest. An important feature of many of the modes for VHF/UHF use is that they work well through voice repeaters.

FLRig handles the job of controlling the transceiver and PTT. It eases the task of configuring a specific radio. FLRig can also be used with other digital programs like WSJT-X which are used for contacts, but not for free form or templated messages.

FLMsg and FLWrap handle message composition and templates.

FLAmp is a unique program that breaks a large message into blocks and attempts error-free transmission of each block. It can be used in a net to ensure accurate transmission to many stations even under adverse conditions. It facilitates error-free relay of large messages as well.

In normal operation, an operator opens the programs, and uses the FLMsg program to select a message template from the Form menu, and compose a message. Clicking the AutoSend button saves the message and initiates transmission.

For receiving, FLDigi automatically detects the presence of a formatted message in the data, and opens the message in an FLMsg window, and, optionally, as an html document in the web browser.

The NBEMS suite is ideal for wide area message dissemination because the modems used are not connection-oriented. They work in a more nearly broadcast fashion. There is on need to change the message creation for differing transports – VHF/UHF FM, HF SSB, whatever. The message is still the message.

A weakness of the NBEMS system is that there is little or no internet email connection available. Java-based client and server programs for a system called PSKMail were available 10 to 15 years ago, but they seem to have died out.

Settings for FLDigi, FLMsg, and FLRig are detailed in Appendix A

There is an NBEMS-compatible program for Android phones and tablets called andflmsg.

B. The Winlink Suite

The Winlink Global Radio Email® system is a client-server system that shines as a gateway to the internet email system. Born alongside a commercial service called SailMail, Winlink has gone by a number of names, including Winlink and Winlink2000. The client program which connects to the radio has also gone by many names; the current program is called Winlink Express, formerly RMS Express. Winlink is not open-source and only runs on the Microsoft Windows operating system.

The Winlink Express program is an all-in-one client that resembles many older email clients. It has an inbox and outbox, and a composer window with templates. A typical session involves creating a message, posting it to the outbox, and then using the menus to establish the radio connection which sends the message, and retrieves and waiting messages. An important feature is that messages must be composed for peer-to-peer delivery or mail server delivery; the two message types are not interchangeable.

Winlink sessions are connection-oriented; you are either connected to a Central Messaging Server (CMS) or a peer station (Peer-to-peer) The modems, which are either hardware TNCs (simple, or sophisticated like Pactor) or Software TNCs like Soundmodem, Direwolf, or the VARA family.

For this reason, Winlink makes a serial connection to a hardware TNC or a virtual serial connection to a software TNC. The soundcard device is not configured by the Winlink Express program, but by the individual software modem. The modem configuration needs to know the soundcard device and PTT device, but radio control (CAT) is handled by the Winlink Express program.

These connection details will be added in a future appendix.

There is a work-alike cross-platform open-source alternative called pat written by Martin Hebnes Pedersen, LA5NTA. It is available at https://getpat.io.

There is a work-alike program for Android phones and tablets called WoAD, available in the Google play store.

There is a work-alike program for IOS phones and tablets called Radio Mail, available in the Apple app store.

IV. Putting it all together

The choice of messaging software and hardware is complex. There are many questions to be answered:

Where does the message go? To one recipient or many? Internet Email or another station?

What protocols and programs are available at the receiving station?

What is the path like? Long or short? HF or VHF? What equipment does the receiving station have?

This document has been an attempt to describe two of the major systems, their strengths and weaknesses, and the basics of common setup and configuration.

Appendix A – NBEMS configuration hints.

FLMsg and FLDigi will both collect user callsign, name, and location on first launch. These are used to fill in respective messaging areas.

Here are hints for other important parameters

In FLDigi Configure → Config Dialog → NBEMS Interface:

Check Enable for NBEMS data file interface. Check Transfer direct to executing flmsg for Reception of flmsg files. Check Open with flmsg, and, if desired, Open in Browser. Use the Locate flmsg buttion to select the FLMsg binary executable.

In FLDigi Configure → Config Dialog → Autostart

On the flrig line, locate the flrig binary and check enable. For Prog 1, locate and enable Flmsg.

In FLDigi Configure → Config Dialog → Soundcard → Devices

Select the record and playback soundcard device. If using a soundcard equipped radio, or a SignaLink or Digirig device, look for USB in the device name. **Important**: If on a Windows 10 or 11 computer system, be certain that all noise supression and sound enhancement settings in Windows are disabled for the devices chosen.

In FLDigi Configure → Config Dialog → Rig Control

If the radio connection is without a serial control connection, do not activate any of the rig control panels. Push to Talk will be handled by vox in the SignaLink device, or a similar facility in the Digirig Lite Device. You do not need to autostart FLRig in this configuration

If there is a control connection (for example, direct USB or Digirig Mobile), activate the flrig panel in the Rig Control settings, and configure FLRig for your radio. Set PTT in FLRig for CAT control

In FLMsg Config → ARQ, I like to check Sync modem to fldigi. Changing Op Mode will then be reflected in FLMsg, and the time to send the message will be updated

Appendix B. Winlink Modem Configuration hints (*to be added*)

Appendix C. Yaesu FT-991A Menu Settings

Taken from the manual for FLRig by W1HKJ

Menu #	Name	Value
31	CAT RATE	38400 bps
32	CAT TOT	10 msec
33	CAT RTS	ENABLE
59	CW FREQ DISPLAY	PITCH OFFSET
60	PC KEYING	DTR
62	DATA MODE	OTHERS
63	PSK TONE	1500 hZ
64	OTHER DISP (SSB)	1500 Hz
65	OTHER SHIFT (SSB)	1500 Hz
66	DATA LCUT FREQ	300 Hz

Menu #	Name	Value
67	DATA LCUT SLOPE	18 dB/oct
68	DATA HCUT FREQ	3600 Hz
69	DATA HCUT SLOPE	18 dB/oct
70	DATA IN SELECT	REAR
71	DATA PTT SELECT	DAKY
72	DATA PORT SELECT	USB
73	DATA OUT LEVEL (RX)	100
74	FM MIC SELECT (PHONE)	MIC
75	FM OUT LEVEL (Rx)	50
76	FM PKT PTT SELECT	DTR
77	FM PKT PORT SELECT	DATA
106	SSB MIC SELECT	MIC
107	SSB OUT LEVEL	50
108	SSB PTT SELECT	DAKY
109	SSB PORT SELECT	USB
110	SSB TX BPF	300-2700
114	IF NOTCH WIDTH	NARROW
146	DATA VOX GAIN	50
147	DATA VOX DELAY	100 msec
148	ANTI DVOX GAIN	0

Appendix D. Resources

Digirig:

https://digirig.net Also available from Amazon and other suppliers, but there is often markup.

SignaLink:

https://tigertronics.com/slusbmain.htm Also available with markup from DX Engineering

NBEMS:

https://www.w1hkj.org Downloads are also available at sourcefoge.net. There are many help resources available at the w1hkj.org site.

Tutorials are also available at https://www.arrl.og/nbems

Winlink:

https://winlink.org Software downloads are at this address for both Winlink Express and the VARA modems.

Soundmodem:

https://uz7.ho.ua/packetradio.htm

Pat cross-platform winlink client:

https://getpat.io