DIGITAL COMMUNICATIONS

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Disclaimer:

These are my comments on digital communications and are not necessarily all there is to know on the subject. As with everything computer related — there are at least six ways to do the same thing. Given this caveat, let me say this is opinion and not the complete story. I only relate to you my experience of 5 or more years using digital modes to give you the benefit of my experience. I will leave the rest for you to research as you see fit.

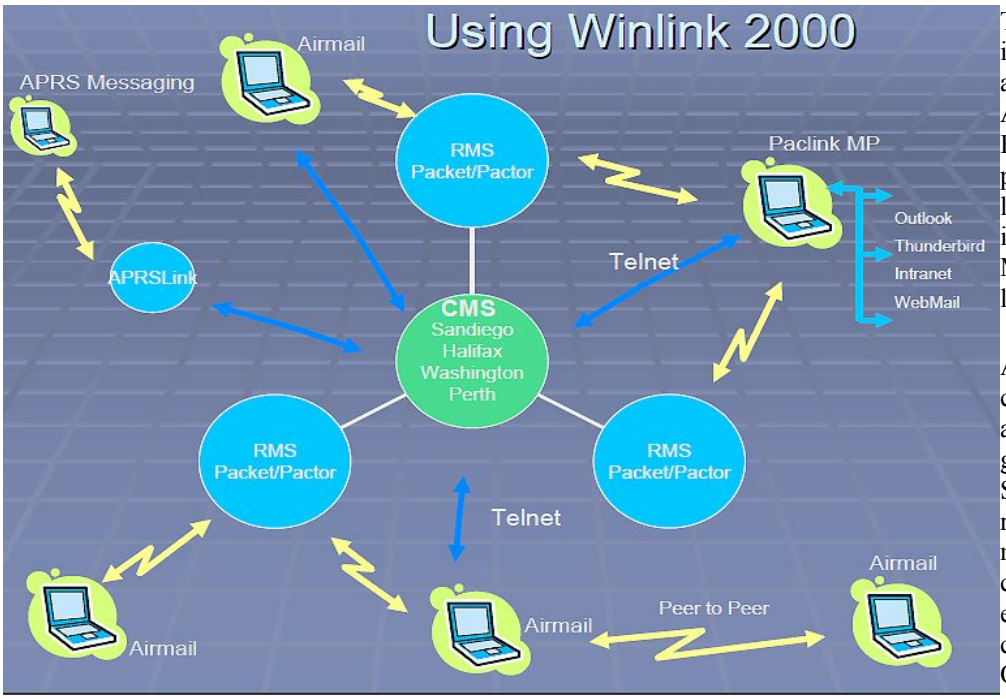
WinLink 2000

Winlink 2000 (WL2K) is a worldwide **system** of volunteer resources supporting e-mail by radio, with non-commercial links to internet e-mail. These volunteer resources come from Amateur Radio, the Military Affiliate Radio Systems (MARS), and other non-commercial organizations. The system provides a valuable service to emergency communicators, and to licensed radio operators without access to the Internet. WinLink mixes Internet technology and appropriate amateur radio, military, and marine RF technologies. Multiple digital modes are accommodated, and the system provides radio interconnection services including: email with attachments (Paclink and Pactor II and III, and WinMor), position reporting (PacLink and APRS), graphic and text weather bulletins (Pactor II and III, and soon maybe WinMor), emergency / disaster relief communications, and message relay. It is particularly important in emergency situations because it can provide direct, digital, "last-mile" delivery of email in affected areas where ground, satellite, and Internet communications have been interrupted. Delivery can be to existing common email programs on common computer systems, without proprietary software or dedicated computer hardware. It does not require a full time connection to the network.

This network provides truly inter-operable messaging to all agencies in the same format. Unlike the amateur packet network, no "home" BBS is required, however, a registered and verified login to the network is required for WinLink access. There is now official support of WinLink 2000 by the Department of Homeland Security through MARS. In fact, Fort Huachuca Army Intelligence Base in Arizona has a complete Winlink system on base. They operate mobile Winlink Airmail and permanent mirrored Common Message Server(s) (CMS) (at least 5 of them) and an unknown number of Radio Message Server (RMS) installations. It is VERY robust and has a better than 99% up time serving the ARMY and MARS. Generally, email communications over amateur radio in the 21st century is now considered normal and commonplace. Email via HF can be used nearly everywhere on the planet, and is made possible by connecting an HF or VHF transceiver system to a computer, modem interface, and appropriate software.

Winlink networking started by providing interconnection services for amateur radio to provide some interoperability with Emcomm and government agencies. It is well known for its central role in amateur radio Emcomm messaging. The system runs several central [common] message servers (CMS), as well as message forwarding server (RMS) stations, around the world for redundancy. During the past decade it has increasingly become what is now the defacto standard network system for amateur radio and maritime email worldwide. A network of radio based mail servers called Participating Mail Box Offices (PMBO) provide mail server functionality to the system. Additionally, in response to recent needs for better communications disaster response, the network has been expanded to provide separate parallel radio email networking systems for MARS and UK Cadet communities utilizing a variety of digital modes including packet, PACTOR, and MT63. The WinLink 2000 network is in fact 99% reliable worldwide since late 1999 through the use of multi-mode, multi-path, and redundancy techniques common in commercial networks. The average delay time from origination to delivery at destination is **just over three minutes on average** (highly dependent on propagation conditions and traffic as well as end points)

The illustration shows the general topology of the Winlink 2000 network.



The HF modem technologies include MT63, PACTOR I, II, and III, WinMor, Packet, and ALE. ALE (Automatic Link Enabled) is not a transmission protocol, but a selective linking protocol widely used in Winlink, Emcomm and MARS which we will cover later.

Amateur radio users in each country worldwide follow the appropriate regulatory guidelines for their license. Some countries may limit or regulate types of amateur messaging (such as email) by content, origination location, end destination, or license class of the operator. Origination of *third party* messages (i.e., sent from or to an end destination who is not an amateur operator) may also be regulated in some countries; those that limit such *third party* messages normally have exceptions for emergency communications. In accordance with long standing amateur radio tradition, international guidelines and FCC rules section 97.113, hams using the Winlink system should know that it is illegal to use it for business communications, third party messages to countries where prohibited, deliberately obscured by private encryption, or use content that can be considered obscene or otherwise violate the laws of the US.

Digital modes such as PACTOR I, WinMor, HSMM (WiFi), AX.25 packet, D-Star, TCP/IP, and ALE are non proprietary protocols used in various RF applications to access the Winlink network systems. WinMor is a new open protocol to be released soon. It promises to be faster and more robust than PACTOR I but short of the proprietary PACTOR protocols. Two hardware based HF data protocols utilize proprietary modems from Specialized Communication Systems (SCS): PACTOR II and PACTOR III. Receivers using any of these protocols have the option to interconnect to another either manually or through software or hardware forwarding. In other words, a message sent by packet can be forwarded to an APRS station then to a PACTOR station and back to a packet mailbox or via Internet to reach a end point mailbox at it's destination. This multi-route, multi-protocol network has established a considerably fault tolerant worldwide network for email delivery under all conditions short of global catastrophe or radio blackout conditions.

In amateur radio service, *AirMail*, an email client software program used by the Winlink system, to send mail over Winlink media directly. This program disables the proprietary compression technology when using the SCS modems and instead relies on the Open FBB protocol, also widely used by packet radio BBS forwarding systems in US. This is designed to be in line with the spirit of US Part 97, homeland security guidelines, and other encryption policies worldwide, more than necessity. Airmail is a self contained mail client program that is made to resemble Microsoft Outlook Express while interfacing with common ham radio telnet and radio media Winlink stations. Unlike PacLink, Airmail will allow peer-to-peer (end user to end user) connections. Peer-to-peer links are sometimes useful in emergencies where longer distance links are not possible or HF links are not available.

Also available to amateurs is the PacLink program which acts as a media link to existing email client programs such as Microsoft Outlook Express, Mozilla Thunderbird, and others using the common B2F protocol. The user can send and receive POP3 and SMTP Internet style email transparently. PacLink also allows multiple addresses and tactical position reporting in the feature list. Paclink services the various Winlink connections and hands off incoming and outgoing traffic to the local email client program. The obvious advantage is that the user can use an existing email client that is familiar while having multiple connections to Winlink media (e.g. pactor, telnet, and packet) and send and receive Internet style email transparently, using Winlink. Polling can be set up to automatically connect and poll each source for data to and from the Winlink system on a regular interval.

For more information on the WinLink 2000 system got to Yahoo! Groups and join the wl2kemcomm group. There is a lot of information in the files section of this group. Or go to the WinLink 2000 web site www.winlink.org.

It is particularly important to note that the Winlink 2000 system delivers messages over multiple paths, using multiple transmission modes, and is **not** entirely dependent on the Internet. If the Internet were to fail catastrophically for any reason (like terrorist cyber attacks), Winlink 2000 could conceivably still operate and deliver messages — albeit with some added delay and lower throughput for propagation on radio channels only.

ALE — Automatic Link Establishment

With the capability to call up a specific HF station, a group of stations, a net, or a networked station, Automatic Link Establishment is a versatile protocol for connecting radio operators for voice, data, text, instant messaging, Internet messaging, or image communications. A radio operator initiating a call, can within minutes have the ALE automatically pick the best frequency that both stations have. It signals the operators on both ends, so they can begin communicating with each other immediately. In this respect, it can eliminate the longstanding need for repetitive calling on predetermined time schedules and monitoring

Each radio ALE station uses a callsign or *address* in the ALE controller. When not actively in communication with another station, each transceiver constantly scans through a list of frequencies, listening for its callsign. To reach a specific station, the caller simply enters the callsign just like dialing a phone number. The ALE controller selects the best available frequency and sends out brief *digital selective calling signals* containing the callsigns. When the distant scanning station detects the first few characters of its callsign, it stops scanning and stays on that frequency. The two stations' ALE controllers automatically *handshake* to confirm that a link is established and they are ready to communicate. The receiving station, which was muted up until then, will typically emit an audible alarm and visual alert for the receiving operator of the incoming call. It also indicates the callsign of the linked station. The operators then can talk in a regular conversation by voice, text, or exchange Internet style email messages. At the conclusion of the QSO, one of the stations sends a disconnect signal to the other station, and they each return their ALE stations to the scanning mode. Some military / commercial HF transceivers are available with ALE options. Amateur radio operators commonly use the **PCALE** or **MultiPSK** soundcard software ALE controller, interfaced to a modern digital ham transceiver (capable of rapidly scanning ALE frequencies) via RS-232 CAT port, and multi-frequency antenna.

For operation as an ALE system, the HF communications system normally has a number of frequencies throughout the HF spectrum. It takes a lot of time for the radio to go through the sequence of calling a station on every possible frequency. But there are several ways the ALE system can be programmed to decrease the time it takes, over simple random scanning and sequential channel calling. Methods for decreasing the time by using a "smarter" way of predictive or synchronized linking can be applied. An ALE system utilizing **L**ink **Q**uality **A**nalysis capability provides periodic sounding and linking signals between other stations in the network, to stay in touch, and to predict which channel is best to call a particular station that may be on at any given time. Various stations may be operating on different channels, and this enables the stations to find and use a common channel that is clear, that they both have.

Here's how it works in an adaptive system using LQA. Once every hour or so, each station in a network will attempt to "sound out" each channel by sending a short transmission to all the other stations in the net, the transmission is its own callsign, and it may be sent on each of the channels it is operating on. All stations in the net who are scanning that channel may receive the sounding transmission and measure the signal quality on each channel for every other station's ID it receives (similar to LAST_HEARD function on packet). The signal quality is given a score and scores are stored in a complex matrix of:

- STATION ID
- TIME DATE STAMP
- CHANNEL NUMBER
- SIGNAL
- QUALITY LEVEL

When a call is initiated to a station, the radio automatically checks its LQA scores matrix to make a determination of the most probable and best quality channel for the call to the desired station, based upon its record of recent LQA data it has logged on that station. It then makes its first attempted linking call on that most probable channel. If the link cannot be

established, it will try again on the next best frequency in the matrix, and so on, until a link is established. Typical ALE systems using LQA make use of recently measured soundings or stations received within the past few hours.

USA hams can use ALE's ***Selective Calling and Alerting features*** in the ***phone subbands,*** and ***all*** of the features of ALE in the ***data subbands***. One of the aspects of operation using digital technology in Amateur Radio is navigating the complexities of the arcane, and sometimes contradictory maze of FCC rules regarding content, modes, bauds, emission types, and subbands. Currently, many countries of the world have easily understood bandwidth-based Amateur Radio rules where most of the protocol and features of ALE can be utilized freely on any frequency with any type of content at any moment. The US Amateur Radio Service has been somewhat more limited in this respect, due to its more antiquated ***content-based*** rules. Thus it is important for USA hams using ALE to be aware of the type of content they are transmitting (voice, data, image, or text) in order to comply with these content-based rules.

While ALE is most widely known as a selective calling system and a way of initiating and maintaining communications on HF, the ALE standard also includes the ability to send/receive short text or data using the same "ALE modem". The ALE modem uses an 8FSK signal (eight different tones), and it may be used within FCC rules to transmit anywhere in the RTTY/DATA sub-bands when the content of the transmission is data or text messaging. Also, within the RTTY/DATA segment, are sub-bands for automatically controlled data stations. An ALE "Pilot Channel" frequency exists within the automated station sub-band of each HF ham band. The ALE channel list includes these as Pilot Channels, and the repetitive sounding activity for hams usually occurs on these Pilot Channels. The main reason for using the automatically controlled data station sub-bands for most repetitive sounding is because these band segments traditionally have stations with similar signals and fast time-sharing methods as ALE, and thus ALE operation fits well in these segments. A secondary reason is to enable easy inter-operation with automatically controlled data stations that are using ALE. Additional frequencies for data are available in the ham radio ALE channel list for texting, keyboarding, and digital messaging. It is important that operators follow the guidelines for use and to avoid interference. If one ALE channel is busy, operators can usually find a clear spot on one of the other channels to communicate by keyboarding or data transfer. Keep in mind that although the ALE "channels" have existed for a long time and are widely recognized by ham operators worldwide, there is no special "ownership" of any particular frequency on the ham bands or right to use it more than any other, and that courtesy and cooperation is the cardinal rule that we should all operate by.

For emergencies and disaster relief, there is often a need for government and non-governmental organizations (NGO) and amateur radio emergency services to communicate with each other. The first step is to gain agreement between counterpart organizations to cooperatively implement inter-operative communications. Some organizations have not been aware that such communication is possible. Until recently, direct infrastructure-less inter-operation has only been available on a very limited basis for local communications, between certain organizations. With the many organizations that increasingly have HF ALE capability in the field, an inter-operation solution now exists for all of these services to communicate with each other on-demand via HF radio. Different parts of the HF spectrum are useful for various distances, including local, national, regional, and international. The capacity to utilize the HF spectrum for communication on-demand with a common calling and alerting system, instantly provides a unique infrastructure-less communication medium. Infrastructure such as Internet base-station networks can also be utilized as part of HF ALE inter-operation. ALE provides unique capability to fluidly use the same system for both infrastructure and non-infrastructure communications, to network independently, or in ad-hoc peer-to-peer networks.

The need to call up emergency nets or inter-operate and liaison with government HF systems has led many hams to adopt the government ALE standard, called **FED-STD-1045** or **MIL-STD 188-141**. This standard caught on slowly in the ham community, initiated by a few operators with limited government surplus gear and some with expensive commercial equipment having embedded ALE or hardware controllers. Recently, the cost of embedded ALE transceivers has been reduced, and they are now available at similar to the cost of a medium priced ham radio. Also, with ALE software, a ham HF transceiver, a PC computer as the controller, and an appropriate antenna system, hams can harness the power of ALE. The PCALE and MultiPSK programs use MIL-STD 188-141 for ALE. This makes stations using these applications during disasters, inter-operable with MARS and other government agencies also using ALE.

The development of ham-friendly ALE standards and coordinated frequencies has not only ensured that hams using ALE comply with FCC rules (as well as other national rules or ITU region IARU band plans); it has enabled ham radio ALE operations to be in harmony with good amateur radio practice and band use patterns, while providing interoperability and emergency/disaster relief communications service without interference problems or complaints for many years. Hams are widely encouraged to use common voluntary ALE standards, and the majority of hams on the air with ALE today are using them.

The ALE pilot frequencies and band plan are available on www.hflink.com/channels

The regional ALE network band plan is available on www.hflink.com/hfn/

The Global ALE High Frequency Network (HFN) is a system of ALE base stations with Internet connectivity. Each HFN *Pilot Station* is rapidly scanning the ALE Primary Data Channels of the ham bands 3.5MHz to 28MHz every 10 seconds, monitoring for calls, and sounding with station identification callsigns approximately once per hour. Ham radio ALE operators anywhere within the coverage area, may link with an HFN Pilot Station on HF, and send or receive short text messages via email or phone texting SMS.

Access to HFN Pilot Stations for Internet services is limited to ham radio operators, holding a valid license of any country for HF operation. To use HFN services, first join HFLink (it's free), get your HF transceiver and computer set up with the latest free software using ALE. ALE activity on the air, around the world, is automatically reported in real time by HFN stations on ALE Channel ZERO.

This is a lot of information to digest at once. Please take the time to review it and research further to get a better understanding of how Winlink and PACTOR can be used in your individual situation.

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Just stay with us for more next month on other interesting digital modes. We will have something for you as we go along. If you missed some of this, I will make a printed version available if you email me a request.

I am also a technical specialist so you can email me with your technical questions and problems as well.