ANNEX 6
HF E-MAIL

A6-1 Introduction

This annex describes "Battle Force Electronic Mail" (e-mail) that is in widespread use within the United States Navy for administrative and logistics messaging, formerly transmitted via satellite. The standard described here is used for U.S. Navy e-mail communications by approximately 50 ships and with approximately 100 Corps of Engineers stations established by DISA.

This BF e-mail system grew from a Navy modification of e-mail for use in HF radio ground-wave propagation paths between ships in a battle group (an aircraft carrier and as many as 20 ships within a defined area), hence the name: *Battle Force Electronic Mail*. This e-mail system has a gateway capability for connection with the Internet. Security concerns associated with such connections are addressed by the Navy's use of a crypto system with e-mail transmissions. The Internet connection allows Navy personnel at sea to use e-mail to communicate with their families at home via AOL and other ISPs (Internet Service Providers).

A6-1.1 System description—general

This section describes the general operating protocols and parameters required to support the Battle Force (BF) e-mail system operation. Features supported by the system include: user-friendly menu-driven client operation, the ability to transfer imagery as well as text messages, error-free file delivery via an ARQ protocol, message return receipt acknowledgment and minimal operator intervention.

The BF e-mail system was intended for use in a half-duplex network configuration over HF ground-wave distances, but it will support skywave long-haul exchanges with proper frequency and data rate selection. System performance has been tested over VHF and UHF line-of-sight (LOS) channels, UHF DAMA satellite channels, cellular channels and land-line telephone connections. The basic shipboard system installation supports HF and UHF LOS channels. The system supports data rates up to 2400 bits per second (b/s) coded.

HF channel selection should be based on surface wave (ground wave) and Near Vertical Incidence Skywave (NVIS) propagation modes. These modes propagate most efficiently in the 2-10 MHz frequency range.

The basic operation of the BF e-mail system simply consists of preparing messages on a client PC using the Eudora® mail software program, transferring them to a server for transmission, and retrieving new mail from the server. The server acts as the HF equipment controller and electronic "mailbox" as it stores messages intended for off-ship delivery and receives messages delivered from other ships. The synchronous board provides the control signals required to key and unkey the transmitter and initiate modem and crypto synchronization preambles.

A6-2 System components

The levels of the ISO 7-layer model accommodating the various elements of this e-mail system are shown in Figure A6-1.

7	APPLICATION	Eudora Pro mailer
6	PRESENTATION	SMTP
5	SESSION	JNOS Session Mgr (multi-tasking)
4	TRANSPORT	TCP
3	NETWORK	IP
2	DATA LINK	AX.25 (HDLC)
1	PHYSICAL	MIL 110A modem

FIGURE A6-1
The ISO 7-layer model as it relates to BF e-mail

A6-2.1 Computer hardware

Variations of the systems computer configurations exist. Currently, the server and client PC's are Pentium 100 MHz PC's with 8 MB RAM and 1.44 MB 3-1/2" floppy drive. They each have an Ethernet board, two communications ports (COM 1 and 2) and one parallel port (LPT1). However, the server/client combined PC consists of a single 100 MHz Pentium "lunchbox" PC with 8-MB RAM, one synchronous board, two Ethernet boards, two communications ports (COM 1 and 2) and a parallel 1 (LPT1) port. The server and client Ethernet boards are connected via coaxial cable with the end points terminated with a 50-ohm terminator.

The server hosts a synchronous communications board for synchronous half-duplex exchanges and uses the two asynchronous communications ports for asynchronous full-duplex exchanges. Thus, it functions as the radio frequency (rf) equipment and gateway controller. The client is used to compose and retrieve e-mail messages.

a. Ethernet Board

(1) 3Com Ethernet boards and driver software are installed in the server and client PC's to allow the computers to communicate and share devices on the network.

(2) Server and client Ethernet boards are normally connected via RG-58 (Thinnet/10BASE2) 50-ohm coaxial cable using BNC connectors.

(3) If the LAN is extended and connected via coaxial cable (Thinnet), the total length of the LAN should not exceed 606 feet and a maximum of 30 client PC's. The end points on the LAN must also be terminated with a 50-ohm terminator.

b. Synchronous Board

(1) A printed circuit board installed on the server PC that provides the system's half-duplex communication functions.

(2) The synchronous board provides the control signals required to key and unkey the transmitter and initiate modem and crypto synchronization preambles.

(3) The synchronous board is connected to the level converter via an RS-232 cable.

A6-2.2 Peripheral equipment

a. Keyboard/Monitor A/B Switch, if installed.

Used to share a single keyboard and monitor between the client and server PC's. (Limited shipboard space is the main reason for sharing a single keyboard and monitor between the two PC's.)

b. Level Converter.

A black box RS-232 to MIL-STD-188-114 synchronous level converter is used for maintaining correct signal levels between the server's synchronous board's RS-232 port and the KG-84C's MIL-STD-188-114 "red" port.

- Provides the capability of a balanced interface to the KG-84C and/or KIV-7 crypto, which permits greater cable distances between the crypto and the server.
- The RS-232 port is configured as a data communications equipment (DCE) and the MIL-188 port is configured as a data terminal equipment (DTE).
- The level converter is usually connected to the KG-84C via the ship's "red" communication patch panel (except in cases of a dedicated KG-84C and/or KIV-7) and directly to the synchronous board, on the server PC.

A6-2.3 Cryptographic Equipment

Provides encryption/decryption for off-ship e-mail communications. Although TSEC/KG-84A and KIV 7 cryptos can be used to support BF e-mail operations, TSEC/KG-84C is the preferred crypto due to its HF synchronous mode and wide availability.

a. TSEC/KG-84C and/or KIV-7

(1) Provides data encryption for rf off-ship half-duplex e-mail communications via the server's synchronous board.

(2) Normally configured 2400 b/s simplex synchronous operation with external clocks.
(3) Uses the HF serial-tone modem's internal clock for timing.
(4) The KG-84C is usually connected to the HF serial-tone modem via the "black" communication patch panel and to the level converter via the "red" communication patch panel. The KIV-7 is connected directly to the HF serial-tone modem.

b. STU-III (Note: Not backward compatible with TSEC/KG-84C or KIV-7)
(1) Provides data encryption for off-ship e-mail communications via landline (telephone), SHF SATCOM, or Battle Group cellular channels.
(2) Configured for 1200-9600 b/s full-duplex asynchronous protocol, using the server's asynchronous serial communication port (COM 2).

A6-2.4 Modem

a. MIL-STD-188-110A HF Serial-Tone Modem
(1) The HF modems used for this effort are the Rockwell-Collins MDM-3001 stand-alone modem.
(2) These HF modems use coding and redundancy techniques that allow the receiving modem to recover the original data in the case of errors caused by hits and fading throughout the HF path.
(3) Provides forward error correction (FEC), bit redundancy, bit interleaving, and is capable of synchronous or asynchronous data transmission at speeds up to 4800 b/s (unencoded).
(4) Uses a phase-shift key (PSK) modulation scheme specifically designed for operation over HF transmission media.
(5) Provides the external clock for the system.
(6) The MDM-3001 HF serial-tone modem is connected to the radio(s) via the transmit and receive switchboards or the Black Analog Switch and to the crypto via the "black" communication patch panel.

b. STU-III modem.
(1) Capable of data rates of 1200-9600 b/s, full-duplex and asynchronous data.
(2) The STU-III modem's DTE port is connected to the server PC's COM 2 (asynchronous) port via a computer serial cable.

- Note: For details of configuration of equipment and software, see the Appendix, "E-mail via a Slip Connection," which is appended to *General Battle Force Electronic Mail System Manual, Ver. 1.0*, January 1997, prepared by Navy Command, Control, and Ocean Surveillance Center Research, Development, Test and Evaluation Division Terrestrial Link Implementation Branch, Code 846,San Diego,CA 92152-5000.

A6-2.5 Shipboard equipment used

a. Communication patch panels - provides circuit interconnections between the level converter, crypto, and HF serial-tone modem.
b. Crypto
c. Transmit and receive switchboards or the black analog switch - provides circuit interconnections between the HF serial-tone modem, transmitters, receivers, and remote equipment.
d. Transmitter and receiver
e. Antenna coupler and antenna
f. Loudspeaker - used for over-the-air (OTA) monitoring.

A6-2.6 Computer software

Common software used on both the server and client PC's and the Server/Client combined PC includes MS-DOS 6.22, Windows for Workgroups, and the 3COM Ethernet LAN Driver (3c5x9) software. MS-DOS is the Disk Operating System (DOS) that acts as an interface between the computer's hardware, the application program(s), and the user. Microsoft Windows for Workgroups is the user interface built on DOS that offers a Graphical User Interface (GUI) for application software. This allows for the use of icons and menus to perform tasks instead of complex commands. The 3COM Ethernet LAN Driver (3c5x9) software activates and controls the computer's network board. It also serves as the connection between the Client PC's application software and the network components.

A6-2.6.1 Unique server PC software

a. JNOS
(1) JNOS is a network operating system that runs on top of DOS and provides overall control and management of the network.
(2) JNOS is designed to operate the TCP/IP protocol stack over a variety of interfaces such as Ethernet, serial ports, and packet radio cards.
(3) It performs TCP/IP traffic management for the PC.
(4) It allows transfer of single PC mail (via Ethernet) or multi-station mail (via a LAN)
(5) It allows the computers attached to the local network to communicate with each other and to access remote host servers to communicate with its computers.

b. BERT.
This is a bit error ratio test (BERT) that runs on the server PC's N: drive and provides testing for:
- Checking through the crypto to the modem and back **(Modem Loopback)**
- Checking the circuit locally over-the-air by transmitting a BERT signal and then receiving the same BERT signal back on board via the ship's radio **(RF Loopback).**
- Checking circuit connectivity between ships/stations **(OTA BERT).**

A6-2.6.2 Unique client PC software

a. TCP/IP networking software.

(1) A program designed to interface Windows with network boards.

(2) Acts as a virtual packet driver wrapper which enables the packet drivers to function correctly within Windows by making sure that packets get directed to the correct network board.

(3) An Application Programming Interface (API) designed to let Windows applications (*i.e.,* Eudora Pro) run over a TCP/IP network.

(4) Facilitates the initial connection through dial-up scripts and then continues to manage the connection for other programs.

b. Eudora PRO by QUALCOMM.

(1) A Microsoft Windows menu-driven e-mail application.

(2) Used to create, modify, send, and receive e-mail messages.

(3) Provides the capability to attach text and binary files to e-mail messages, therefore allowing for text and imagery transfer throughout the net.

(4) Provides for message return-receipt (RR) acknowledgment (ACK).

- This function forces the remote client's server to acknowledge the received message by sending a receipt message back to the originator.

A6-3 BF e-mail addressing scheme

A6-3.1 Addressing scheme

Addressing is the means by which the originator or control station selects the unit to which it is going to send a message. Each ship/unit is assigned a unique Class C Internet Protocol (IP) address. IP addresses are 32-bit binary numbers that contain sufficient information to uniquely identify a network and a specific host on the network, *i.e.,* 205.253.70.1. The first 24 bits will always represent the network portion of the address and the final 8 bits will always represent the host portion of the address. Thus, "205.253.70" would be the Network Address and "1" would be the host on that network. An IP address is assigned to the server and a sub-address is assigned for the client(s) PC's on the ship's LAN.

Note: IP addresses and domain names must not be changed after installation unless the change is requested and coordinated by the ship's/units network manager.

A6-3.2 Server address

An assigned IP address and domain name that identifies a destination.

(1) IP address is a 32-bit, four-part number that uniquely identifies a machine on the network. For example, "205.253.70.1" could be the IP address for USS NAVY SHIP.

(2) Domain Name is an addressing scheme for associating numeric IP addresses into strings of word segments denoting user names and locations. All domain and user names must start with an alphabetic character (numerics are allowed within names). In the case of ships named for individuals, only the last name of the individual will be used. In the case of ships with multiple word names, a hyphen ("-") will replace all spaces between words. For submarines, hull type and number without a space or hyphen will be used. The unique server address name convention used with BF e-mail is associated with the name of the ship/unit. For example, "navy-ship.navy.mil" is the domain name associated with USS NAVY SHIP's IP address.

A6-3.3 Client address

An IP address and domain name associated with the host server's IP address.

(1) Client IP address consists of the first three parts of the host server's IP address, with the fourth part being modified to include an additional number to identify each client PC on that host server. For example, "205.253.70.11" is attached to host server IP address "205.253.70.1".

(2) Clients' sub-address name convention is the SMTP server's POP Account name mail@"shipname".navy.smil.mil. For example, "mail@navy-ship.navy.mil".

A6-3.4 User's address

a. The user address is the login name or user's name associated with the SMTP server's POP3 account. For example, "como@navy-ship.navy.mil".

(1) "Como" is the login name or user's name. Remember, all domain and user names must start with an alphabetic character (numerics are allowed within names).

(2) The @ symbol is the separator between user name or system name and commands domain name.

(3) "navy-ship" refers to the actual name of the command. The "-" (hyphen) symbol is used within all user and ship/mobile activity domain names instead of spaces. Spaces or blanks are not allowed in any part of the user/domain name. The underscore symbol "_" is also not permitted in domain names.

(4) The "." (dot or period) symbol is the separator between elements of the domain name.

(5) "navy" indicates the host computer's (server) domain name.

(6) "mil" indicates the type of organization (*i.e.*, mil, gov, edu, com) of the network.

b. While awaiting X.500 standard address guidance, it is recommended that user names be based upon existing Navy billet names or functions, *e.g.*, xo, ops, como, n00, n3 or cic, radio, flag.

A6-3.5 SMTP gateway

The BF e-mail server onboard the Flagship/Ground Unit Command Post can provide the small ships/unit's in the group with SHF e-mail connectivity to shore by using an existing domain name mail server (previously installed) which handles the SHF connection. The domain name mail server will determine if the message is for onboard LAN delivery or for transmission to a shore secure gateway over super high frequency (SHF) channels.

(1) Messages from ships/units in the battle group destined for shore/headquarters connectivity will be received by the respective BF e-mail server onboard the Flagship/Ground Unit's Command Post via HF or UHF channels and re-routed to the respective shore or unit's headquarter's domain name mail server via the shipboard/ground unit's LAN. The mail server will transmit the messages to the shore net gateway via SHF channels.

(2) Messages from shore/headquarter's destined for ships/units in the battle group will be received by the Flagship/Command Post via SHF and routed by the Flagship's/Command Post, respective domain name mail server. Mail for ships in the battle group will be re-routed to the Flagship's/Command Post's BF e-mail server via the shipboard/unit LAN. The BF e-mail server will, in turn, re-route the messages for transmission over HF or UHF channels to the appropriated ships/units.

(3) Messages from ships/units in the battle group destined for an embarked Flagship or unit command will be received by the BF e-mail server onboard the Flagship/Command Post via HF or UHF channels and re-routed to the domain name mail server via the shipboard/unit's LAN.

A6-4 Basic information flow

The user turns on the client PC, activates the Windows program, and selects the Eudora Pro application program. Once the Eudora Pro program is loaded, the user logs into the e-mail system by typing in the user's password. The password could be the pre-installed password or one supplied by the ship's/unit's LAN coordinator or Automated Data Processing (ADP) officer to meet the commands security requirements. At this point, the user can either create a new message or modify an existing message, send pending messages to the server, and/or check for incoming mail. Eudora provides the capability to attach text and binary files to e-mail messages, therefore allowing for text and imagery transfer throughout the system.

A6-4.1 Sending mail

To send mail, the user composes the message, addresses the message to its appropriate destination and then selects "Send". The message is sent to the server using the Simple Mail Transport Protocol (SMTP) via Ethernet boards that connect the server and client. Messages sent from the client will be stored on the server's hard disk and queued for delivery at a later time.

To send queued mail, the server raises the "Request To Send" (RTS) line on the RS-232 communications port provided by the PC's synchronous board. This keys the transmitter and initiates the modem synchronization preamble transmission. When the modem has completed this 0.6 second transmission, it the provides a "Clear-to-Send" (CTS) back to the crypto causing it to send its synchronization preamble. When the crypto has completed its preamble transmission, it passes the CTS to the server which in turn starts a connection attempt. At this point the server will call up the remote station server to whom the message is addressed. Once an acknowledgment is received, the server will start transmitting the message.

The message goes from the "mailbox" on the server, to the synchronous board, to the level converter, through the "red" communications patch panel (if used), to the KG-84C and/or KIV-7 crypto, through the "black" communications patch panel (if used) to the HF high-speed serial-tone modem. The modem's audio and keyline interface goes to the radio equipment (this connection is made via the Transmit/Receive switchboards or the Black Analog Switch). When the HF radio equipment is online, the server will call the distant station(s), handshake, connect, and start transmitting its mail. If a remote station does not answer, then the sending server will continue to the next station which it has mail for, and will attempt to make a connection. If that station does not respond either, then the server will move on to the next station. A server can receive calls from other stations while it is waiting for a particular remote station to reply.

Ship-to-ship e-mail transfers are performed as point-to-point exchanges. In order to avoid net interference, the server JNOS software monitors the "data carrier detect" (DCD) line provided by the modem. The modem detects transmissions from other units, and inhibits own-ship transmissions until the circuit is clear. This provides signal collision control so that any particular unit will not normally try to establish a link in the middle of an exchange between two other units. If a called unit does not respond, the server will retain the message in its memory and try again later.

A6-4.2 To Receive Mail from a Remote Server

Since the e-mail system operates on a single net frequency, all active units will listen in on e-mail exchanges between the servers on other ships.

Note: A ship's and/or unit's HF modem and KG-84C and/or KIV-7 crypto will synchronize to all incoming transmissions; however, its respective server will not respond to any call which does not include its unique IP address.

The ship's receiver will pick up the signal and interface directly to the HF modem's audio line (this connection is made via the Transmit/Receive switchboards or the black analog switch). The modem and crypto will synchronize to the incoming transmission, and pass it to the server. If the server recognizes its IP address, it will respond to the calling station with an acknowledgement that it is ready to receive mail addressed to it. once the calling server receives the acknowledgement, it will initiate a handshake, connect, and will start transmitting the mail. After the ship's server receives the transmission data, it will acknowledge receipt back to the sending party and will store the mail in its electronic "mailbox" for retrieval by the addressed user via the client.

A6-4.3 Checking for received mail

To receive mail on the client, the user selects "Check Mail" from the file menu on EudoraPro. The client will then link to the server and will retrieve the mail from the server's electronic "mailbox" using the Post Office Protocol 3 (POP3). The user will see a progress window showing the logging in to the server's POP account and retrieval of mail that it finds addressed to the user. The user will then see a message stating that there is new mail or a message stating, "Sorry, you don't have any mail."

A6-5 Testing and Test Results—Summary

In an NTIA report (Redding and McLean, in press, 1998), data are presented that characterize the performance of the subject HF E-mail system in a controlled environment using HF channel simulators. The objective of these tests by Redding and McLean were to evaluate E-mail throughput over degraded HF channels using the JNOS software and configurations similar to those used in the NraD implementation (*i.e.*, as TCP/IP settings, AX.25 card, and HF modem). HF propagation conditions were simulated through the use of a digital signal processor (DSP)-based Watterson model HF channel simulator using degraded conditions defined by the International Telecommunications Union Radiocommunications Sector (ITU-R) Recommendation F.520-2. In the course of testing, optimum settings and anomalies were reported as they affected performance.

There are many variable parameters in the HF e-mail system, but only a few variables were used so as to limit the testing to a reasonable length. Table 1 shows the parameters that were used. For all tests, the MSS, MTU, and compression were fixed while the window, maxwait, and IRTT were varied. Other variables were the HF modem data rate, e-mail attachment size, and channel simulator conditions. Several experimental changes to the MSS, MTU, window, and maxwait were also made to show their affect on the performance.

TABLE 6A-1

Parameters and associated conditions

Parameter	**Set of Conditions**
Channel Conditions	ITU-R Good[1] @ 0-15 dB SNR in 5 dB steps
	ITU-4 Poor[2] @0-25 dB SNR in 5 dB steps
Modem Data Rate	300 bps
	1200 bps
Modem Interleaver Length	0.6 s (short)
Attached Message size	1 kByte text file
	50 kByte text file
TCP/IP: MSS/MTU/Window	216/256/1024
	216/256/3072
TCP/IP maxwait	90 s for 300 bps, 360 s for 1200 bps

[1]ITU-4 Good channel consists of a multipath of 0.5 ms and a doppler spread (fading) of 0.1 Hz
[2]ITU-4 Poor channel consists of a multipath of 2 ms and a doppler spread (fading) of 1 Hz.

The configuration used for this test is shown in Figure A6-2. The JNOS software ran on a PC-compatible computer, which also interfaced to the AX.25 card. Output from the AX.25 card was fed into the HF modem, which was connected back-to-back with another modem via the simulator. The transmit audio paths passed through the independent paths of the simulator, and into the HF modem receive line. Radios were not used because the simulators operate at baseband.

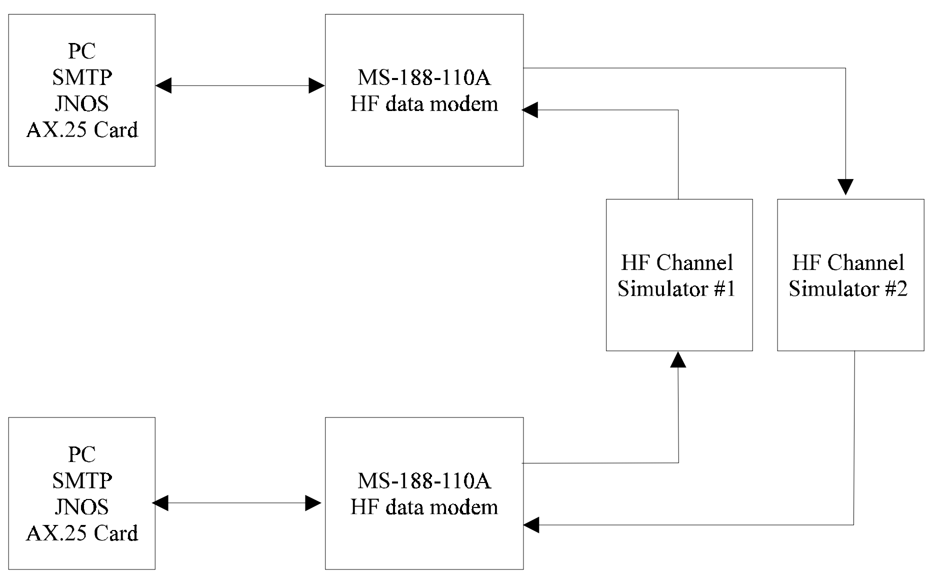


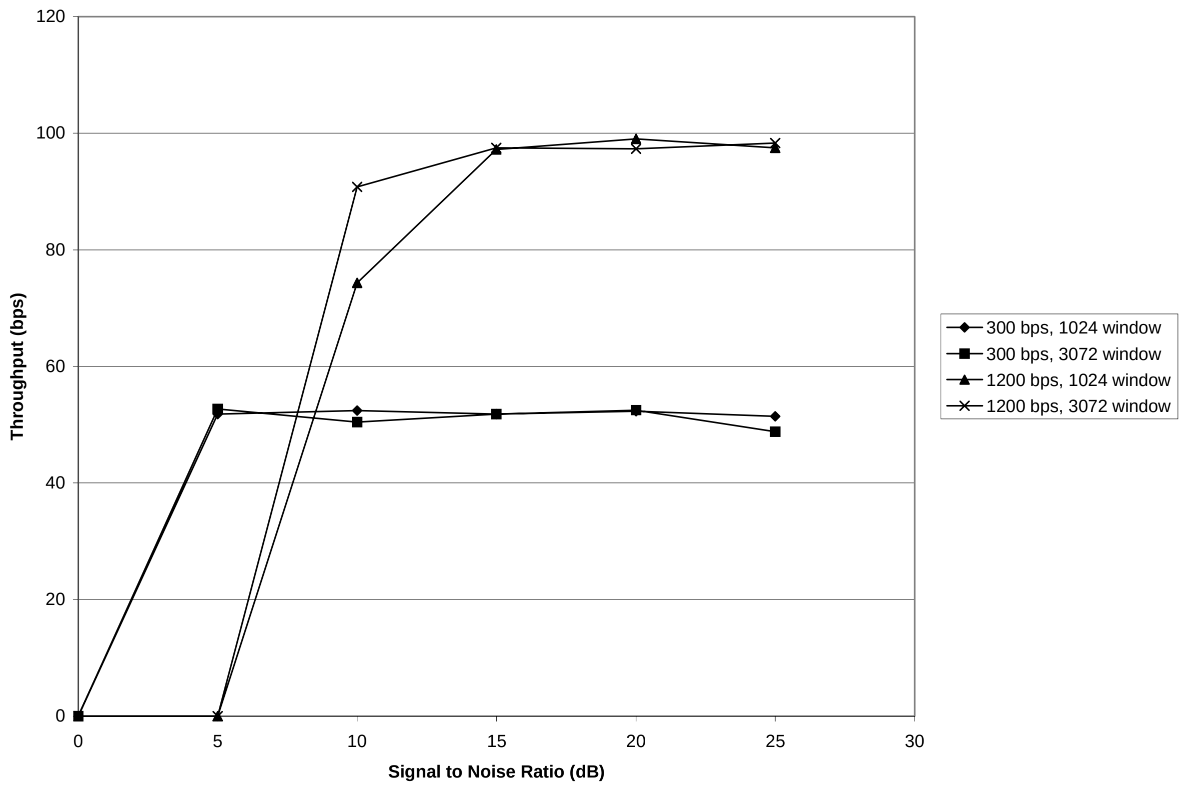
FIGURE A6-2

Configuration used for e-mail tests reported above

A6-5 Test Results

Plots of throughput versus channel conditions all exhibited the same type of pattern, notably: throughput increased from a minimum of 0 bps to a plateau. See Figures A6-3 through A6-6 for an illustration of this pattern. Depending on file size and modem data rate, the plateaus occurred at different maximum data rates and SNRs. Minor differences in throughput occurred as the window varied from 4 times the MTU to 12 times the MTU for a particular modem data rate, indicating that a larger window has no significant affect on performance. In the cases where there is a difference in throughput, the larger window almost always produced the better results. Contributing to the variances was the small number of trials performed.

FIGURE A6-3



Throughput vs. CCIR Good channel with short file attachment

It was observed that as the SNR decreased, a lower data rate was required to pass traffic, as shown by the 75 b/s test performed at 0 dB. This was expected since there is increased error correction coding applied at lower data rates. Conversely, higher modem data rates could be used as the channel SNR increased. This effect occurred with the 3 data rates that were used. The difference in maximum throughput between the 1200 and 2400 b/s data rates was not that significant, although optimization of the data rate should be made if the channel supports higher rates. The test results showed that throughput increased from a minimum of 0 b/s to a data-rate dependent plateau. The knee of the curve moves right, or occurs at a higher SNR, as the data rate increases. Optimization of the data rate versus channel SNR could be accomplished with an adaptive data-rate modem, such as the data link protocol specified in FED-STD-1052.

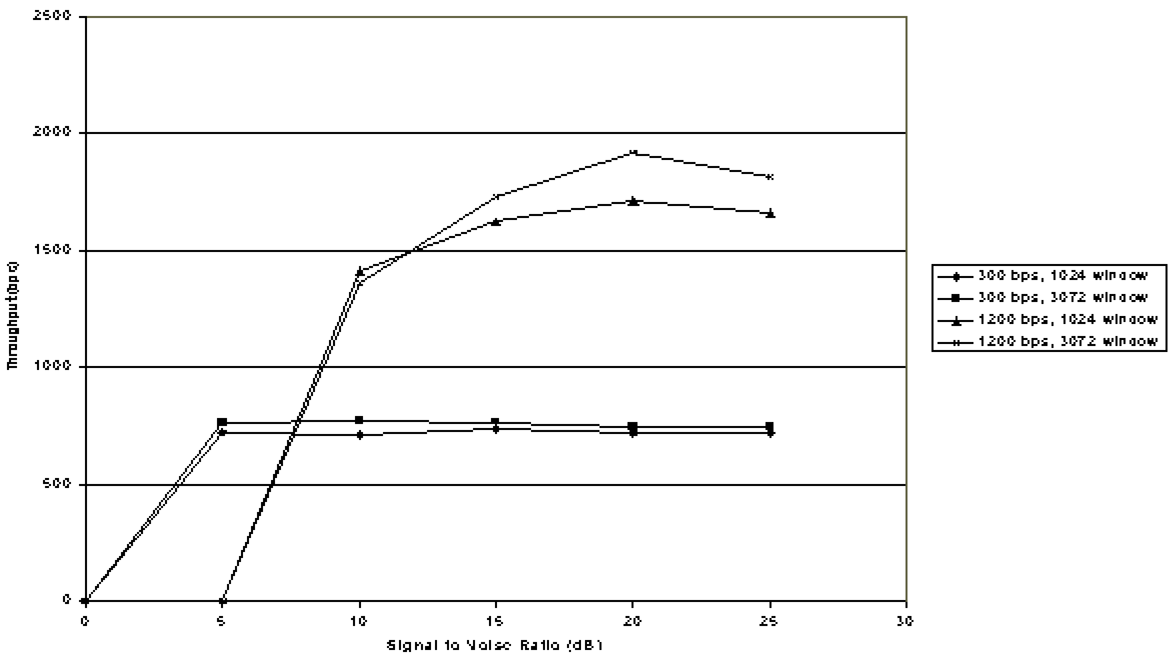


FIGURE A6-4
Throughput vs. CCIR Good channel with long file attachment

Another conclusion of the tests is that users should choose the compression method with regard to the processing power of their computers, since compression is performed in real time. The actual compression level used will be a result of a negotiation between the two stations involved in the transmission. Users should be aware that the JNOS documentation erroneously states that the compact compression is the default. To be sure that the compact compression is being used, autoexec.net should contain the statement "`lzw bits = 16`."

Other than the effect of compression, the tests showed the best performance occurred when a large file attachment was sent. There are two reasons for this result: 1) because the overhead is relatively constant, the ratio of message size to total transmission increases significantly; 2) with longer messages, the TCP window can be used more efficiently, which allows transmission up to the maximum window size before an acknowledgment is expected. Comparing the differences in throughput between the long files and the short files sent shows a 15 to 1 increase in throughput. Although this was not tested, mailers that support SMTP service extensions for command pipelining theoretically would increase throughput since short packets are combined and sent, reducing the number of link turnarounds.

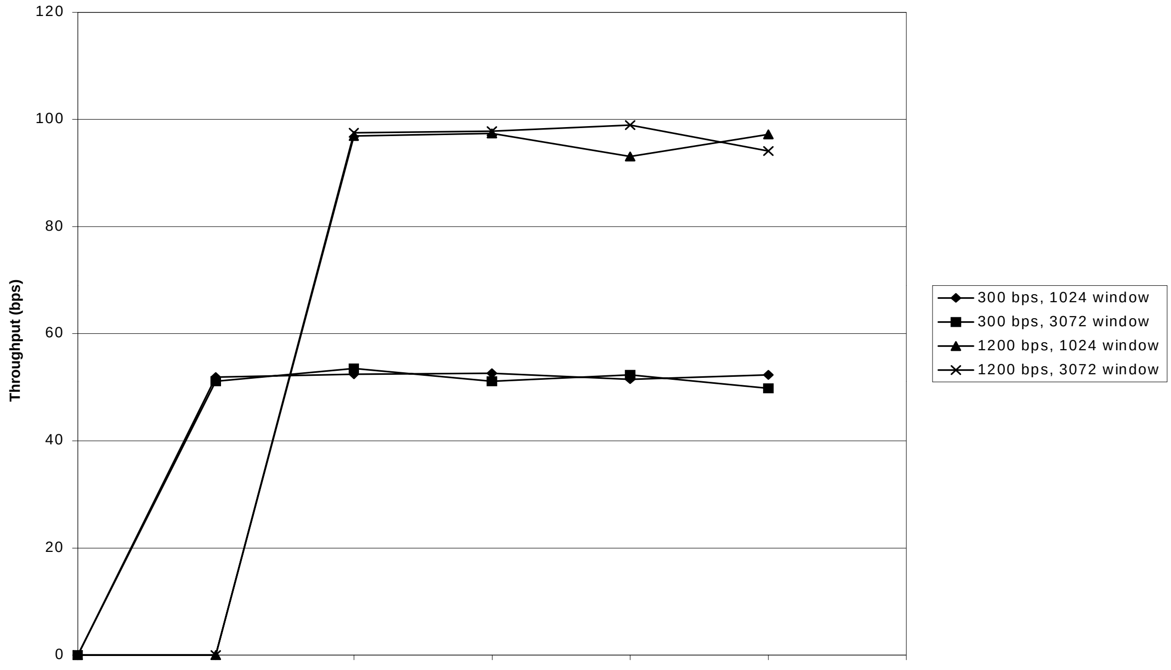


FIGURE A6-5

Throughput vs. CCIR Poor channel with short file attachment

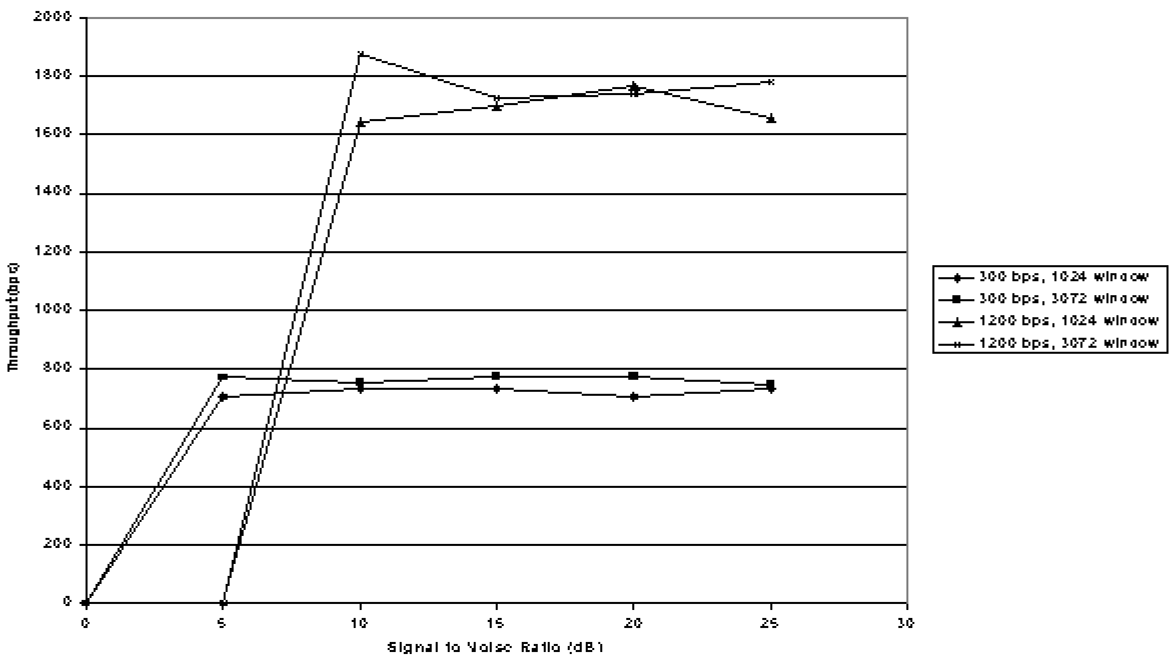


FIGURE A6-6

Throughput vs. CCIR Poor channel with long file attachment