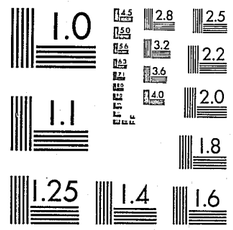

NALECOM FACSIMILE STUDY

15 December 1974

Prepared by

B. L. Goldstein
Section 338

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1.0 Introduction

The goals of this study are:

1. To identify digital facsimile hardware for use on the NALECOM message switching network, providing cost, performance and integration details.

2. To identify hardware cost and performance for alternative facsimile transmission medias and compare these costs with NALECOM costs.

3. Determine whether the NALECOM facsimile capability is cost effective with the present traffic estimates and, if not, indicate when a facsimile capability on NALECOM is cost effective.

NALECOM will be designed for message switching of formatted, segmented digital data using Binary Synchronous Communications (BSC) line protocol. Therefore, analog facsimile transmission is excluded. The NALECOM network will not provide storage of a digitized document image for transmission or reconstition. That function is reserved for the user.

Methods of transmitting digital facsimile over NALECOM will be proposed.

Alternate facsimile transmission either digital or analog (not via NALECOM) are examined insofar as they can provide law enforcement agencies with facsimile capability more advantageously than digital FAX via NALECOM.

A FAX hardware survey is presented to identify the equipment that the NALECOM network or alternates might employ. Examination of available equipment is necessary to develop cost and performance comparisons. Trends in facsimile equipment development and transmission techniques which can drastically change the practical application of facsimile, either of NALECOM's network or alternative networks are discussed.

2.0 NALECOM FAX Requirements

National Criminal Justice Telecommunication Requirements (NCJTR), JPL Document 1200-133A, predicts that by 1983 FAX communications will account for 4% of NALECOM's traffic. Total FAX traffic in 1983 is estimated as 7800 messages per year state-to-state, 3900 messages per year state-to-national and 3900 messages per year national-to-state.

FAX transmission is described as "criminalistics information" between crime laboratories having the form of 8 1/2 x 11 inch pages requiring approximately 300,000 characters or 2.4×10^6 bits.

NALECOM network requirements state that all messages shall be divided into 400 character segments. Transparent text mode is permitted over NALECOM so that useful equivalent graphic bit stream is close to 3,000 bits per segment. See NALECOM User Interface Guidelines JPL 1200-168, June 6, 1974.

Assuming the FAX documents are 8 1/2 x 11 inch, 300,000 characters per page, with equal horizontal and vertical resolution, 160 picture elements and lines per inch resolution are implied.

3.0 User Requirement Implications

3.1 Resolution

For comparison of the NALECOM resolution of 160 square elements per inch with requirements for various types of data the following table is given.

Description	Lines per inch
Line Drawings (like weather maps)	48 to 96
Regular typewritten letters	67 to 100
Medium density printed matter (books, magazines)	100 to 150
High density printed matter (telephone book)	200
Photos and Fingerprints	400
Newspaper half-tone photos	600

More information about the kinds of Law Enforcement documents to be sent via facsimile is neccessary in order to provide sufficient information for selection of FAX hardware.

As indicated by the table above, the resolution requirements for NALECOM are inadequate for reproducing higher detailed information, including fingerprints.

3.2 Transmission and Response Times

If a document image is transmitted as a continuous stream of digital data at 2.4 Kb/s it would take 1000 seconds (16.7 min) of transmission time. Transmission time may be reduced by transmitting at higher speeds or sending fewer bits by using data compression techniques. These methods require sophisticated and expensive equipment.

Table 8.1 of NCJTR lists a maximum response time delay of 8 hours for "users engaged in investigatory activity without personal contact." This response time is from the National Advisory Commission of Criminal Justice Standards and Goals (23 January 1973). NALECOM's goal for the same activity is 24 minutes (5% of the total). If facsimile only accounts for 4% of the total NALECOM traffic as projected, this response time goal can be met providing other messages of higher priority require minimal use of the transmission channel during a facsimile transmission. Because other NALECOM messages take higher priority, facsimile data must be capable of interruption and continuance on a low priority basis. Digital FAX equipment can provide signals in a form suitable for store and forward interruptible operation. Alternatively Digital FAX may be modified to stop and start in real time under program control. This implies additional programming requirements on computerized state terminals to control data flow. Each state terminal would be required to provide application programs that would perform the following functions:

1) Tag each FAX message.
2) Accept FAX HALT message from NALECOM.
3) Generate halt signals to source or destination FAX machine.
4) Check source and destination equipment for status. Special tag status messages to NALECOM.
5) Accept abort messages and stop FAX operation or accept "continue" messages and start FAX equipment accordingly.

4.0 Other FAX Requirements

4.1 Quality

The specifications of resolution is important, but is insufficient to describe the quality of a FAX copy. Other factors such as spot size, ability to vary spot size, geometry of the spot and darkness of the spot contribute to copy quality.

4.2 User Concurrence

4.2.1 Equipment

Digital FAX equipment compatible with NALECOM's network and compatible end to end would be needed. The ability to reach such concurrence or compatibility must be evaluated.

4.2.2 Procedures

NALECOM should be able to message switch (route) FAX documents automatically. Computer control would require appending to each document (or identifying separately) a computer readable addressing code. Presently FAX documents are routed over switched circuit paths set up through manual operator/telephone methods. Facsimile users would have to train their operators for new procedures over NALECOM if automatic routing is elected.

4.3 Growth Potential

It is possible that facsimile communications could take the place of mail. Local Law Enforcement use might include Polaroid pictures transmitted from patrol cars. I believe there are unidentified uses for facsimile that could significantly alter the low 1983 projections.

5.0 Facsimile Configuration for Compatibility with NALECOM

The hardware configuration proposed in this section will provide the capability for facsimile transmission per the requirements given in Section 2.0. These requirements are summarized again here:

1) Volume: 15,600 messages per year
2) Page Size: 8 1/2 x 11
3) Data Density: 2.4 million bits per page, equivalent to 160 lines per inch resolution suitable for medium density printed matter.

I have made some additional assumptions to permit reasonable comparisions of several nationwide network configurations that can provide facsimile for the law enforcement community.

1) Nalecom transmission facilities (leased lines) may be used on a low priority, no cost basis for FAX transmission.
2) Each state terminal will be furnished with compatible FAX equipment.
3) Networks using digital FAX techniques will employ 4.8 Kbps modems.
4) Because dial network costs are particularly sensitive to message volume (and time and distance) and because the actual requirement of less than 1 document per day per terminal is unrealistic, I have assumed a higher figure of 10 documents per day per terminal for those cases. Other dial network costs relating to distance and time of transmission are listed in related paragraphs.
5) Maintenance and Spare Parts will cost 5% of hardware purchase price/yr.
6) Operator costs are not included.

5.1 Off-Line Fax Preparation - Method 1 (See figure 1)

5.1.1 Equipment Required

1) Digital FAX equipment modifications may be required to provide a continuous bit stream to the local computer. The bit stream would include initializing conditions, graphical data, synchronizing information and terminating codes.
2) Computer (possibly microprocessor size) with core or solid state memory.[a]
3) 1 or 2 mag tape units.[a]
4) Operator console (keyboard/typer or TTY)a

5.1.2 Scenario

1) The source document is positioned by an operator on the Digital FAX machine.
2) The operator enters his identifying code via keyboard. The computer responds via typewriter and requests operator entry of address. Operator initiates FAX sequence.
3) The FAX document binary image is recorded on mag tape #1 as an unblocked record.
4) The computer reads the contiguous data from tape #1 or from the digital FAX and prepares transparent text messages of required length and Format for NALECOM as an object tape[b] on mag tape #2.

Steps 1 through 4 may be repeated for several documents.

5) The object tape is loaded into the compatible state terminal mag tape unit.[c]

6) The operator would initiate object data transmission via state terminal interface to NALECOM.
7) Receiving state terminal operator would take the recovered object tape and manually reload it onto FAX subsystem tape unit.
8) Operator would initiate tape to FAX operation which is automatic reformatting to binary image and transfer of control to digital FAX for reproduction.

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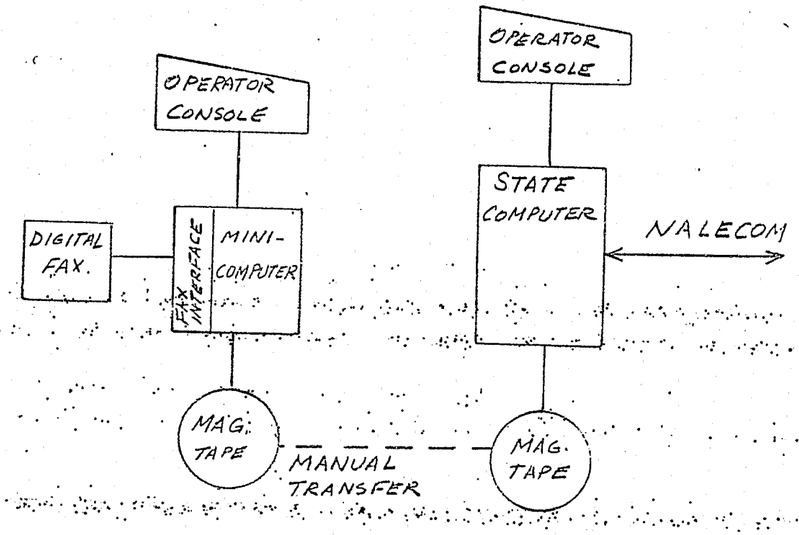
a. One or more of these functions may be performed using available equipment.

b. Producing a document image on tape may be necessary if direct processing to NALECOM format cannot be done in time.

c. If FAX subsystem is remote, object data may be accessed by the state computer using normal interrupt and communications techniques, bypassing steps 5 and 6.



TYPICAL STATE TERMINAL

Figure 1

Method 1 - Off Line FAX

5.1.3 Facsimile Configuration Method 1 - Costs

Hardware - per terminal estimate	Purchase Option: Purchase	Purchase Option: Maint./yr	Lease Option: Lease/mo	Lease Option: Maint./mo
Dedicated minicomputer	$ 5,000	$ 250	$ 150	$ 21
1 Mag tape with Controller	11,000	550	400	46
1 High Quality Digital Facsimile	12,000	600	550	50
1 Operator Console	1,200	60	50	5
Totals	$29,200	$1,460	$1,150	$122

Both Hardware interface and Software application program cost should be around $10,000. Assuming all 52 facsimile subsystems are identical, this amount is insignificant in relation to total costs when distributed over the system lifetime of 7 years.

Supplies - paper, toner, etc. = $100/mo
Installation and Checkout of hardware and software - one time cost per terminal = $4,000.

Method 1 - Per terminal summary

	Purchase Option: Purchase	Purchase Option: Maint./yr	Lease Option: Lease/mo	Lease Option: Maint./mo
Hardware	$29,200	$1,460	$1,150	$122
Supplies (7 years)	8,400	0	100	0
Installation and Checkout	4,000	0	50	0
Totals	$41,600	$1,460	$1,300	$122

Method 1 Facsimile Capability added to NALECOM

	Purchase Option: 7 yr Purch. + Maint.	Lease Option: 7 yr Lease + Maint.
52 terminals, 7 year system life	$2,163,200 P	$5,678,400 L
	531,440 M	531,440 M
	$2,694,640 Total	$6,209,840 Total

5.2 On Line FAX Method - Method 2

5.2.1 Equipment Required

1) Optical code typewriter used to create machine readable address data needed for automatic routing of FAX data.

2) Digital FAX transmitter (modified to read optical code preceeding text, plus ability to send or receive line at a time).

3) Local computer.

4) Disc buffer - temporary storage medium to hold FAX data when local computer is unable to process or transfer FAX data in real time.

5.2.2 Scenario

1) Source documents are appended with machine readable code of address, transmission speed and other set up parameters, using the optical coded typewriter.

2) Operator then loads source documents into FAX document loader.

3) Document is automatically scanned and binary data output to local computer.

4) Local computer converts to NALECOM format.

5) Local computer to State computer data transfer for supervised output via NALECOM. A minimum of one line of FAX data buffering is needed in the State computer to accommodate NALECOM system retransmission requirements.

6) Addressed state computer receives and transfers data in NALECOM format to local FAX's computer.

7) NALECOM to binary FAX code conversion.

8) Set up parameters decoded and FAX copy made.

9) Acknowledge or error message returned to origin for display.

TYPICAL STATE TERMINAL

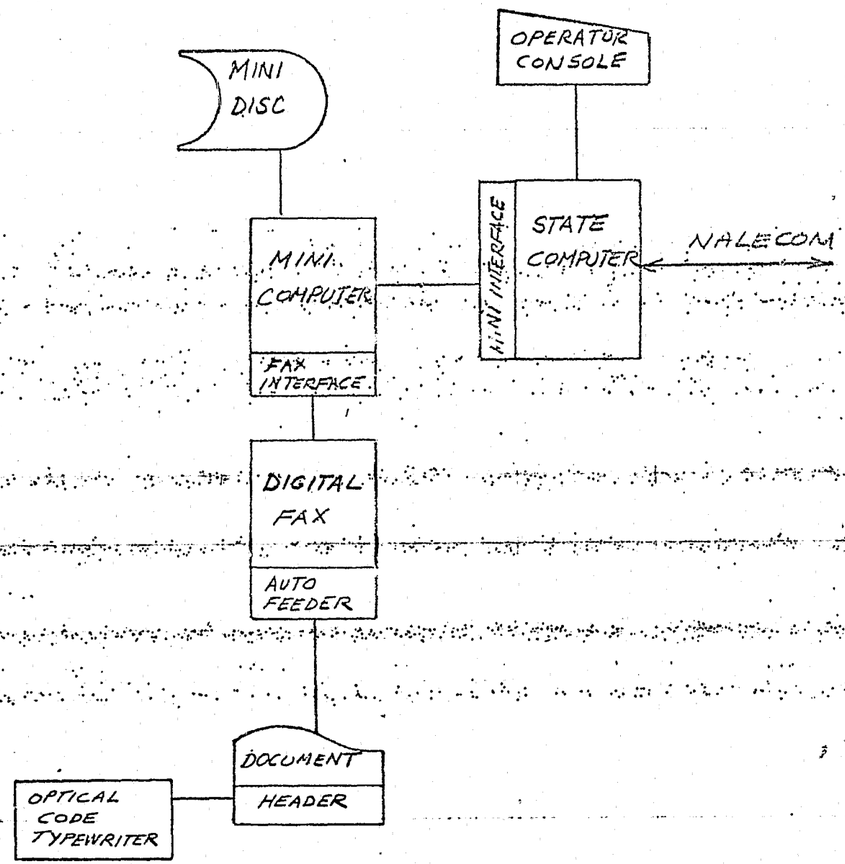


Figure 2

Method 2 - On Line FAX

5.2.3 Facsimile Configuration Method 2 - Costs

Hardware	Purchase Option Purchase	Purchase Option Maint./yr	Lease Option Lease/mo	Lease Option Maint./mo
Optical character typewriter	$ 400	$ 20	$ 15	$ 2
Dedicated Minicomputer	5,000	250	150	21
High Quality Digital Facsimile Transceiver	12,000	600	550	50
Operator's Console (keyboard/typewriter)	1,200	60	50	5
Mini Disc	2,000	100	75	8
Totals	$20,600	$1,030	$840	$86

Hardware interface costs:
Same comment as in Method 1.

Hardware maintenance and spare parts @ 5% of Purchase Price.

Hardware installation and checkout - one time cost = $2,000/terminal.

Supplies - paper, toner, etc. = $100/mo

Software Applications programs to control and buffer Facsimile equipment plus interface with state computer are required. The state computer programs would also require modification to communicate with the FAX dedicated minicomputer. Because state computers may be different, each interface must be considered a separate task. I will assume a 6 man month effort at a cost per state of $10,000.

Method 2 - per terminal summary

	Purchase Option Purchase	Purchase Option Maint./yr	Lease Option Lease/mo	Lease Option Maint./mo
Hardware	$20,600	$1,030	$ 840	$86
Installation and Checkout	2,000	0	25	0
Supplies	8,400	0	100	0
Software	10,000		120	0
Totals	$41,000	$1,030	$1,085	$86

Method 2 Facsimile Capability added to NALECOM

	Purchase Option 7 yr Purch. + Maint.	Lease Option 7 yr Lease + Maint.
52 terminals, 7 year system life	$2,132,000 P	$4,739,280 L
	374,920 M	374,920 M
Totals	$2,506,920	$5,114,200

5.3 Method 3 - Independent Overlay Digital Facsimile Network

5.3.1 Description: 5 Region Multidrop Network - See Figure 3.

Five regions were selected to balance and limit the traffic to a manageable flow within each region. The regions would be adjusted from the hypothesized 5 region NALECOM network to limit the number of terminals in a loop to a reasonable number using polling techniques. Each regional loop can handle up to 500 pages per day. Interregional FAX traffic will be handled using additional regional Facsimile equipment whose master controller is arbitrarily located in Washington. This network is completely independent of the NALECOM network, but could function as an alternative or fallback to NALECOM. The approximate cost of the configuration is the sum of the following:

	Purchase Option			Lease Option	
	Purchase	Maint./yr	Lease/mo	Lease/mo	Maint./mo
Line cost - 13,715 mi @ 54¢/mi/mo			$7,400	$ 7,400	
60 Service Terminals @ $40/ terminal/mo			2,400	2,400	
60 - 4.8 Kb Modems @ $125/ modem/mo or @ $4,800 P	$ 288,000			7,500	
5 FAX Controllers @ $300/ mo L or @ $8,000 P	40,000	$ 2,000		1,500	$ 168
60 FAX Transceivers @ $500 L or @ $12,000 P	720,000	36,000		30,000	3,000
Supplies @ $100/transceiver	6,000			6,000	
Totals	$1,054,000	$38,000/yr	$9,800/mo	$54,000	$3,168

7 yr System Lifetime	Purchase Option	Lease Option
Purchase	$1,054,000	$ 0
7 yr maintenance	266,000	266,000
7 yr lease	823,200	4,603,200
Total	$1,402,300	$4,869,200

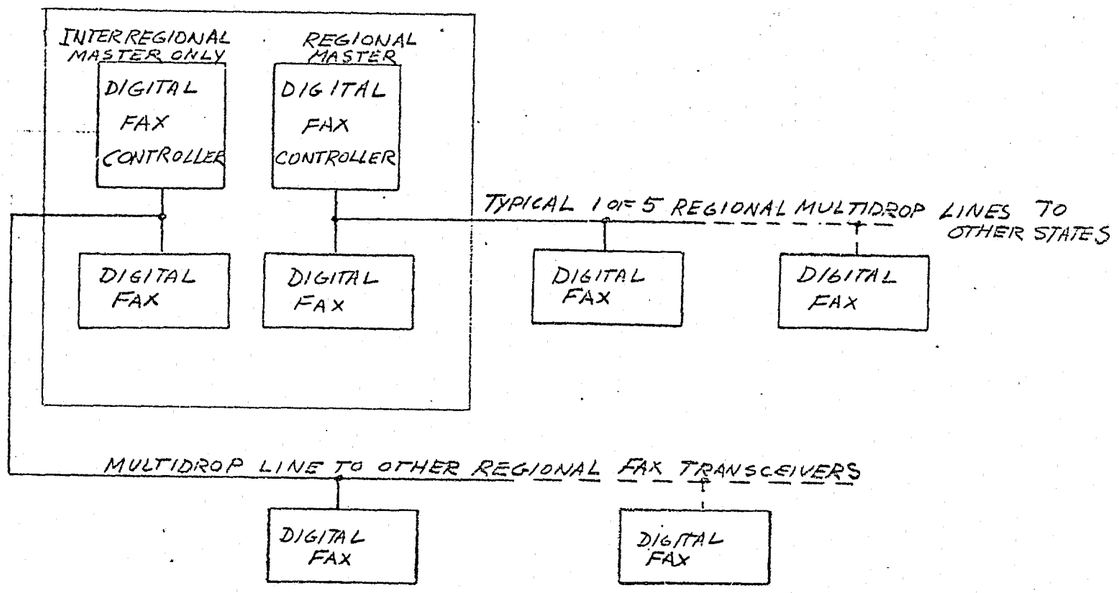


Figure 3

Method 3 - Regional Multidrop Network

5.4 Method 4 - Direct Distance Dial Network - See Figure 4

5.4.1 Digital Transmissions - Method 4A

Equipment and Services Required

Digital Facsimile Equipment
External modem
Dial equipment

Scenario is typical of operator initiated calls and automatic answer equipment, and no further description is considered necessary.

5.4.1.1 Assumptions

Long distance telephone toll charges depend on connect time and distance as tables below show. The most unpredictable factor is the volume of traffic involved.

1) 10 documents per day = 300 documents per month, per terminal.
2) Average document will require moderate resolution (ie. handshake, send and terminal time will be around 2 minutes).
3) Average distance sent between 676 and 925 miles.
4) Average toll cost per call is 70¢ (3 minute minimum).
5) Paper cost is 5¢ per copy.
6) Purchased equipment maintenance cost is 5% of original price per year.

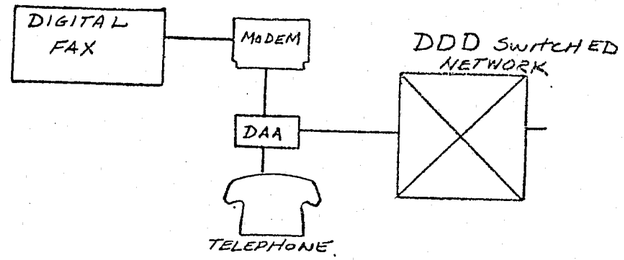
5.4.1.2 Equipment and Service Costs per terminal.

	Purchase Option			Lease Option	
	Purchase	Maint./yr	Lease/mo	Lease/mo	Maint./mo
High Quality Digital Facsimile	$12,000	$600		$550.	$50
Measured Business Line			$ 7.50	7.50	
4.8K modem	4,600	230		125.	
Data Access Arrangement			5.00	5.00	
Interstate toll charges and supplies			225.00	225.00	
Totals	$16,600	$830/yr	$237.50/mo	$912.50	$50

Transmission (toll) cost per terminal per month with assumptions above is [300 documents/mo(.70/toll call + .05/paper] = $225.

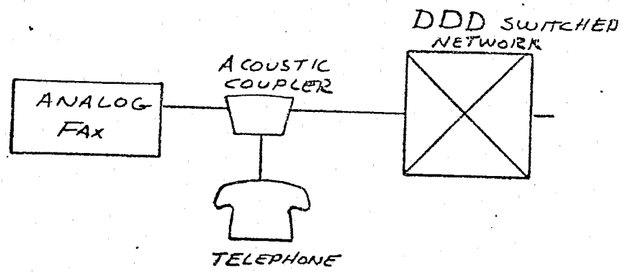
Method 4A DDD Network-Digital Equipment

52 terminals, 7 year life system		Purchase Option	Lease Option
Purchase		$ 863,200	
7 yr Maintenance		302,120	$ 218,400
7 yr Lease		1,037,720	3,985,200
	Totals	$2,203,040	$4,204,200



TYPICAL TERMINAL

Method 4A - Digital Dial



TYPICAL TERMINAL

Method 4B - Analog Dial

Figure 4 - Method 4
Direct Distance Dial Network

5.4.2 Analog Transmissions

Analog equipment capable of sending and receiving documents whose quality is comparable to digital equipment and at rates comparable to digital equipment speeds has not been identified. However Analog Facsimile Equipment transmission facilities are available which can meet the same requirements and assumptions given in Section 5.4.1, except for speed.

Equipment and Service Costs per terminal

	Purchase Option			Lease Option	
	Purchase	Maint./yr	Lease/mo	Lease/mo	Maint./mo
Moderate quality Analog equipment	$6,000	$300		$150.	$25
Data Access Arrangement			$ 5.	5.	
Measured Business Line			7.50	7.50	
Interstate toll charges and supplies			525.	525.	
	$6,000	$300	$537.50	$687.50**	$25

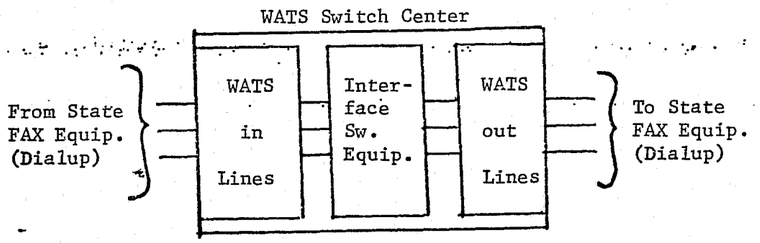
** Interstate toll costs per terminal per month calculation:

300 Doc/mo(1.70 avg. toll cost/doc + .05 paper cost/transmission) = $525.

Method 4B DDD Network - Analog Equipment

52 terminals, 7 year life system	Purchase Option	Lease Option
Purchase	$ 312,000	
7 yr lease	2,347,800	$3,003,000
7 yr maintenance	109,200	109,200
Totals	$2,769,000	$3,112,200

5.5 Method 5 - WATS FAX Switcher



A pair of interstate inbound and outbound FAX lines (to and from) the WATS Switching Center will cost approximately $3,400/month for up to 240 hours useage. The requirements from Section 2.0 are easily met. It is necessary to add about 2 more minutes of transmission time per document for handling

at the interface of the WATS Switching Center. Because each document now requires 4 minutes of WATS time and because one can expect some other inefficiencies, we can expect to handle about 12 documents per hour on each pair of WATS lines. At least 2 sets of WATS lines would be needed and preferably 3 sets (to reduce the queueing time for randomly arriving FAX messages). This system may be expanded to accomodate up to 12 pair of WATS lines. The approximate cost for such a system would be as follows:

	Purchase Option			Lease Option	
7 year Lifetime	Purchase	Maint/7 yr	Lease/7 yr	Lease/7 yr	Maint./7 yr
Equipment (same as Method 4A)	$863,200	$302,120		$3,003,000	$ 302,120
WATS costs: 6 full period lines			$856,800	856,800	
Manual/Automatic Switchboard	35,000			60,000	
	$898,200	$302,120	$856,800	$3,919,800	$ 302,120

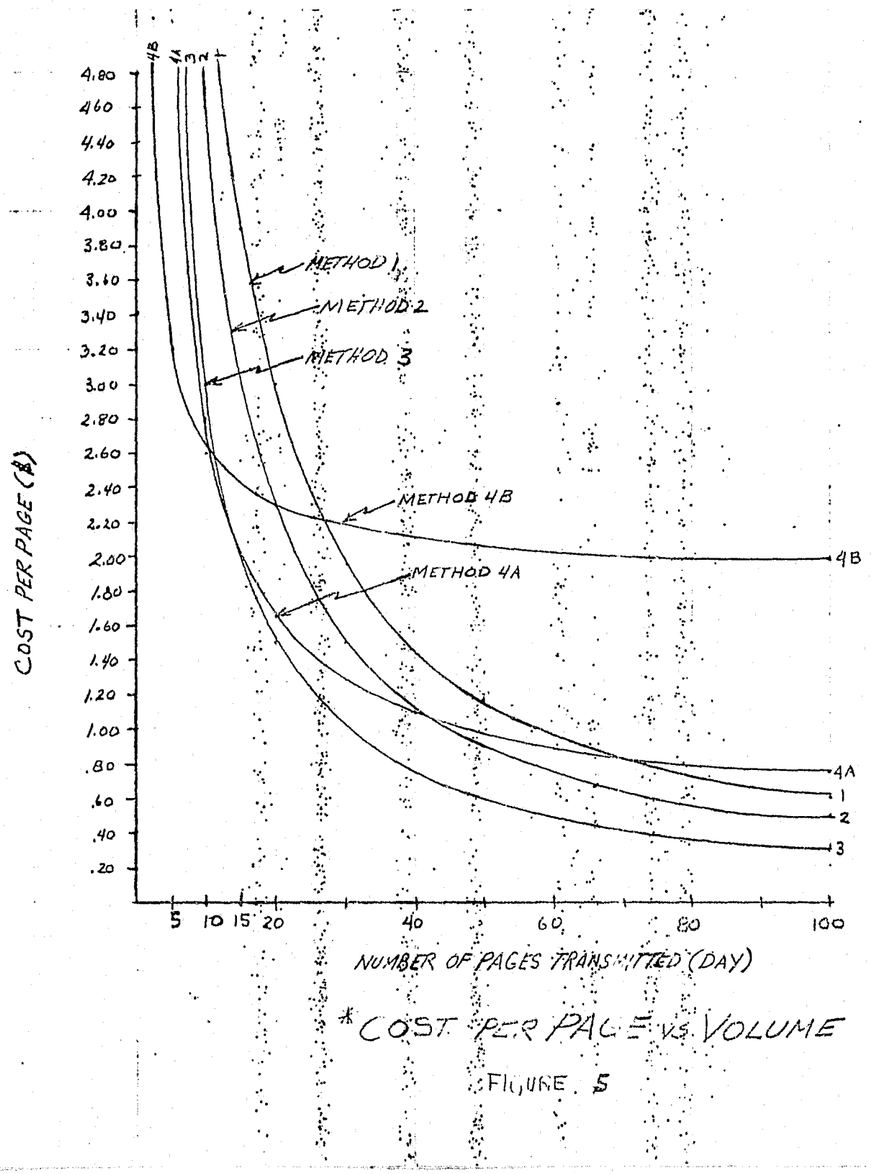
	Purchase Option	Lease Option
7 Year Totals	$2,057,120	$4,221,920

5.6 Comparison of Facsimile Methods

Excluding other factors such as cost of money, operators and power, a cost summary of the configurations considered for a 7 year operation is shown in Table 1 below:

Method	General Description	7 yr Purchase + Lease as Required + Maintenance	7 yr Lease + Maintenance
1	Off-line Digital	$2,700,000	$6,210,000
2	On-line Digital	$2,500,000	$5,114,200
3	Independent Reg. Overlay-Digital	$1,400,000	$4,870,000
4	DDD Network		
	A) Digital Equipment	$2,200,000	$4,050,000
	B) Analog Equipment	$2,770,000	$3,110,000
5	WATS Switching Center	$2,060,000	$4,220,000
Other			
Graphnet	(Digital FAX Equipment)	$3,000,000	$5,140,000
Graphnet	(Analog FAX Equipment)	$5,925,000	$6,179,000

Table 1



METHOD 1 - OFFLINE DIGITAL - NALECOM
METHOD 2 - ON LINE DIGITAL - NALECOM
METHOD 3 - REGIONAL OVERLAY - DIGITAL
METHOD 4A - DIGITAL DIAL - OVERLAY
METHOD 4B ANALOG DIAL - OVERLAY

*ASSUMPTIONS INCLUDE MEDIUM RESOLUTION PAGE, 4 MINUTE ANALOG WITH 1 MINUTE OVERHEAD, 1 MINUTE DIGITAL TRANSMISSION, AVERAGE DAILY TELEPHONE TOLL RATES, PRO RATA EQUIPMENT COSTS, NO LABOR COST ALLOWANCE, AND 10 YEAR LIFETIME.

*COST PER PAGE VS VOLUME

FIGURE 5

Because factors other than cost enter into network selection, candidate networks are rated in Table 2 using a subjective weighting method. Weighting factors and weights are my choice and may be challenged. The higher the total, the more desireable the method.

Method	Lowest Cost	Simplicity	Flexibility/ Expansibility	Security & Controllability	Total
	Max. 50	Max. 20	Max. 20	Max. 10	Max. 100
1	30	5	5	7	47
2	30	3	5	7	45
3	50	10	5	4	69
4A	35	20	20	5	80
4B	30	20	20	5	75
5	40	18	18	5	81
Graphnet A	20	15	10	0	45
Graphnet B	0	15	10	0	25

Table 2

Table 2 Characteristics Described

- Lowest Cost - This factor considers purchase and maintenance costs of equipment and transmission facilities.
- Simplicity - This factor considers the ease of implementing, integrating with other facilities, and educating personnel how to use the facsimile equipment.
- Flexibility and Expansibility - This factor rates the ease of carrying more messages with any additional costs required to add more equipment or transmission facilities.
- Security and Controllability - This factor considers costs of physical security and logical security to ensure proper message delivery. Network control includes ease of administration and regulation.

6.0 Digital Facsimile Networks

Facsimile communication is experiencing rapid growth in applications and equipment variety. Consequently digital facsimile networks or digital networks that will add digital facsimile capability are in various stages of development. Four such networks are described below.

6.1 AUTODIN

This is a Department of Defense digital network operating at 2400 bps, employing computerized message switching store and forward of packetized data. Character code is ASCII and protocols are similar to those proposed for NALECOM. Facsimile transmission over AUTODIN is in the test stage at the Army Electronic Proving Ground in Fort Huachuca, Arizona, and is expected to be implemented in 1 or 2 years. See IOM 3385-74-130 from B. Goldstein.

6.2 Graphnet Systems, Inc.

This is a new communication common carrier authorized to establish a nationwide packet switched store and forward facsimile and data communications network. Subscribers will be charged for connect time. They plan to permit any FAX machine to communicate with any other regardless of type.. However the service, which is scheduled to begin in December, will be limited to 4 and 6 minute type machines. The Graphnet system concept is an alternative means of providing Law Enforcement agencies with Nationwide Facsimile Capability while overcoming disadvantages such as low volume, heterogenous FAX equipment and high FAX network implementation costs..

Using Graphnet's tariff below, and assumptions given for Method 4B, an approximate equivalent cost using Graphnet's system is also shown.

On July 12th, Graphnet filed its Tariff with an effective date of September 12, 1974. The Tariff covers those services which Graphnet will offer as a first step toward the implementation of the overall network which the FCC authorized. It is anticipated that these rates will decrease once the network is in full operation.

SUBSCRIBER OUTPUT DELIVERY OPTIONS
INFORMATION IS DELIVERED ON A STORE AND FORWARD BASIS BY THE GRAPHNET SYSTEM TO A:

FACSIMILE DEVICE

	7 am - 7:59 pm		8 pm - 6:59 am	
	15 Mins.	2 Hrs.	15 Mins.	2 Hrs.
SERVICE CLASS	1A	1B	2A	2B
PER MINUTE	$ .75	$ .55	$ .45	$.25
MINIMUM CHARGE	$1.50	$1.10	$1.35	$.75

	Purchase	Lease
Equipment (same as Method 4B)	$ 312,000	$ 556,920
Equipment Maintenance (same as Method 4B)	109,200	109,200
Lease (Graphnet Toll) Transmission Costs	5,503,680	5,503,680
	$5,924,880	$6,169,800

1,310,400 documents/7 yrs @ avg. 60¢/min x 7 min = $5,503,680

OR

Using Method 4A with Graphnet facilities:	Purchase	Lease
Equipment (same as Method 4A)	$ 863,200	$3,003,000
Maintenance (same as Method 4A)	302,120	302,120
Graphent toll transmission costs (1,310,400 documents x $1.40 avg minimum charge)	1,834,560	1,834,560
	$2,999,880	$5,139,680

6.3 FTS Digital FAX

The Federal Telecommunications System will have a digital facsimile network in operation by November, 1974. It will interconnect their 10 regional offices by way of dedicated unconditioned voice grade lines. A Dacom 430 system FAX with a 610 FAX controller located in Washington which polls and addresses the terminals will be used. Terminals are connected on multipoint lines and operate at 4800 bps. The FTS dial system will serve as a backup. The system also has the capability of broadcasting a document to any number of terminals. Documents will primarily be interregional messages in original form that were sent over teletype before. Plans are to operate this system 19 hours a day. After a 6 month test period the system, if successful, might be expanded to include other locations.

6.4 IRS Digital Facsimile

Since April, 1974 the Internal Revenue Service has been testing a Dacom 430 FAX with 610 controller located in Washington. Seven regional IRS offices are tied on a multiport C2 conditioned line provided by GSA. Data is transmitted at a 4800 bps rate. There is no dial backup capability and the system is used during the business day to transmit mainly typewritten form informations. They had hoped to use facsimile to replace TTY transmissions and employ store and forward techniques in the future. Copy quality is not as good as they would like, so they are looking at other equipment for possible improvement at the end of the lease period.

7.0 Facsimile Trends

Facsimile equipment is in a transitional state. The most popular equipment is inexpensive business oriented analog equipment of the 4 to 6 minute variety whose copy quality is adequate for low and medium density documents. The direction which this equipment development appears to be taking is to continue using the DDD network as the principal transmission medium more efficiently by employing compression techniques, thereby shortening the transmission time to between 15 seconds and 2 minutes for low and medium density documents. Lower cost digital transmission facilities will soon be available from A T & T in the form of Digital Data Service and Graphnet's computer switched network. These digital facilities will match the digital FAX equipment trend. Xerox, who holds about 60% of this market, will probably introduce speedier equipment in 1975. Although it will probably be priced somewhat higher, the increased thruput and convenience of faster copy should set the pattern for competitors who will probably make compatible equipment available later in the year.

Data compression technology will likely employ digital techniques similar to those used by Rapifax, Dacom and Electronic Associates, Inc. These machines were designed, however, for a more specialized facsimile market that could afford the much higher prices in exchange for speedy transmission of volume traffic. Those original digital FAX manufacturers will probably direct their efforts toward producing even higher quality copy at 15 seconds to 2 minute speeds capable of efficiently using private networks or high speed common carrier channels. Law enforcement agencies, like the business community, will find applications for low, medium and high quality facsimile. It is unlikely that any single manufacturer's model of equipment will fill all requirements, since agency (state and federal) traffic volumes will range to both extremes. By 1976 one can expect optional compatibility between business oriented digital equipment and digital specialized equipment when operated at speeds up to 4800 bps. This will encourage the use of facsimile over NALECOM digital network.

Other trends are toward more unattended operation, use of "plain paper" and ability to use one's facsimile equipment locally as an office copier. This last mentioned trend would also encourage integration with NALECOM.

8.0 Relationship of Methods Proposed and NALECOM

The NALECOM network is being designed with voice grade leased lines meant to carry short interactive messages. Methods 1 and 2 propose using NALECOM network on a fill-in basis. As long as the FAX traffic volume is low, all is well. Even a small increase in FAX traffic, however, can tax NALECOM's ability to transmit more FAX messages. This is mainly due to the fact that each FAX message requires at least an order of magnitude more bits than ordinary NALECOM messages.

Law enforcement useage of facsimile could mushroom, much like the copy industry' introduction of Xerox Copiers caused business and industry copy to multiply. If this should happen, Method 1 and 2 might not be able to handle it.

Methods 3, 4A and 4B would not use NALECOM transmission facilities, but would be colocated and require NALECOM personnel to run them. Method 3 Facsimile thruput is highly dependent upon traffic volume and document types. Each region could probably handle up to 500 documents per day before saturation. Expansion by Method 3 would require a large expenditure with subsequent predictable saturation. Methods 4A and B utilizing the dial network are more attractive in terms of flexibility since bottlenecks can be releived simply by adding terminals.

Method 5 is almost as flexible, but takes advantage of lower dial network costs of WATS. It is possible that the added switching required might degrade the speed of transmission which in turn would result in less document thruput and higher cost.

The Graphnet System has no track record. High cost and lack of security appear to rule out use of this commercial network.

Another alternative method should be mentioned: the U. S. Mail. A letter can be sent via U. S. Postal Air Mail for 13¢. As you can see, this is still the cheapest way to send copies anywhere.

9.0 Conclusion

Digital facsimile hardware suitable for useage on the NALECOM message switching network is identified in Table I. At this time there are only a few digital manufacturers whose equipment appears to meet NALECOM's vague requirements. NALECOM requirements need expansion to allow a proper selection of FAX equipment.

Considerable further study of FAX requirements is needed to define: 1) which terminals want FAX, 2) what type of documents are transmitted, 3) what degree of copy quality is required, 4) what number of documents each terminal sends, 5) what response (copy speed) is required and 6) what degree of operator assistance is tolerable.

Other alternative networks for facsimile transmission were compared with FAX via NALECOM's network for cost and performance. These comparisons indicate the following:

- Implementation of a facsimile network to accomodate 1983 traffic projections and requirements will cost between 1.5 and 6 million dollars (ignoring inflation, cost of money and personnel costs) depending on lease or buy.

- Adding facsimile capability to NALECOM's system would not be cost effective (compared to other methods) unless FAX traffic increased by at least 5 times over 1983 projections.

- On balance, for 1 to 3 copies per terminal per day FAX over dial-up facilities appears best.

- Technological trends are toward faster copies - 2 to 4 times the number of copies presently made in a given time. Equipment costs are not likely to decline for medium and high resolution FAX equipment. This means that even in the future, low FAX traffic volumes still will not make FAX over NALECOM's system cost effective.

- If resolution requirements were reduced to 96 lpi rather than 160 lpi, a much larger selection of low priced FAX equipment becomes available. The combination of lower equipment cost and faster copies enhance the use of FAX equipment over both dial and leased line facilities. But unless law enforcement FAX traffic increases significantly the ease and convenience of using dial facilities outweighs the cost benefits of FAX sharing NALECOM facilities.

- Last, but not least, one should compare the convenience and cost of obtaining copies via facsimile with the low cost, but longer delivery time system, of the U. S. Mail. The key word is "convenience" and only the reader can place a value on its worth.

Table 3

DIGITAL FACSIMILE HARDWARE* COST/PERFORMANCE DATA

MFG & Model	Transmission Rate Kb/s	Line Cond.	Max Doc. Size W" x L"	Resolution (1) Vert.	Horz.	Transmission Time (1)(2)(3)	Transmit Bed Doc Moves	Transmit Bed Doc Static	Special Printer Paper	Wt Lbs	Dimensions H W D	$Purch./ Lease/mo.
Dacom 400 Series	4.8/2.4	--	8 1/2 x 14	67	200	1 1/2 to 2 min						$13,000 to $15,000] $475-550]
				100	200	50 - 60 sec	✓		✓	375	39x25x33	
				200	200	35 - 45 sec						
	Model 410 - Data scrambler with 7×10^9 selectable encryption code selections.											
	Model 412 - Militarized version of 410 with use of externally interfailed modem up to 19.2 Kb/s.											
	Model 430 - No encryption. Has selective address and polling electronics.											
	Model 450 - Controlable from a local computer. Optional keyboard data entry.											
	Model 441 - Has higher vertical resolution (400 Lpi). Horizontal res. same. Questionable acceptability for fingerprint quality.											
Rapifax 100	Same specifications as Dacom 400 series above except:										42x ?x ?	$15,000] $350]
EAI FAX I Series	9.6/4.8/2.4	C2@9.6	9 1/2 x 14	96	125	1 1/2 min	✓		✓	250	43x36x21	$9,800 to $11,300] $300]
	9.6			128	187	30 sec						
	4.8			192	249	15 sec						
	Model 60 modem req. is 2.4 Kb Model 30 modem req. is 4.8 Model 15 modem req. is 9.6 (2 conditioned) } Only 2 resolution choices per model available and one must be the lowest indicated. Also transmission time for Model 60 ranges from 1 minute to 7 minutes and for Model 30 from 30 seconds to 3 1/2 minutes.											
Litton Datalog Model DIGIFAX	9.6		8 1/2 x 11	96	?	3 1/2 min		?		?	?	?

DIGITAL FACSIMILE HARDWARE* COST/PERFORMANCE DATA cont.

MFG & Model	Transmission Rate Kb/s	Line Cond.	Max Doc. Size W" x L"	Resolution① Vert.	Horz.	Transmission Time ①②③	Transmit Bed Doc Moves	Doc Static	Special Printer Paper	Wt Lbs	Dimensions H W D	$Purch./ Lease/mo.
Alden 11" Digital	4.8		11 x cont.	96	-	1 to 1 1/2 min	✓		✓	300	50x30x21	$600 L
Dest Data Model OCR/FAX	2.4 - 9.6		8 1/2 x 11	120	120	15 sec		✓	✓	270 90	27x36x35Trans 15x17x27Rec	$32,700 $ 9,000

* Standard page and voice grade channel
1) Average density text on an 8 1/2 x 11 page
2) Also average depending on compression algorithm
3) Assuming highest transmission rate

Table 4

ANALOG FACSIMILE HARDWARE* COST/PERFORMANCE DATA

Make & Model	Fastest Transmission Speed	Other Speeds	Resolution (lines/in) Vert.	Resolution (lines/in) Horz.	Compat. with Xerox Telecopiers	Copy Paper Cost (cents per sheet)	Wt Lbs	Size	Purchase Price/ Lease/mo
Litton Datalog									
Policefax	4 - 5 min	--	91	--	--	1	25	R 6x21x17	$,000P
MXR Series	4 - 5 min	--	91	--	--	1	25	R 6x21x17	$4,000/pair
MXT Policefax			91	--			35	T 6x21x17	R$ 65L T$ 65L
DM 9*	9 min	--	200	200	--	35		35x30x20	$1,495P/ $ 225L
Graphic Sciences									
Dex 520	2 min	4	62	96	--	5	47	5x15x22	$4,600P/ $ 95L
580	3 min	6	88	96	--	5	47	5x15x22	$4,600P/
		6	96	96	✓				$ 95L
585	6 min	--	176	96	--	5	47	5x15x22	$4,600P/ $ 95L
270	4 min	--	124	96	--	5	47	5x15x22	$4,700P/ $ 100L
4100	6 min	--	176	96	--	5	75	34x12x17	-- P/
		3	88/96	96	--				$ 153L
		2	62/64	96	--				
3M VRC II	4 min	--	64	96	✓	6	59	12x24x17	$3,195P/
		6	96						$ 90L
VRC 603	3 min	--	64	64	--	6	18	5x14x18	$1,645P/
		4	64	96	✓	6			$ 58L
		6	64	64	✓	6			

ANALOG FACSIMILE HARDWARE* COST/PERFORMANCE DATA cont.

Make & Model	Fastest Transmission Speed	Other Speeds	Resolution (lines/in) Vert. Horz.	Compat. with Xerox Telecopiers	Copy Paper Cost (cents per sheet)	Wt Lbs	Size	Purchase Price/ Lease/mo
FAXON 811	1/2 min	3	100 x 70/100	Optional	1	200	36x40x21	Est. competitiv with Xerox 410
Telautograph 300	3 min		83.3 --	--	3	71 65	T15x16x19 R15x16x14	$3,000P/ $ 105L
Victor Graphic Systems 3618	3 min	-- 6	100 x 100 100 x 100	--	3	63 60	T13x16x18 R14x16x19	$5,500P/ $ 195L
6030	1.8 min	-- 3.6	100 x 100 100 x 100	--	3	63	T13x16x18	$5,700P/ $ 210L
Stewart Warner Datafax 360	3 min		90 x 100	--	4	45	12x15x21	$4,895P/$12
180	6 min		96 x 96		4	45	12x15x21	$4,295P/$11
150	9 min		115 x 138	--	4	45	12x15x21	$4,895P/$12
Xerox Telecopier410	4 min	-- 6	96 x 64 96 x 96		5	65	9x23x30	$4,580P/ $ 100L
400	4 min	-- 6	96 x 64 96 x 96		5	18	5x19x14	$1,540P/ $ 60L

*Page size handled - nominal 8 1/2" x 11", except for Litton Policefax 8 x 8 fingerprint cards. Works with voice grade transmission channels.

Names and Addresses of
Organizations Mentioned in This Study

Alden Electronic and Impulse
Recording Equipment Co. Inc.
Alden Research Center
Westboro, Mass. 01581

Dacom Inc.
1060 Morse Ave.
Sunnyvale, Calif. 94086

Dest Data Corporation
1285 Forgewood Ave.
Sunnyvale, Calif. 94086

Electronic Associates, Inc. (EAI)
West Long Branch
New Jersey 07764

FAXON Communication Corporation
34 South Broadway
White Plains, New York 10601

Graphnet Systems Inc.
99 W. Sheffield Ave.
Englewood, New Jersey 07631

Graphic Sciences Inc.
Corporate Drive
Commerce Park
Danbury, Conn. 06810

3M Company
Duplicating Products Division
3M Center
St. Paul, Minn. 55101

Litton Industries Inc.
Datalog Division
1700 Walt Whitman Rd.
Melville, New York 11746

Rapifax Corporation
Columbus Ave.
Valhalla, New York 10595

Stewart-Warner Datafax Corporation
1300 North Kostner Ave.
Chicago, Ill. 60651

Telautograph Corporation.
8700 Bellanca Ave.
Los Angeles, Calif. 90045

Victor Graphic Systems Inc.
3900 North Rockwell
Chicago, Ill. 60618

Xerox
Xerox Square
Rochester, New York 14644

Federal Telecommunications System
Office of Telecommunications Operations
1121 Vermont Ave. NW
Washington, D. C. 20405

Headquarters
U.S. Army Electronic Proving Grounds
Fort Huachuca, Arizona 85613

American Telephone & Telegraph Co.
195 Broadway
New York, New York 10007

Dept. of Treasury
IRS Regional Office
Falls Church, Virginia

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