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A cost and performance analysis of the three electronic communication systems currently in use in the printing and publishing industry

Susan Richards

A COST AND PERFORMANCE ANALYSIS OF THE THREE ELECTRONIC COMMUNICATION SYSTEMS CURRENTLY IN USE IN THE PRINTING AND PUBLISHING INDUSTRY

by

Susan L. Richards

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Printing in the College of Graphic Arts and Photography of the Rochester Institute of Technology

December, 1986

Thesis Advisor: Dr. Joseph DeLorenzo

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DEDICATION

This thesis is dedicated to Mr. John J. Tuohey, who is presently the Senior Vice-President of Technology, at U.S. News & World Report in Washington, D.C.

In his long and distinguished career with U.S. News & World Report, Mr. Tuohey has been responsible for many of the technical electronic communication advances that exist in the printing and publishing industry today. His far reaching vision has always recognized the full potential of electronic communications, providing the printing and publishing industry with a rich legacy.

It has been my privilege to work with Mr. Tuohey on my Graduate Thesis for my degree in Printing Technology, at Rochester Institute of Technology. I have been greatly influenced by his view of the printing industry as a profession, and his friendship has encouraged me to strive for and attain a Graduate Degree in Printing Technology.

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AUTHOR'S STATEMENT

In the development of this study the author has assumed a certain level of technical background by the reader regarding the design and use of electronic graphic communication systems. The three electronic communication systems under analysis in the study are:

System 1: Page Facsimile

System 2: Character-Encoding

System 3: Pixel Density-Map

To provide the basic technical background necessary for those readers who are not familiar with the field of electronic communication systems, please refer to the following sections of the study prior to reading Chapter I:

Appendix A - Basic Electronic Communication Concepts

Appendix B - A Glossary of Electronic Terms

For those readers who have an interest in acquiring additional technical information regarding electronic communication systems, please refer to the following part of the study:

Literature and General Readings

ABSTRACT

This study describes and evaluates the three electronic graphic communication systems presently used by the printing and publishing industry. The author has selected generic system names for each of the systems. These are:

System 1: Page Facsimile
System 2: Character-Encoding
System 3: Pixel Density-Map

Page Facsimile systems are primarily used by newspaper publishers. The Character-Encoding and Pixel Density-Map systems are alternate methods primarily used by newsweekly magazine publishers.

All three communication systems offer the user a means of transmitting editorial, and in some cases advertising pages, to remote printing facilities for manufacturing and distribution.

Each electronic graphic communication system is investigated in depth. The study provides specific information for the potential user, and the current user.

The problem for the user is how to best match the communication system, i.e. how the system operates, the cost and performance of that system, with the user's requirement for transmitting graphic information.

Based on the full evaluation of each of the systems in the study, the author concludes the following:

System 1: Page Facsimile

The Page Facsimile system is relatively simple for the user to install and operate. However, all pages must be prepared as camera ready copy prior to transmission.

The component costs for this system design are relatively low. Conversely, the method of encoding generates the most data to be transmitted. As a result, the user is required to use expensive transmission lines. Also, with limited data storage, this system requires the immediate transmission and reception of data. From an overall cost standpoint the Page Facsimile system is the least expensive system in the study.

The quality levels attained by this system are best suited for newspaper applications, where the text and 4/color quality requirements of the publications are not paramount. These systems offer the user the many advantages of a full communication system, i.e. the transmission of all editorial and advertising pages. Broadcast transmission is used for remote printing locations.

System 2: Character-Encoding

The Character-Encoding system is more complex to install and operate, particularly if 4/color pages are transmitted.

The component costs for this system design are relatively high. Character-encoding is the most efficient method used to encode graphic information, enabling the user the advantage of using less expensive transmission lines. From an overall cost standpoint the Character-Encoded system is the second most expensive system in the study.

The high text quality levels attained by this system are best suited for publications that are text oriented. Conversely, this system has inherent limitations in the levels of 4/color quality which can be transmitted, limiting its use as a communication system. At present, point-to-point transmission is used, a factor which will eventually limit the number of remote printing locations.

System 3: Pixel Density-Map

The Pixel Density-Map system is more complex to install and operate because of the level of system sophistication.

The component costs for this system design are very expensive. In addition, the method of encoding the graphic information is data intensive requiring the use of expensive data transmission lines. However, the data storage built into this system offers the user the advantage of selecting variable data rates and transmission times. From an overall cost standpoint the Pixel Density-Map system is the most expensive system in the study.

The Pixel Density-Map system is the best 4/color transmission system. This communication system is best suited for publications that are pictorially oriented. However, this system has inherent limitations in the levels of text quality which can be achieved. The major advantage of this system is its potential to be eventually used as a full communication system. At present, broadcast transmission is used for remote printing locations.

INTRODUCTION

The need for timely dissemination of information, and the high distribution costs of printed matter, has given rise to the development and increasing use of electronic graphic communication systems in the publishing industry.

At the present time there are three electronic graphic communication systems being used by the printing and publishing industry. For the purposes of this study the three communication systems are referred to as follows:[1]

System 1: Page Facsimile

System 2: Character-Encoding

System 3: Pixel Density-Map

Currently several publishing companies, who publish daily national newspapers and weekly news-magazines, are the primary users of these communication systems. The national market approach of these publications has brought about the further development of electronic graphic communication systems, which offer the many advantages of timeliness and reduced national distribution costs.

A typical electronic communication system used in printing and publishing consists of a single transmission site, usually at place at the publisher's editorial offices, and a remote, or a number of remote, receiving locations.

At the transmission site the graphic information is assembled in the desired publication format, prepared for transmission and transmitted. The remote receiving site(s), located at printing facilities throughout the country and around the globe, receives the transmitted graphic information. At the remote location, the printing facility converts the received graphic information into suitable prepress form, manufactures and distributes the publication in a particular geographical location.

For the average publication, whether a daily, weekly or a monthly, the costs of these electronic graphic communication systems and the network design necessary to implement them, are economically prohibitive. However, as these systems improve in availibilty and cost effectiveness, it will be feasible for other publishers to utilize existent electronic communication system designs and develop their own communication systems.

The major impetus for the publisher to adopt the new electronic communication technology is the advantage of more timely closing schedules for editorial and advertising pages, and sizable savings in distribution costs.

Another significant advantage of electronic communication systems is the potential for the publisher to develop a full communication system. A full communication system is comprised of the transmission of the entire publication, including all advertising and editorial pages.

At present a limited number of full electronic communication systems are in use.[2]

Most publishers using these systems ship the films for advertising pages to the remote locations conventionally, either by mail or overnight courier services.

The Purpose Of This Study

The purpose of this study is to describe, analyze and compare existing electronic graphic communication systems currently in use by the printing and publishing industry.

The primary objective of this study is to determine, evaluate and compare system designs, costs and performance for each of the three communication systems.

This study is based on detailed functional descriptions and cost and performance data supplied to the author by vendors and current users of each of the three major communication systems.

For the purposes of comparison in this study these specific descriptions and data have been developed into representative generic descriptions of design, components and costs.

Detailed system descriptions, including functional block diagrams, are provided for each communication system.

The cost analysis portion of the study includes the cost of the system components, storage capacity requirements and transmission media necessary for implementation. This

cost analysis data is used to determine the relative cost of each system for comparison purposes. An analysis is also conducted using this data to determine the costs of multiple receiving sites for each communication system.

The performance analysis is divided into two parts. The first part consists of a capacity analysis of the amount of data necessary for each system to encode and transmit a sample standard 4/color page, including text, using different line screens. An analysis is also conducted using this data to determine the amount of time needed by each communication system to transmit that standard page via various data rate transmission lines.

The second part of the performance analysis consists of a quality analysis of representative 4/color and text subjects from each system. This data is used to assess the effect, if any, on the quality of the received film and the printed copy caused by the transmission system used by each representative communication system.

Finally, the detailed descriptions, cost and performance analysis data is used for the overall evaluation of each communication system in the study.

The final evaluation is comprised of a discussion of the relative advantages and disadvantages of each electronic graphic communication system.

The material contained in this study is intended to provide detailed information for those publishers who are

interested in entering the remote graphic communications publishing market.

There are also at present some publishers who are in a position to consider a technical upgrade and/or an alternate method of transmitting graphic information. This material is also intended to provide information on alternative communication systems for those publishing companies presently using some form of electronic graphic communication.

The Communication Systems In Use

At present there are three major electronic graphic communication systems in use in the printing and publishing industry. These communication systems are usually specified in terms of the particular user. In this study each of the three systems is given a generic title based on its major distinction from the other two systems in the study.

Each electronic communication system is described and analyzed according to generic functional descriptions. The introductory section which follows is intended to provide the reader with basic system information such as: a brief system introduction, including a history of system development, and basic system design and operation.

Specific descriptions, including functional diagrams, for each of the communication systems in the study follow in Chapter II.

System 1: Page Facsimile[3]

The System Introduction

In an article entitled "Page Facsimile in the Eighties" published in the 1981 TAGA proceedings, Richard E. Amtower describes Page Facsimile as follows: "In its simplest form, page facsimile is the transmission of complete newspaper pages in electronic form to a remote site for platemaking and printing."[4]

Page Facsimile systems have been been developed for and primarily used as newspaper graphic communication systems. The systems in use today have evolved from the original systems pioneered in the 1920's for the news services for transmitting wirephotos.[5]

Over the past two decades the use of Page Facsimile systems has increased significantly. These systems offer the newspaper publisher the many advantages of the electronic media including, savings in distribution costs and a reduction in the time between closing pages and press starts.

Also for many newspaper publishers there has developed a strong competition with the broadcast media, for the timely dissemination of information.

Page Facsimile systems also provide a means for those publishers who need to expand from outmoded or overloaded facilities in central metropolitan areas, to remote regional locations.[6]

Basic System Description

Prior to transmission in the Page Facsimile system the text is typeset and prepared as reproduction copy. All the graphics and photographs, black and white or 4/color, are reproduced as halftone films. Contact prints are made from the output films.

The page is then pasted-up conventionally as a mechanical with the photographs, graphics and text in position. The page mechanical, one for each process color, is photographed and reproduced as a page negative film. A contact print is made from each process color page negative.

During transmission the facsimile scanner, at the transmission site, scans the page print and converts the entire page, photographs, graphics and text, into data elements. The transmission system transmits the data via a suitable telecommunication link to the remote receiving location(s).

Upon receipt of the data, the facsimile recorder at place at the receiving location(s) images an exact copy, a facsimile, onto film of the page from the data elements received. The page film, per color, is used to make plates for printing.

System 2: Character-Encoding[7]

The System Introduction

Character-Encoding communication systems were initially developed for use by text oriented weekly publications. The

original system was pioneered by "U.S. NEWS & WORLD REPORT" in the mid 197Ø's.

Ten years ago when the character-encoding system was first developed, the emphasis of news-weekly publications was based on high text quality requirements used to communicate information. At the time there was much less emphasis on the photographs and other aspects of graphic design contained in these publications.

The primary quality requirement of this communication system was based on a means of reproducing the highest quality text possible, at each remote printing location. The technology which was developed to meet this text quality requirement was a method of creating another "original text", also referred to as "local font generation", by having the typesetting equipment at each remote site.

The equipment designed for this purpose consisted of an intelligent photo imager at place at each remote site served by the transmitter, to provide this "local font generation."

The users of this system also needed a means to transmit black & white photographs to each remote printing location. A black and white scanner was designed to scan the original photographs prior to transmission. The intelligent photo imagers, at the remote sites were adapted to process the halftones by out-putting a local font of halftone dots to reconstruct the original halftone scanned at the transmission site.

The first black & white halftones transmitted were of marginal quality when compared with today's standards. However, at the time, the halftone quality level achieved with this system met the needs and the limited expectations of the users of these communication systems.

Gradually the emphasis of the news-weekly publications shifted to an increasing use of 4/color subjects. Much more emphasis was placed on the graphic design of the weekly publication. At its inception there was no need for this communication system to transmit 4/color pages. To accommodate the use of extensive 4/color pages all 4/color films had to be shipped conventionally to each remote site.

However, for editorial purposes the need arose to transmit late closing 4/color pages. The communication system was adapted to transmit a limited number of 4/color pages per issue. To meet this requirement the users of these systems designed an interface between the transmission electronic color scanner and the receiving photo imagers. The device introduced was called a Color Conversion Unit.

There were 4/color quality limitations using the CCU from the start, but the quality level achieved was adequate for the transmission of 4/color editorial pages.

At present this communication system design has far exceeded its original capabilites, which was the transmission of only text material. The system has 4/color graphic quality limitations but remains in wide use today due to its

economy of data transmission. Data transmission will be discussed in the Performance part of the study.

The Basic System Description

Prior to transmission all graphics, including black and white photographs and 4/color, are scanned and stored on magnetic tape as halftones. The text is typeset in a front-end typesetter and stored in a data storage queue. A device called a communication controller is used to character-encode the text characters by assigning symbolic character codes to each letter.

In some communication systems, the 4/color graphics portion of the page is assembled using a color preview system with a video display terminal (VDT). If these 4/color pages are to be transmitted to a remote site, a Color Conversion Unit (CCU) device is used to assign 8 bit codes to the 4/color halftone dots.

The 4/color page is assembled on a typesetting preview system using the VDT. A File Manager is used to merge the text and graphics, per process color, in the appropriate publication format.

The codes generated at the transmission site to encode the original page are then transmitted over a suitable telecommunication link to the remote receiving location(s).

Upon receipt of the transmitted character codes the intelligent photo imager, at each receiving location, converts the symbolic character codes into locally stored

fonts, including a halftone font, creating a new "original" at each remote location. The photo imager outputs page film, per color, for film assembly and platemaking.

It should be noted that at this writing only a limited number of text color pages are transmitted in this manner. The majority of color text pages, and all advertising pages are shipped conventionally to the printing sites.

System 3: Pixel Density-Map[8]

The System Introduction

The Pixel Density-Map system incorporates the most current communication system technology in use today. This system has been primarily developed over the past few years by "TIME" magazine. The major design requirement of this new commmunication system is based on the latest 4/color quality and transmission requirements of news-weekly publications. These publications are now predominantly 4/color oriented.

Over the past five years there has been much more emphasis on the graphic design of news-weekly publications. The primary quality requirement of this communication system is based on a means of transmitting and reproducing the best 4/color quality possible at each remote location.

The technology developed to meet this 4/color quality requirement is a method of creating another "4/color original", as a color scanner does at a pre-press location. Essentially the equipment designed is the placement of the

input part of the color scanner at the transmission site, with the output part of the color scanner at each remote receiving location.

However, the users of these systems also needed a way of transmitting text material to each remote location.

Initially a character-encoding system, similar to the one used for System 2, was used for transmitting the text. However there was a limitation using this method. Two different output devices were required at each remote location. One for the text and another for the 4/color. Another means had to be devised to use only one device to output the entire 4/color page, with the text in position.

To meet this need a typesetting device was introduced into the system with a raster image processor to convert all the text to raster format. In this manner the entire page, including text and graphics, could be imaged by the output part of the scanner, at each remote printing location.

There have been limitations in reproducing the text in this manner. Essentially what this system has gained in 4/color quality capability it has to some extent sacrificed in the quality of text output. However, the quality of the text has generally met the expectations of the user.

Perhaps the greatest potential that this system offers is a full communication system approach. The high level of 4/color quality makes it possible to eventually transmit all advertising and editorial pages using this system.

The Basic System Description

Prior to transmission all graphics are scanned and stored as continuous tone data elements, called pixels, by an electronic color scanning device. All pixels reside in the memory of the system as density values, also called gray levels. The text is typeset in a front-end typesetter and converted to raster form, for transmission and imaging, by a Raster Image Processor (RIP) built into the typesetter.

A preview system with a VDT is used for color and graphics page assembly and storage. The text portion of the page is assembled with a typesetting preview system. Text and graphics, including photographs are kept separate during the transmission. A File Manager equipped with an extensive disk storage system stores all the page data, per color, including text, for as long as necessary.

During transmission the density values, encoded from the original page, are transmitted via a suitable telecommunication link to the remote receiving location(s).

Upon receipt of the data at the remote site the receiving imager, essentially the output part of an electronic scanner, receives the density values of the images on the page and the color computer assigns a line screen creating halftones at each receiving location. The text is merged with the graphics in the receiving photo imager. The imager output is page film for film assembly and platemaking.

Statement Of The Problem

From a communication standpoint, the problem for the user is how best to match the electronic communication systems available, to the user's need for communicating graphic information. To achieve an efficient match, each publishing company must be in a position to assess its present requirements and future communications needs.

At present, electronic communications technology is rapidly changing, and there is very little specific and comparitive information available on any of the communication systems in use today. As a result, very little has been published by the electronic communication manufacturing industry to aid the potential user in making communication system decisions.

The lack of specific system information can impose severe limitations on those publishing companies who are presently in a position to investigate possible electronic communication systems options.

In order to best match the system with the user's requirements for communicating graphic information, it is critical for the potential user to know specific information about any communication system under consideration. This specific information is categorized as follows:

First: The user must understand what each communication system does and specifically, how each communication system

performs those functions. Also the user must understand how each communication system is similar and different from the other systems, presently in use.

Second: The user must know what the approximate costs to operate each communication system are. Specifically, the costs of components, storage, error checking, maintenance, transmission media and the cost of adding remote sites.

Third: The user must know the approximate amount of data that each communication system requires to encode the information to be transmitted, 4/color and text, at the transmission site.

Fourth: The user must be able to determine the approximate transmission time each communication system requires to transmit the graphic information, using different data rate transmission lines.

Fifth: The user must be able to assess, and compare, the quality of the transmitted 4/color and text film received at a remote location by each communication system.

Sixth: The potential user must also be able to assess, and compare, the final reproduction quality of the printed copy from the film received at those remote sites, for each electronic communication system.

When the above information is analyzed and compared for each graphic communication system, the potential user is then in a better position to choose one electronic graphic communication system approach over another.

FOOTNOTES - CHAPTER I

1
The author has chosen generic names to describe the three electronic graphic communication systems in use today.

2
"USA TODAY" uses a full Page Facsimile system, which includes the transmission of full page 4/color ads. "THE WALL STREET JOURNAL" uses a facsimile system to transmit advertising pages which are generally line art.

3
Present users of Page Facsimile systems include, "USA TODAY", "THE WALL STREET JOURNAL" and "THE NEW YORK TIMES."

4
"Page Facsimile in the Eighties", by Richard E. Amtower, 1981 TAGA Proceedings. Page 264.

5
Ibid. This article contains a detailed historical account of the development of facsimile systems.

6
Ibid. Page 264.

7
Present users of Character-Encoding systems include: "NEWSWEEK", "U.S. NEWS & WORLD REPORT" and "BUSINESS WEEK."

8
At this writing "TIME" magazine is the only publication using this electronic communication system.

CHAPTER II

COMMUNICATION SYSTEM DESCRIPTIONS

The following material is intended to provide specific descriptive information for the three electronic communication systems in the study. These are:

System 1: Page Facsimile
System 2: Character-Encoding
System 3: Pixel Density-Map

All descriptive system information was obtained during interviews with representative users, equipment vendors and common carriers for each communication system. For the purposes of this study, the information obtained for each communication system has been expanded and developed into generic system diagrams and descriptions.

Additional technical information was obtained during interviews with system technicians and operators during tours of representative transmission sites, and a remote receiving site for each communication system.

A specific list of questions was requested, evaluated and is presented for each electronic communication system as follows:

A. General System Information

B. System Diagrams

1. Transmission Site
2. Receiving Site

C. Functional Descriptions

1. Transmission Site
2. Receiving Site

D. Specific System Information

1. Color Transmission
2. Speed and Quality Levels
3. Data Compression Techniques
4. The Transmission System

E. System Similarities and Differences

1. System 1: Page Facsimile
2. System 2: Character-Encoding
3. System 3: Pixel Density-Map

I - System 1: Page Facsimile

A. The General System Description

Facsimile systems utilize scanners to read an original and to transmit the attendant imagery to a remote reproducing imager.

Prior to transmission the typesetting is done on a front-end system and the text is pasted up with the graphics on a full page mechanical. Black and white graphics and line art are reproduced with a camera, and velox prints are made for placement on the page mechanical. 4/color graphics are scanned on a color scanning device, and velox prints are made for placement on the mechanical. Advertising pages are prepared in the same way. In some cases the mechanical is photographed and a screened positive print is made.

For transmission purposes another scanning device is used in which the full page velox paper print is either

mounted on a revolving drum or placed in a flat bed device.

In drum fax, the scanning head moves along the axis of the drum while the drum revolves. In flat bed fax, the copy is placed flat and generally moves slowly, while the scan beam moves across the page in the opposite direction. Both drum fax and flat bed fax scanner equipment speeds can be designed to be variable depending on the desired transmission data rate.

All facsimile system transmission scanners read and transmit the data in the original, element by element. In every Page Facsimile system, the facsimile scanner at the transmission site is designed with a particular scanning speed and imaging spot size. These design characteristics are determined by the resolution requirements specified by the user of the communication system.

The elements the scanner records on a revolution of the drum, or a sweep of the scanner head, are converted into signals that electronically turn on or turn off according to the resolution of the system, as often as the scanner reads black or white, i.e. image or non-image.

As the print is scanned, the laser records the original image element by element and translates the image into an electronic signal that can be transmitted in either a broadcast or point-to-point transmission mode.

Essentially all the data is transmitted to the receiving locations. However, high data compression ratios are

possible in Page Facsimile, depending on the complexity of the image content in the original. Importantly, the graphics are usually screened prior to scanning and transmission.

As the transmission scanner progresses down or across the page, the signals are synchronized with receiving imagers at each location via a suitable telecommunications link. The receiver imager plays out the data element by element in most cases, just as it has been transmitted. Each remote receiving location records all the relevant image data onto film with a simple playout imager.

B. System 1: Page Facsimile Diagram

1. Transmission Site

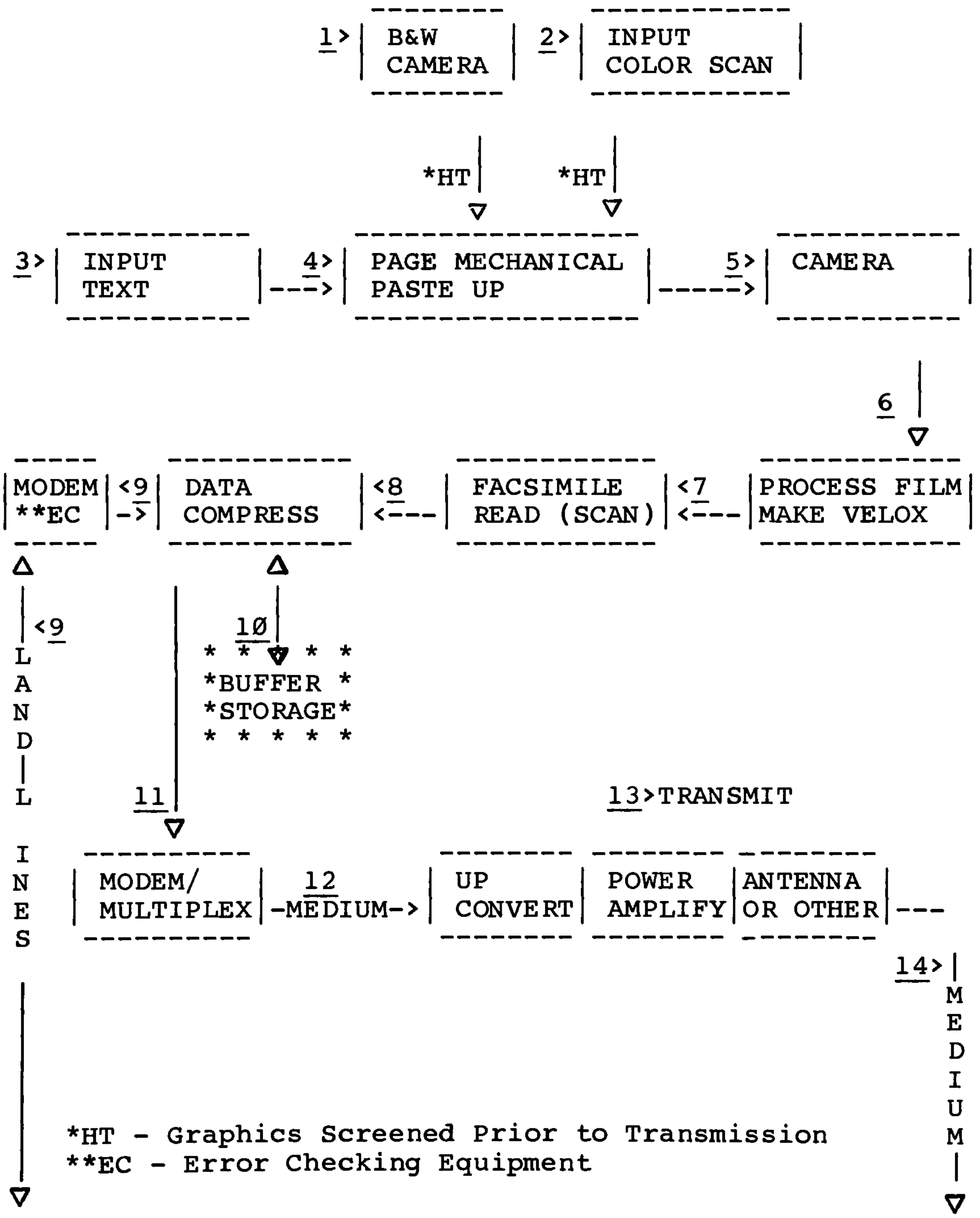
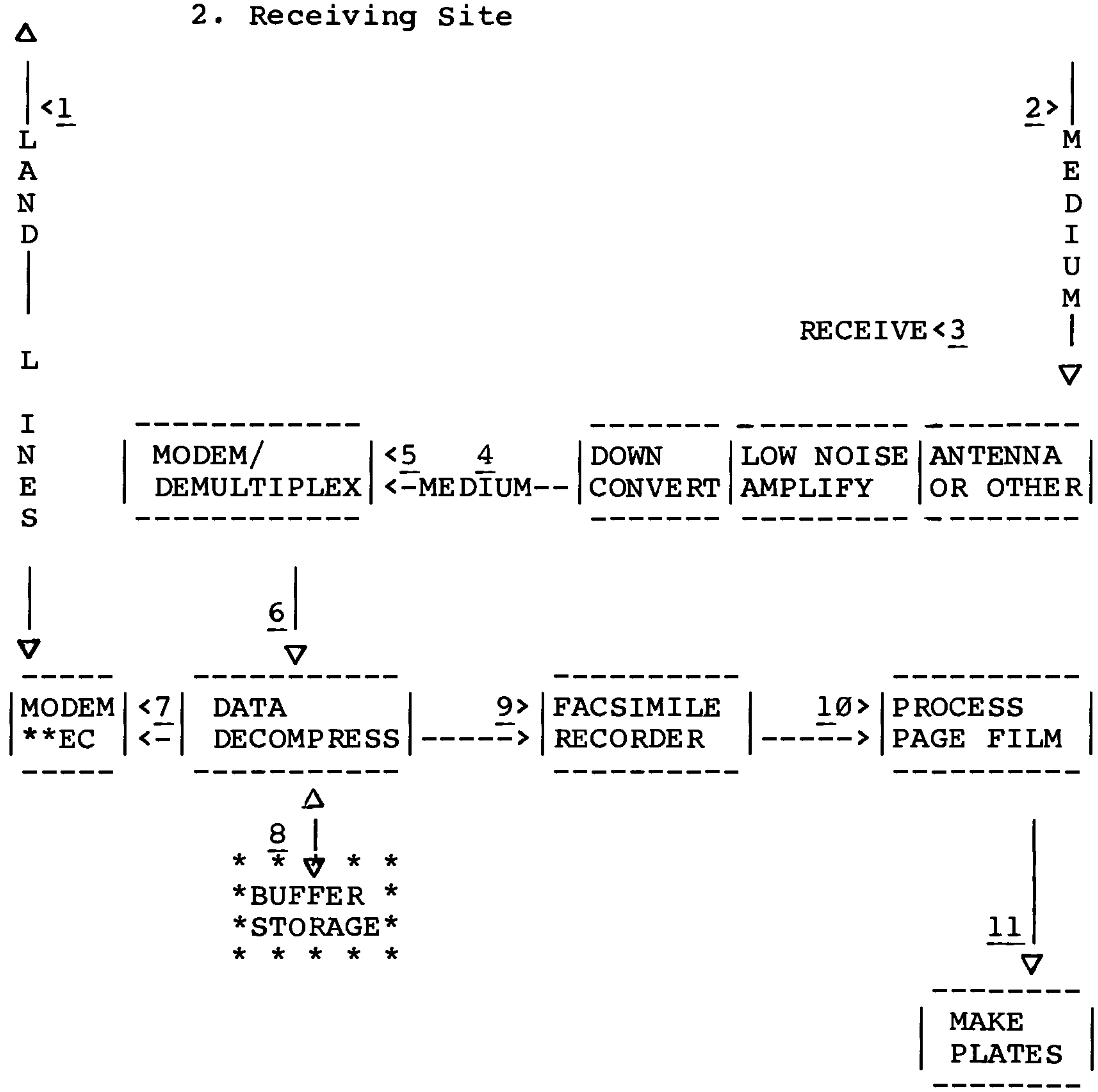


Figure 1: System 1 - Transmission Site Diagram

B. System 1: Page Facsimile Diagram

2. Receiving Site



**EC - Error Checking Equipment

Figure 2: System 1 - Receiving Site Diagram

C. Functional Description

1. Transmission Site

Please refer to Figure 1: System 1 - Transmission Site Diagram on page 23 for the following functional steps placed on the diagram:

Step 1: A camera is used to photograph both black and white photographs and color graphics for line art subjects. Graphics are output as screened film and converted to camera ready copy.

Step 2: A color input scanner is used to produce halftone color separations or original 4/color continuous tone subjects. Separations are output as halftone film and converted to camera ready copy.

Step 3: Input text is done on a front-end typesetting system. Text is output as camera ready copy.

Step 4: A camera ready mechanical paste up is made, per color, per page, with all text and pre-screened graphics in position.

Step 5: A camera is used to photograph each page mechanical per page, per color. Pages are output as composite film per color.

Step 6: The page film is processed and converted to a "contact" print, usually a velox, for each color.

Step 7: The page velox for each color is mounted and scanned on a Facsimile Scanner for data transmission.

Step 8: The data from the scanned image is compressed prior to transmission.

Step 9: A transmission modem, transmission landline and a receiving modem are used for error checking purposes.

Step 1Ø: Limited buffer storage is built into the data compressor unit.

Step 11: The modem unit modulates the compressed data for transmission. The multiplexer unit multiplexes signals from other sources for transmission.

Step 12: An appropriate medium is used to transfer the data from the modem/multiplexer unit to the transmitter.

Step 13: The transmitter processes the signal through up conversion, power amplification and passes the signal to an antenna or other suitable device, for transmission.

Step 14: An appropriate transmission medium is used to transfer the signal from the transmitter to the receiver.

C. Functional Description

1. Receiving Site

Please refer to **Figure 2: System 1 - Receiving Site Diagram** on page **24** for the following functional steps placed on the diagram:

Step 1: Landline used for error checking purposes.

Step 2: An appropriate transmission medium is used to transfer the signal from the transmitter to the receiver.

Step 3: The receiving unit receives the signal through an antenna or other suitable device, low noise amplifies and down converts the signals.

Step 4: An appropriate transmission medium is used to transfer the received signal to the modem/demux unit.

Step 5: The demux unit demultiplexes the received signals. The modem demodulates the signals in preparation for data decompression.

Step 6: The data is decompressed to its original form.

Step 7: Receiving modem used for error checking purposes.

Step 8: Limited buffer storage is built into the data decompressor unit.

Step 9: A facsimile recorder, a simple photo imager, images the data, element by element, per color, immediately upon reception. Page film, per color is output.

Step 1Ø: The page film, per color is processed.

Step 11: The film is used to make plates for printing.

D. Specific System Information

1. Color Transmission

Color photographs are generally scanned prior to transmission on a laser color scanner. In Page Facsimile systems, these scanners are programmed to produce color separations, tailored specifically for that user's newspaper reproduction requirements.

After scanning, each film per color is prepared in an appropriate page format. Usually this preparation consists of a paste up mechanical page for each color. The black graphic is combined with the text. The other three colors, yellow, cyan and magenta are individually placed in position on a page for each color. The pages are then prepared for transmission. If drum fax is used each page mechanical per color, is photographed separately and a contact velox print is made of each. If flat bed fax is used then the mechanical as prepared and each color page can be placed into the transmission scanning device.

An example of a color transmission system used for Page Facsimile is the one used by the Gannett Company for its national newspaper "USA TODAY." This transmission system, including color page transmission, is described as follows:[1]

> "Black and white pages are sent in one transmission. Full color pages require four separate transmissions; one each for red, blue, yellow and black. A standard black and white newspaper page can be sent in about three and a half minutes; each of the individual color transmission takes from seven to fifteen minutes."

2. Speed and Quality Levels

In an article titled, "Page Facsimile in the Eighties" the author, Mr. Amtower discusses the importance of speed and quality levels in Page Facsimile systems as follows:[2]

> "All page facsimile systems to date utilize picture element scanning, digitization, and transmission to a similar system which re-contructs the image; the problem is that the best image quality takes more scan lines and scan elements per inch, which result in more data. More data to transmit means either more time is required or more bandwidth -or possibly both- and increased time and bandwidth mean higher transmission cost."

As the name of the system implies, essentially all facsimile systems are designed to faithfully record and reproduce whatever they read with or without data compression. In the simplest Page Facsimile systems every bit of information in the original is scanned and is transmitted to the receiving end of the communication system. However, higher quality requirements necessitate finer resolution, creating more data elements. Higher quality requirements can greatly increase the amount of data generated and transmitted.

Since every element in the original is scanned in Page Facsimile systems, there often is considerable redundancy of image, such as large white areas and text matter. Improved methods of data processing have been developed to handle the higher quality requirements being demanded of these systems.

3. Data Compression Techniques

There are continued improvements in the data processing technology used in Page Facsimile systems. The technology developments consist of the following methods: "...continued reduction in communication link cost and with new techniques for reducing the required bandwidth and transmission times - among them bandwidth compression for analog circuits and data compression..."[3] and combinations of the two methods.

In any Page Facsimile system used, an intensive amount of data is generated by the method of encoding the information in the original. To reduce the amount of data transmission time, a form of data compression becomes critical.

Page Facsimile systems use run length, multiple run length encoding, and other data compression techniques to speed up the transmission. Less data reduces the time needed for transmission, resulting in sizable savings in communication transmission costs. Generally compression ratios are approximately 15:1 for text and 5-7:1 and possibly higher, for the graphics. Compression ratios are determined by the complexity of the original.

Bandwidth reduction is another method of generating savings in communications costs. Bandwidth reduction can be accomplished through the use of specially designed transmission modems, which binary encode the data into levels for transmission.

4. The Transmission System

As the page is being scanned at the transmission site, the electronic signal carrying the page data is being sent immediately to all the remote sites. Transmission systems can consist of phone lines, or other media for point-to-point transmission or a satellite can be used for broadcast transmission.

Page Facsimile transmission systems that have multiple receiving sites, generally operate via satellite in a broadcast mode.

An example of a Page Facsimile transmission system is the system used for the transmission of "USA TODAY." In this system, each remote printing facility is equipped with a 5-meter, approximately 16 feet in diameter, satellite receiving antenna and a facsimile recorder. The transmitted signal is received by the antenna and passed over to the facsimile recorder, which is installed in a photographic darkroom.

The facsimile recorder at each receiving site translates the electronic signal into a full page negative, or positive, using a laser or other light source to expose the film. The recorder is simply an imaging system, faithfully reproducing the signals received. The full page films are then used to produce offset printing plates.

II - System 2: Character-Encoding

A. The General System Description

The File Manager, also known as a character-encoder, at the transmission site assigns symbolic character codes, usually ASCII, to the type. Line art and graphics are encoded with 8 bit bytes. This assignment of codes is called character-encoding.

The major advantage in encoding the information from the original in this manner is that a small amount of data, a symbolic character code, is generated and transmitted.

A flat bed scanning device is used to scan continuous tone black and white original photographs, including line art with 8 bit byte encoding. This data is sent to the File Manager which stores this data as symbolic character codes.

4/color continuous tone originals are scanned on a color scanner and through the use of a color conversion unit are also character-encoded.

The coding language widely used to encode the textual matter is ASCII.[4] At the transmission site the line art and halftone data is assigned a distinctive 8 bit byte code. These codes may also be used to assign font, type size and location on the page, information for that character, graphic or halftone dot.

The symbolic character codes are transmitted to the receiving site(s) for image processing. The receiving imager must be intelligent enough to recognize the ASCII codes for

the text, and the byte codes for graphics, and convert these codes into type and graphics images, in the proper image position and location.

It is important to note that the transmitted byte codes already contain the screening requirements for the halftones and graphics whether black and white, or color.

At the transmission site the File Manager also merges the text files, which have been generated on a front-end typesetting system, with the previously scanned and stored graphics into a page format. The intelligent photo imager interfaced to the File Manager at the transmission site is not only capable of creating alphanumeric characters from stored digital fonts or bit-maps, but is also capable of creating byte codes for a select group of halftone dots from stored digital halftone fonts. The intelligent photo imager at the receiving site also has stored bit-maps for fonts of characters as well as fonts for halftone dots. This is considered to be the local font generating capability of this communication system.

The symbolic codes are transmitted to the receiving site, not the bit-map data for these images. The original bit-map data remains in storage in the imaging computer at the transmission site. In effect it is like sending the name of a character, and the character itself is locally stored and imaged anew at each of the receiving sites.

The symbolic code instructs the intelligent photo imager at the receiver how to create the desired images from the transmitted codes.

The Character-Encoding system requires that every receiving site have an intelligent photo imager to translate and recreate the required images from the transmitted symbolic codes. Each receiving photo imager must have the adequate computer storage and the appropriate software necessary to operate the photo imager in this manner.

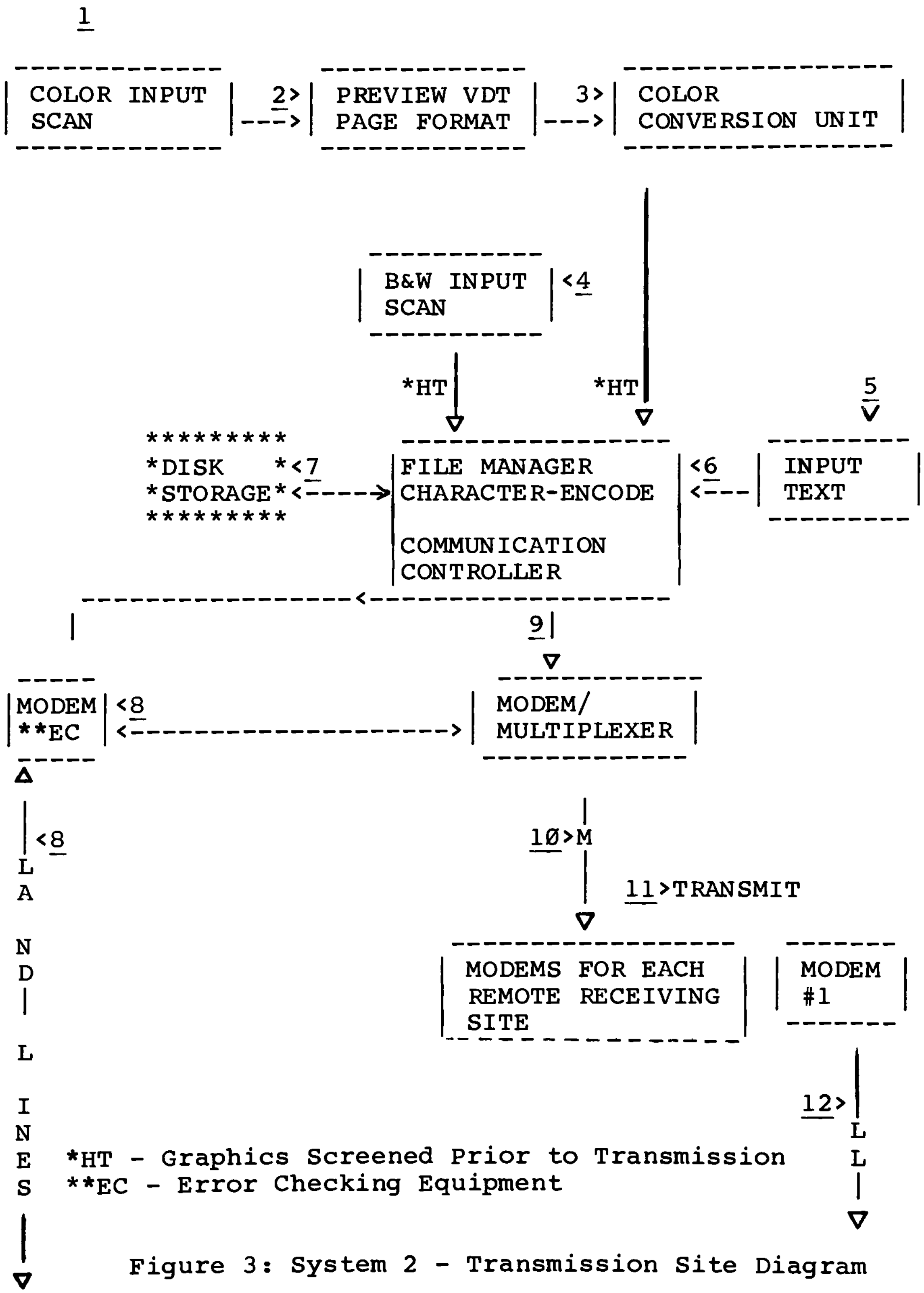
The Character-Encoding system requires that those text and halftone fonts needed to create the images, for a particular publication, are stored and available on-line in the photo imager at each receiving location.

If the receiving photo imager does not recognize a transmitted character code representing an image, the imager will play out an error message. The alternative for users of photo imagers that do not have the correct font in its stored font library is for the transmission site to scan the original type image as a graphic. The image is then transmitted as though it is line art. The codes can then be imaged at the receiving site.

Scanning text material as a graphic can be done as often as necessary until the correct font is stored and available on-line at the receiving site.[6] In some cases, time permitting, the transmission site will physically ship a piece of film for this page to the receiving location.

B. System 2: Character-Encoding Diagram

1. Transmission Site

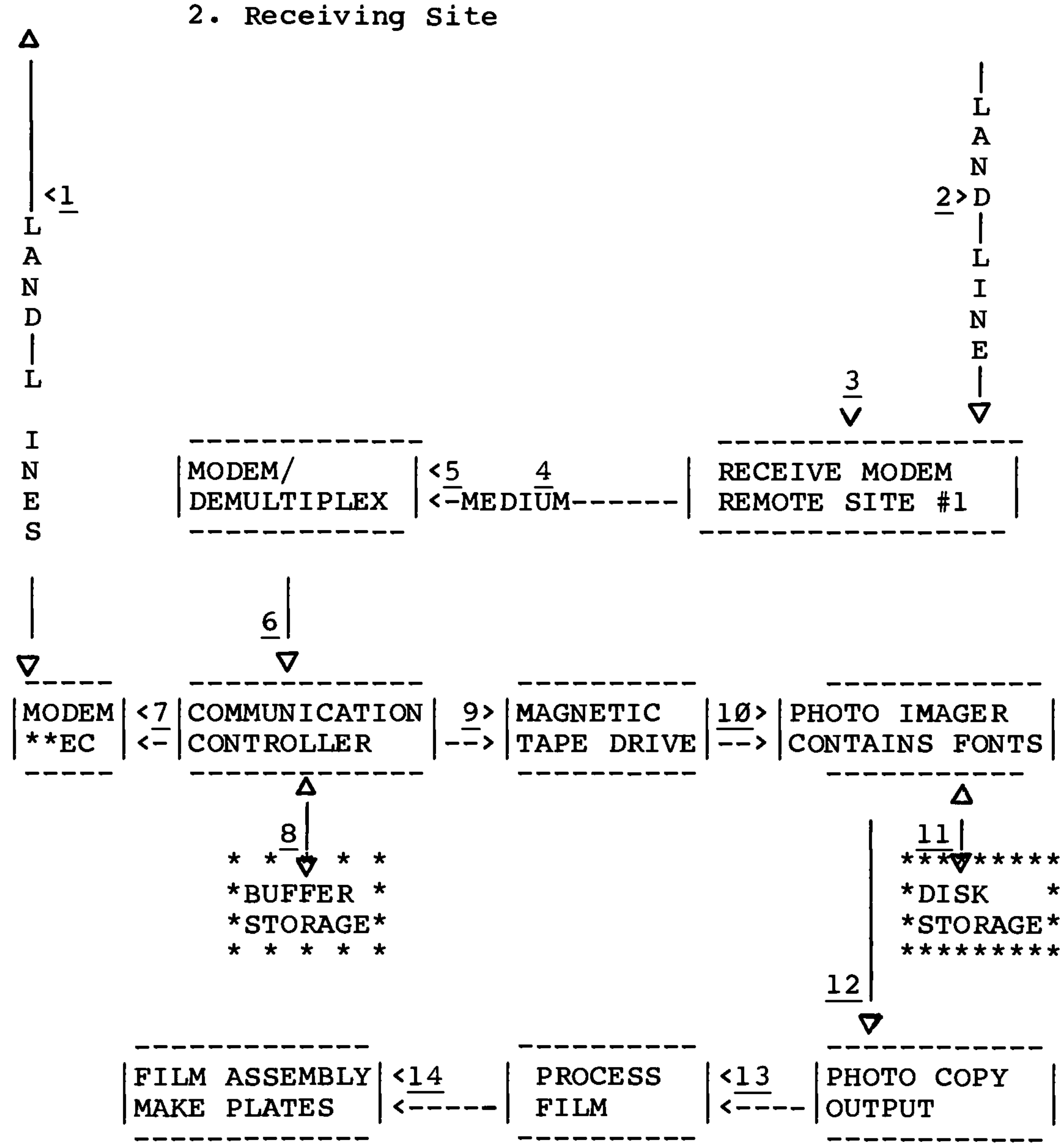


*HT - Graphics Screened Prior to Transmission
**EC - Error Checking Equipment

Figure 3: System 2 - Transmission Site Diagram

B. System 2: Character-Encoding Diagram

2. Receiving Site



**EC - Error Checking Equipment

Figure 4: System 2 - Receiving Site Diagram

C. Functional Description

1. Transmission Site

Please refer to Figure 3: System 2 - Transmission Site Diagram on page 34 for the following functional steps placed on that diagram:

Step 1: A color scanner is used to produce 4/color continuous tone separations.

Step 2: A Preview System with a VDT (Video Display Terminal) is used for color manipulation and page formatting.

Step 3: The continous tone separation tape produced in Step 1 is processed through a Color Conversion Unit (CCU) for halftone conversion prior to transmission.

Step 4: The black & white photographs and all line work are scanned prior to transmission.

Step 5: Input text is done on a front-end typesetting system connected to a photo imager. Text can be output as camera ready copy if desired.

Step 6: 4/color and black & white halftones and all text files are processed through the communication controller for character-encoding. All halftone dots and text characters are assigned ASCII character codes. Data compression of the graphics is done in this unit. Text and graphics are merged at this time, prior to transmission.

Step 7: All ASCII character codes are stored in a buffer unit prior to transmission.

Step 8: A transmission modem, transmission landline and a receiving modem are used for error checking purposes.

Step 9: A modem unit modulates the data for transmission.

Step 10: An appropriate medium is used to transfer the data from the modem unit to the transmitter.

Step 11: A transmission modem is used for point-to-point transmission to each remote receiving site being served by the transmission system.

Step 12: A transmission landline is used to transmit the data to each remote receiving location.

C. Functional Description

1. Receiving Site

Please refer to Figure 4: System 2 - Receiving Site Diagram on page 35 for the following functional steps placed on that diagram:

Step 1: A landline is used for error checking purposes.

Step 2: A landline is used to receive the transmitted data at each remote receiving location being served by the transmission site.

Step 3: The receiving modem at place at the receiving location receives the signal.

Step 4: An appropriate transmission medium is used to transfer the received signal to the modem unit.

Step 5: The modem demodulates the signals in preparation for the processing by the Communication Controller.

Step 6: The Communication Controller reads the ASCII codes and converts them to type and halftone fonts in preparation for the receiving photo imager. Graphics data is decompressed in this unit.

Step 7: A modem is used for error checking purposes.

Step 8: Buffer storage is built into the Communication Controller unit.

Step 9: All data is off-loaded onto magnetic tape storage.

Step 10: The magnetic tape is read into the receiving photo imager. The output is page film, per color.

Step 11: Disk storage is built into the photo imager.

Step 12: The film is processed.

Step 13: Pages are stripped and plates are made.

C. Specific System Information

1. Color Transmission

In the Character-Encoding system original continuous tone color graphics are scanned on a color scanner. As in other color scanners, this scanner records the continuous density values of each color in the original through three filters. Red, green and blue filters are used. Four computer files are created, one for cyan, magenta, yellow and black.

At this time the computer can either direct the image directly to a film recorder or transfer the data to a preview color manipulation system. Preview systems with a video display terminal (VDT) are used to size, crop, color correct and airbrush the color image as desired by the user/client.

Once the image has been approved, any changes or adjustments to the data is updated and transferred to the appropriate storage medium in the graphics format. In some cases this graphics format prepares the magnetic tape in a symbolic form, usually byte encoded, as though the data were coming from the front-end typesetter. The magnetic tape is then run through what is a essentially a halftone computer, called a Color Conversion Unit.

The Color Conversion Unit (CCU) takes the continuous tone pixel data and processes this data through its computer. The CCU computer converts this data into four separate halftone tapes with the proper screen angle and

resolution, created for each process color. The halftone tapes are then read into the front-end File Manager. The front-end system stores four versions of the graphic, instead of one continuous tone version. It subsequently runs out four pages, one for each color, and combines the text with the black graphic of the page.

If a hard proof is required at the transmission site, the front-end system can create a tape to be output onto film and a suitable prepress color proof can be made from this film for color approval.

Once the 4/color page is approved, it is transmitted along with other text pages to each receiving site for image processing and reproduction. At present in the Character-Encoding system the text and graphic are transmitted together as color separated pages.

In the near future one user will be adapt their system with the capacity to transmit the text and graphics separately. Keeping the text and graphics independent is an advantage since the data intensive graphics can be transmitted ahead of time. The ASCII codes for the text can be left for immediate transmission, prior to printing.

2. Speed and Quality Levels

Generally, the type in the Character-Encoding system is of very high quality, relative to the other two systems. In effect, the text is generated locally through the receiving

photo imager, as a new "original." However, while superior quality type can be created with this approach, high quality halftones are not yet possible as will be described below.

The graphics whether black and white or color, like the type, are processed and transmitted as 8 bit byte codes. As stated earlier, it is important to note that the 8 bit codes for the graphics have the size, cropping, screening and resolution requirements already built into them prior to transmission. The receiving photo imager must convert the transmitted codes into the correct halftone font dots to match the densities, as closely as possible, to the original halftone image.

Processing and imaging the graphics with this method is considered by certain users to be an inherent disadvantage in this communication system. The speed/quality levels created effects the graphic reproduction capability at the receiving location.

In the CRT imagers presently used in this system, the main quality limitation is based on the inability of the CRT to resolve sharp dropout type or a fine enough halftone dot within a photograph. Halftones of 133 line per inch are basically the maximum that can be transmitted and run out on CRT photo imagers.

For 4/color editorial pages the color reproduced using a 133 lpi screen is considered to be adequate. However at present, the reproduction quality of this system is not

considered to be adequate for the quality requirements of 4/color advertising pages.

Advertising pages generally require higher line screen resolutions of 150 lines per inch or higher. The higher the resolution of the screen the more data is generated. More halftone dots necessitate an increase in the number of byte codes needed to encode them. Additional codes take longer to transmit, increasing significantly the time necessary to transmit each page.

The speed/quality level limitation in the Character-Encoding system is based on the resolution determined by the user. Once the amount of data to be encoded is determined, then the transmission time can be determined to transmit the required resolution data within a reasonable amount of time.

3. Data Compression

Essentially character-encoding is considered to be a form of data compression for both text and graphics.[6] In this system the amount of data that is transmitted to get a halftone dot created is much less than the 100 bits of information required if that same dot were built from pixels, as is done in System 3: Pixel Density-Map.

Bandwidth reduction is accomplished with this system through the use of specially designed transmission modems that binary encode the data into levels for transmission.

4. The Transmission System

Due to the method of encoding the data, the Character-Encoding transmission system can generally be handled with a narrow bandwidth transmission line. In many cases a voice grade 9,6ØØ Baud circuit is used. One user employs a new modem which transmits 16,8ØØ bits per second, through the same 9,6ØØ Baud lines; 19.2 KB modems will be available.

An example of a Character-Encoded transmission system, is the one used by Publisher's Phototype (PPI) for the weekly transmission of "Newsweek." In an article titled "Composition Takes To The Sky", PPI's transmission system is described as follows:[7]

> "Using its Codex digital communications system, PPI transmits through a landline to Western Union's Glenwood, N.J., microwave transmitter which is aimed at the WESTAR satellite. WESTAR retransmits the Newsweek editorial material to receivers at regional U.S. printing plants."

For "Newsweek's" international editions PPI transmits via satellite to Switzerland, Hong Kong, and Australia.

Presently this system operates on a point-to-point transmission mode. If desired, it is possible for this system to be adapted to a broadcast mode of transmission.

III - System 3: Pixel Density-Map

A. The General System Description

At present the type is set in a front-end typesetting system which uses symbolic ASCII codes. In the front-end

typesetting system used, the bit-maps for each of the text characters resides in the computer of the typesetter itself.

The text files are sent to a Raster Image Processor (RIP) which is used to convert the symbolic text language to raster form. The symbolics represent individual character shapes which are converted by the RIP to raster information.

The type resides temporarily in these symbolic character codes in the RIP. The RIP then expands the symbolic codes for use in the raster format needed. This conversion of text from symbolics to a raster format is necessary because the Pixel Density-Map system writes in a raster format. Symbolic codes are written in vector formats so the conversion from symbolics to raster is necessary.

The RIP conversion generally takes 2 to 5 minutes per page of text. Once the type is raster image processed, called ripping, the type can be called up on a preview screen console where it can be merged with the graphics, if necessary. A preview system is used to tint, drop out and manipulate the text in whatever way predetermined by the design layout of the page.

In most cases, the page design is a simple one, and the type is approved prior to ripping. Once the text is approved the type is ripped and stored for eventual transmission.

Ripping the type creates an intensive amount of data. At present, even with the data compression done in the RIP, the amount of data needed to encode the type into a raster

format is considered to be a problem by users of this system. Large amounts of storage are needed for the text.

It should be noted however, that there is also an advantage of ripping the type. Later in the transmission process the text becomes part of the graphics in this system. Once the type is ripped all the data is in a common format. The graphics and type can then be merged at the output of each receiving site. The major advantage in merging the text and graphics later on in the process, is less stripping is required. Also the text portion of any page can be closed last, which is the case in most publications.

In the Pixel Density-Map system, the 4/Color graphics are scanned in from the continuous tone original, and the density values are recorded and stored in pixel form.[8]

At the present time black and white graphics, and line art are also scanned on a color scanner and stored in pixel form. Only the black signal in the color scanner is used.[9]

The scanners used in this system have input graphic resolution ranges of 300 pixels per inch by 300 pixels per inch, to resolutions of 450 x 600.[10]

With a 300 x 300 input resolution the Pixel Density-Map system scanners can output screen rulings of 85 lpi up to 175 lpi, at each receiving location.

The File Manager computer in this system assembles the data from the text and graphics separately, and stores the

images, element by element, in pixels. Normally, for the quality requirements of this system the original continuous tone density information is quantized into 256 gray levels.

Other quantization levels are possible depending on the number of bits used, from 4 gray levels up to 512 gray levels. As more gray levels are used, more data is created for transmission and reception.

Continuous tone density data requires large system extensive computer storage capacity, for image assembly, transmission and imaging. As in System 1: Page Facsimile, Pixel Density-Map systems are data intensive systems. Some data compression is possible depending on the complexity of the original image.

It is important to note that with this system the halftone screen ruling is not selected when the original is scanned. Screen rulings and dot sizes are determined at each receiving site, based on press equipment, paper and other manufacturing requirements.

After the graphics are scanned from the continuous tone originals, or original line art, the images are usually called up on a preview console. At the preview console the 4/color images can be cropped, sized, and corrections can be made. The images are placed into the appropriate page format for that publication.

As in the other two communication system a hard proof is usually required prior to transmission for 4/color pages.

The photo imager at the transmission site can output the film for each 4/color page, usually without text, and an appropriate prepress proof can be made. Once the page is approved, the text and graphics are then ready for separate graphics data transmission.

At each receiving site the photo imager merges the text and graphics as one page image and stores them as density values, pixels, in the memory of the receiving computer. The transmitted density values are processed by the receiving photo imager, into screened images. This photo imager contains a halftoning computer, which is essentially the output part of a color scanner. A halftoning or screening computer is necessary at each receiving site.

Higher resolution data processing is possible with Pixel Density-Map. The tone reproduction requirements, such as screen rulings and dot size are controlled at each of the receiving sites for particular press conditions.

B. System 3: Pixel Density-Map Diagram

1. Transmission Site

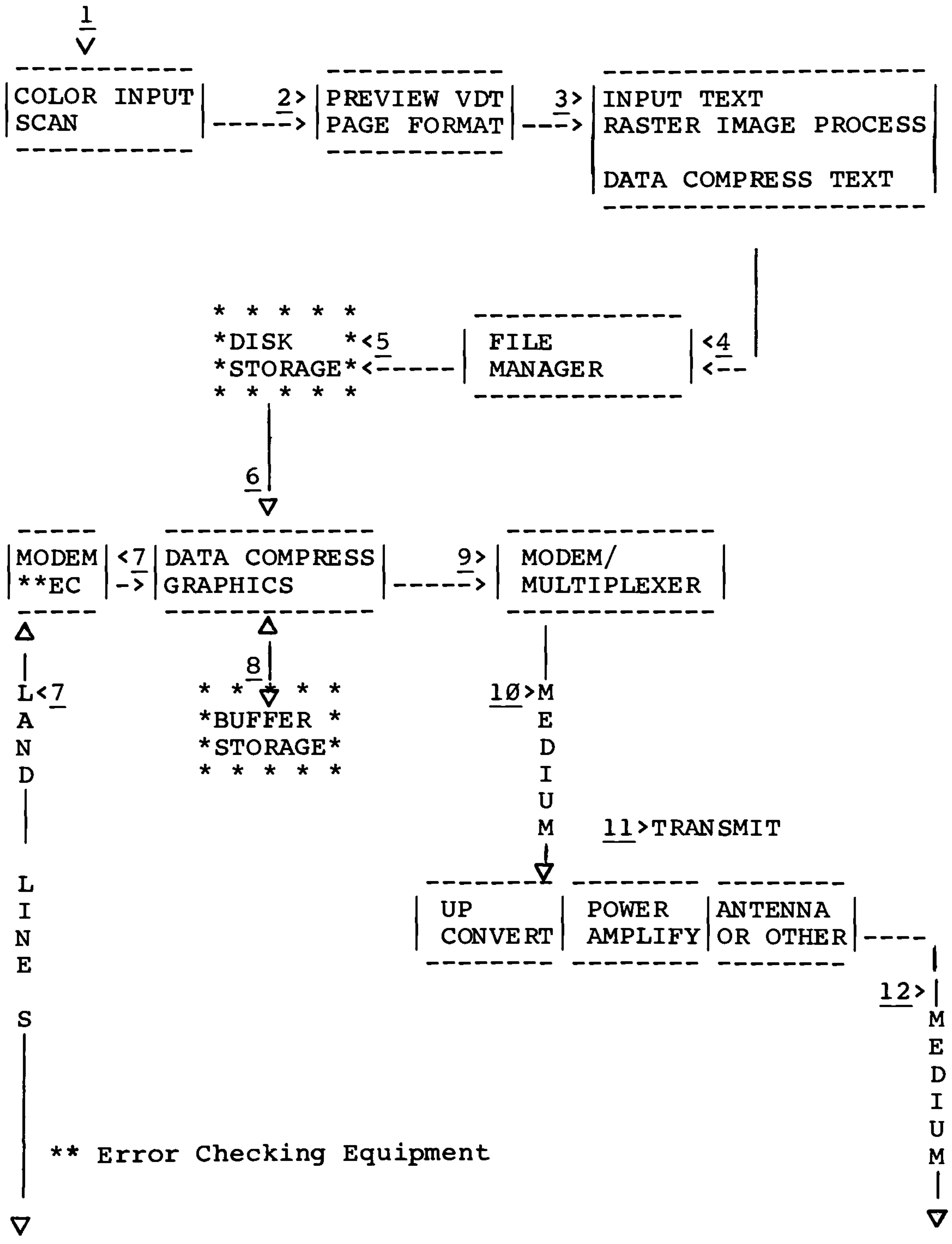
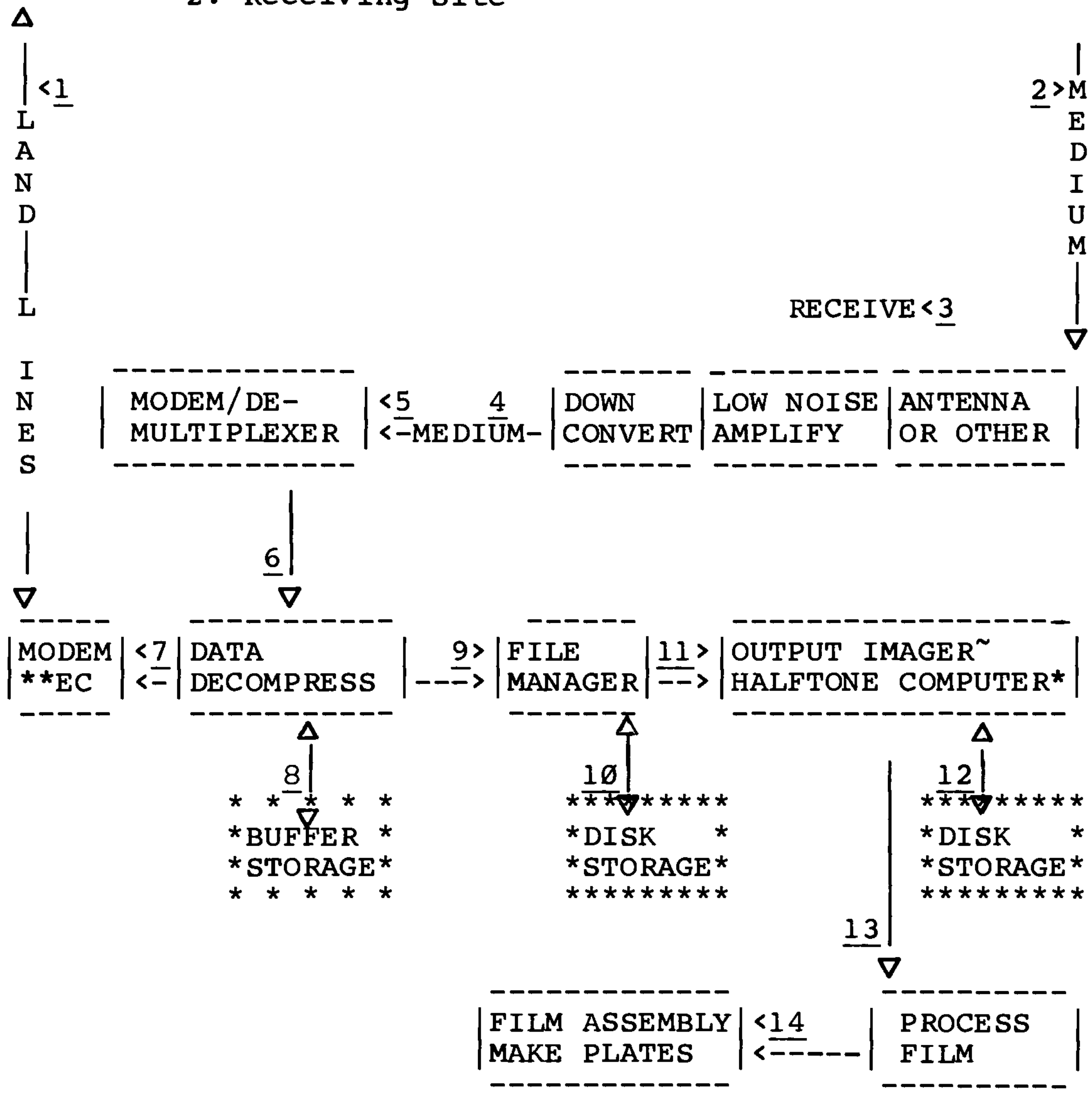


Figure 5: System 3 - Transmission Site Diagram

B. System 3: Pixel Density-Map Diagram

2. Receiving Site



* Graphics Screened At Receiving Site
** Error Checking Equipment
~ Text & Graphics Merged

Figure 6: System 3 - Receiving Site Diagram

C. Functional Description

1. Transmission Site

Please refer to Figure 5: System 3 - Transmission Site Diagram on page 47 for the following functional steps placed on that diagram:

Step 1: A color scanner is used to produce continuous tone color separations. Black & white and line art are also scanned. Film can be output if desired.

Step 2: A Preview System with a VDT is used for color manipulation and page formatting. Text material can also be previewed and manipulated if desired.

Step 3: Text is input via a front-end typesetting system. The text is raster image processed. The RIP is used to convert the type from symbolic codes to a raster format. Data compression of the text is done in the RIP.

Step 4: A File Manager is used to assemble the graphics and text into a page. All images are stored as pixel data. Text and graphics files are not merged at this time.

Step 5: Disk Storage are used to store all pixel data prior to transmission.

Step 6: Data compression of the graphics is done in preparation for transmission.

Step 7: A transmission modem, transmission landline and a receiving modem are used for error checking purposes.

Step 8: Buffer storage is used for data compression purposes.

Step 9: The modem unit modulates the compressed data for transmission. The multiplexer unit multiplexes signals from other sources for transmission.

Step 1Ø: An appropriate medium is used to transfer the data from the modem/multiplexer unit to the transmitter.

Step 11: The transmitter processes the signal through up conversion, power amplification and passes the signal to an antenna or other suitable device, for transmission.

Step 12: An appropriate transmission medium is used to transfer the signal from the transmitter to the receiver.

C. Functional Description

1. Receiving Site

Please refer to Figure 6: System 3 - Receiving Site Diagram on page 48 for the following functional steps placed on that diagram:

Step 1: Landlines are used for error checking purposes.

Step 2: An appropriate medium is used to transfer the signal from the transmitter to the receiver.

Step 3: The receiving unit receives the signal through an antenna or other suitable device, low noise amplifies it and down converts the signals.

Step 4: An appropriate transmission medium is used to transfer the received signal to the modem unit.

Step 5: The modem demodulates the signals in preparation for data decompression.

Step 6: The data is decompressed to its original form.

Step 7: A modem is used for error checking purposes.

Step 8: Buffer Storage is used for data decompression purposes.

Step 9: A File Manager is used to merge the text and graphics.

Step 1Ø: Disk storage is used to store pixel data, prior to image output.

Step 11: An output device, essentially the output part of a color scanner, uses a color computer to apply half-tone screens to images per color, per page. The black graphic and text are combined and output as one piece of film.

Step 12: Disk Storage is used in the output device.

Step 13: The film is processed.

Step 14: The final page film is stripped and plates are made.

D. Specific System Information

1. Color Transmission

For each 4/color page, three files are transmitted. The magenta, cyan and yellow printers for each page are transmitted in advance. Once the text is approved and ripped, it is sent as a separate file along with the black printer. Upon receipt at each receiving site, the black printer and the text are merged.

2. Speed and Quality Levels

The Pixel Density-Map system scans every element of the graphics into density levels, stored pixel by pixel. This method of encoding the data is very data intensive. Ripping the type creates large amounts of data as well. The large amounts of total data per page to be transmitted requires the used of sophisticated controllers on both the transmission and receiving end of the communication system to process the data flow. Extensive storage capacity must be built into the entire system design.

There is also a significant benefit of the storage capability required to operate this system. This storage can serve as a buffer for graphic data compression applications, as well as for determining a time to conduct the actual transmission. The data can be transmitted at whatever rate and time predetermined by the user, through the use of transmission protocols.

In order to transmit this amount of data in a reasonable amount of time, broader bandwidth communication lines are a necessity. Higher speed transmission lines, "T-1" for example, are well suited to the Pixel Density-Map system. These broad bandwidth lines, although offering the advantage of speed, are relatively more expensive when compared to the narrow bandwidth transmission lines used by System 2.

If a number of receiving sites are used then transmission can take place via satellite in a broadcast mode.

3. Data Compression Techniques

Various data compression algorithms are used in the Pixel Density-Map system. Generally the graphics are compressed to an average ratio of 1Ø:1. Text are compressed to an average ratio of 4:1. Other data compression ratios are possible based on the complexity of the original image.

As in the other two systems in the study, bandwidth reduction can be accomplished with this system through the use of specially designed transmission modems.

4. The Transmission System

Transmission can take place in a broadcast mode to all the receiving locations via satellite. This decision is based on the user's needs and the number of remote receiving locations.

The Density-Map system in place at Time Inc. for its publication "TIME" uses "T-1" digital lines. It should be

noted however that at present the transmission rates used with the "TIME" system are half the available bandwidth. Specifically, .768 megabits per second. This is a variable rate chosen by the user of this communication system.

E. System Similarities and Differences

All three of the systems use front-end typesetting systems, electronic color scanners and similar transmission system designs. Many of the differences are based on the level of sophistication of the system components, and the technology level at the time the original communication system design was developed. There are however inherent specific differences in the operation of each system. These differences are as follows:

System 1: Page Facsimile

1. Conventional paste up and scanning of a page print.

2. All graphics are pre-screened prior to transmission.

3. All the graphic information in the print is transmitted element by element. An exact duplicate of the page print is reproduced at the receiving location.

4. Simple photo imagers are in place at each receiving location.

5. This system is capable of transmitting all editorial and advertising pages.

System 2: Character-Encoding

1. All text and graphics (including photographs) data elements are assigned symbolic character codes prior to transmission.

2. All photographs are prescreened prior to transmission.

3. Text and graphics are merged prior to transmission.

4. Only symbolic character codes for the text and 8 bit byte codes for the graphics are transmitted.

5. An intelligent photo imager, for local font generation, must be in place at each receiving location.

6. Local font generation creates another original at the receiving location.

7. All black & white pages are transmitted. A limited amount of color text pages are transmitted. At present, the majority of color text pages and all advertising pages are shipped conventionally.

System 3: Pixel Density-Map

1. All photographs (including graphics) are assigned density values prior to transmission. All the text is raster image processed prior to transmission.

2. Continuous tone density values are transmitted. Halftone screening requirements are applied at the receiving location.

3. Text and graphics are kept separate prior to transmission. They are merged at the receiving location.

4. The output part of a color scanner, including the color computer, must be in place at each receiving location.

5. The output part of the system creates another original at the receiving location.

6. All editorial pages including color pages are transmitted. Advertising pages are shipped conventionally. This system has the potential to transmit all parts of the publication, including advertising pages.

FOOTNOTES - CHAPTER II

1
"The Technology Behind USA TODAY", published by the Gannett Company. December 5, 1985.

2
"Page Facsimile in the Eighties", by Richard E, Amtower, 1981 TAGA Proceedings. Page 268.

3
Ibid. Page 268.

4
ASCII is an 8 bit code set. Other character code standards exist but ASCII is commonly used in publishing and will be used herein.

5
Usually new fonts are scanned and loaded onto a magnetic tape that is physically sent to each remote imager site to be added to the local font disk library.

6
One character-encoding system studied uses a CCU with a 4:1 compression ratio built into the graphics.

7
Graphic Arts Monthly, April 1983 issue. Page 43.

8
A pixel is a contraction for a picture element. Pixels are continuous tone density data.

9
Other methods of producing black and white graphics are being considered at this time.

1Ø
Other input resolution options include 3ØØ x 45Ø, 6ØØ x 6ØØ and 45Ø x 6ØØ.

CHAPTER III

COMMUNICATION SYSTEM COST ANALYSIS

I. Methodology

A. Purpose of the Cost Analysis:

The System Cost Analysis is intended to provide approximate cost information for the operation of each communication system. This information is intended for comparison purposes only.

The analysis is comprised of the following approximate costs: components, data storage, error checking, system maintenance, transmission media and the costs of additional remote receiving sites for each communication system. These approximate costs have been obtained by contacting current users of each communication system. Also contacted were technical representatives from equipment manufacturers and companies supplying transmission services for each communication system.

In some instances cost data has not been made available to the author. In these cases, the author has approximated costs based on the available data from the other communication systems. All author approximations are noted as they occur, in each section of the cost analysis.

B. Items Analyzed:

1. System Components: An analysis of system component requirements, i.e. all operating equipment, including error checking, for the transmission site and a receiving site. Included are the costs of these components for each communication system.

2. System Data Storage: An analysis of system data storage requirements at the transmission site and a receiving site. Included are the costs of this storage for each communication system.

3. Error Checking: An analysis of the costs of error checking service for a transmission site and a receiving site, computed on a monthly basis, for each communication system.

4. System Maintenance: An analysis of the cost of system maintenance for a transmission site and receiving site, computed on a monthly basis, for each communication system.

5. System Transmission Media: An analysis of the transmission media currently used by each communication system, and the costs of the transmission media, computed on a monthly basis for each communication system.

6. Overall System Cost Comparison and Evaluation: A comparison and evaluation of the overall costs, based on the use of one receiving location for each communication system. Also Included are pre-press costs per issue for each communication system.

7. Multiple Receiving Sites: An analysis and evaluation of the costs of additional receiving locations for each communication system.

II - System 1: Page Facsimile

A. System Components:

1. Transmission Site

	Costs
Front-end typesetting system -----------	$ 99,000
Camera for B&W halftones ---------------	$ 89,000
Input color scanner - ------------------	$329,000
Facsimile scanner ---------------------- (includes buffer storage)	$125,100
Data compressor ------------------------	$ 92,500
Total ---	$734,600

2. Remote Receiving Site/per site

	Costs
Data decompressor ----------------------	$ 77,900
Output facsimile imager ---------------- (includes buffer storage)	$125,350
Film processor -------------------------	$ 18,000
Total ---	$221,250

B. Transmission Components:

1. Transmission Site

	Costs
Earth Station Antenna, RF, Up Converter, LNA (power amplifier), waveguide -----	$200,000
Civil Works (mounting, foundation work roof or on land 125 miles) -------------	$ 45,000
Modems & Digital Equipment a TMT (Transmission Monitor Terminal) including 2/152.6 KB channels (2 Redundant TMT, (could be used as 4) -----------------	$140,000
Shout down circuit (for site contacts) -	$ 50,000
Total ---	$435,000

2. Remote Receiving Site/per site — Costs

Earth Station, LNA, Down Convert	$ 50,ØØØ
Civil Works	$ 25,ØØØ
Terminal (Redundant Receive)	$ 90,ØØØ
Shout down channel (FM)	$ 10,ØØØ
Total	$175,ØØØ

C. Error Checking Components:

1. Transmission Site — Costs

Capital cost per channel $18,ØØØ x 2 ---- $ 36,ØØØ

2. Remote Receiving Site/per site — Costs

Transmission modem ---------------------- $ 5,ØØØ

D. System Data Storage:

1. Transmission Site — Costs

A minimal amount of data storage is used in this system. The data storage is built into the component costs.

2. Remote Receiving Site/per site — Costs

A minimal amount of data storage is used in this system. The data storage is built into the component costs.

E. Error Checking Service/per month — Costs

1. Transmission to 1 Remote Receiving Site

Error checking equipment, per site
2 channels ---------------------------- $1,ØØØ/mo.
(includes hardware & software)

F. System Component Maintenance/per month:

1. Transmission Site — Costs

Transmission component maintenance ----- $ 7ØØ/mo.

2. Remote Receiving Site/per site — Costs

Component system maintenance ----------- $ 4ØØ/mo.

G. Transmission System Maintenance/per month:

1. Transmission Site — Costs

System maintenance ---------------------- $1,450/mo.

2. Remote Receiving Site/per site — Costs

System maintenance --------------------- $ 365/mo.

H. Transmission Media/per month:

1. Transmission to 1 Remote Receiving Site

Space segment (transponder rental) per month is charged per channel ($6,500/mo.) for 2 channels ----------- $13,000/mo.

I. Pre-press (includes stripping & plates):

Based on 50 - 4/color newspaper pages — Costs

Mechanical paste-up ---	Labor ---	$15/page x 50 =	$750 x 4 =	$3,000
	Mat'ls --	1/page x 50 =	50 x 4 =	200
Line shot ---	Labor ---	$1/shot x 50 =	50 x 4 =	200
	Mat'ls --	1.60/shot x 50 =	80 x 4 =	320
Velox -------	Labor ---	$1/sheet x 50 =	50 x 4 =	200
	Mat'ls --	1.50/sheet x 50 =	75 x 4 =	300
Plates ------	Labor ----	$1/plate* x 50 =	50 x 4 =	200
per page	Mat'ls ---	1/plate* x 50 =	50 x 4 =	200
			Total ---	$4,620+

+ approximation based on available data.

J. Total System Costs:

Table 1: System 1 - Total System Costs

1. System Components:

Transmission Site --------------------	$ 734,600
1 Remote Receiving Site --------------	$ 221,250
Total System Components ------	$ 955,850

2. Transmission Components:

Transmission Site --------------------	$ 435,000
1 Remote Receiving Site --------------	$ 175,000
Total Transmission Components -----	$ 610,000

3. Error Checking Components:

Transmission Site ------------------- *based on 2 transmission channels	$ 36,000*
1 Remote Receiving Site ------------	$ 5,000
Total Error Checking Components -----	$ 41,000

TOTAL COMPONENTS ------ $1,606,850

4. System Data Storage:

Transmission site -------------------	$ **
1 Remote Receiving Site --------------	$ **
Total System Storage -----	$ **

** a limited amount of storage is built into the components in this system.

5. Error Checking Service/per month:

Transmission to 1 Remote Receiving Site ------------- *based on 2 transmission channels	$ 1,000/mo.*

6. System Component Maintenance/per month:

Transmission site -------------------	$ 700/mo.
1 Remote Receiving Site -------------	$ 400/mo.
Total System Component Maintenance ---	$ 1,100/mo.

7. Transmission System Maintenance/per month:

Transmission site -------------------	$ 1,450/mo.
1 Remote Receiving site -------------	$ 365/mo.
Total Transmission System Maintenance --	$ 1,815/mo.

TOTAL SYSTEM MAINTENANCE -- $ 2,915/mo.

8. Transmission Media/per month

Transmission to
1 Remote Receiving Site ------------ $ 13,ØØØ/mo.*
*based on 2 transmission channels

9. Pre-Press

Stripping & Plates/per issue* ------ $ 4,62Ø+
*based on 5Ø - 4/color newspaper pages
+ approximation based on available data.

III - System 2: Character-Encoding

A. System Components:

1. Transmission Site

	Costs
Color input scanner ------------------	$ 25Ø,ØØØ
Preview VDT (including storage) ------	$ 395,ØØØ
Color Conversion Unit --------------	$ 15Ø,ØØØ
File Manager -------------------------	$ 75,ØØØ
Scanner for B&W graphics -------------	$ 2ØØ,ØØØ
Front-end typesetting system and the photo imager -------------------	$ 275,ØØØ
Total ---	$1,345,ØØØ

2. Remote Receiving Site/per site

	Costs
Output photo imager ------------------ (includes photo copy output device)	$ 275,ØØØ
Film processor ---------------------	$ 2Ø,ØØØ
Total ---	$ 295,ØØØ

B. Transmission Components:

1. Transmission Site

	Costs
Transmission modem -------------------	$ 15,ØØØ
CPU to control disk & transmission ---	$ 75,ØØØ
*or Tape transmitter ----------- or --	13,ØØØ
Total ---	$ 9Ø,ØØØ#
*or Total ---	$ 28,ØØØ

* either can be used.
\# the larger number is used in the Components Total

2. Remote Receiving Site/per site — Costs

Receiver modem ------------------------	$	15,000
CPU to control disk and transmission -	$	75,000
*or tape drive ----------------- or --		13,000
* either can be used. Total ---	$	90,000#
# the larger number is used in the Components Total *or Total ---	$	28,000

C. Error Checking Components:

1. Transmission Site — Costs

Transmission modem -------------------	$	5,000+

2. Remote Receiving Site/per site — Costs

Receiver modem ----------------------	$	5,000+

+ approximation based on available data

D. System Data Storage:

1. Transmission Site — Costs

300 MegaByte Disks 4 @ $13,000 -----	$	52,000

2. Remote Receiving Site/per site — Costs

300 MB Disks 2* @ $13,000 -------------	$	26,000

*1 minimum 2 disks if backup needed.

E. Error Checking Service/per month:

1. Transmission to 1 Remote Receiving Site

Cost of error checking service ----------- *

*costs are included in transmission media cost per month

F. System Component Maintenance/per month:

1. Transmission Site — Costs

Transmission component maintenance ----- $10,140/mo.

2. Remote Receiving Site/per site — Costs

Maintenance for photo imager ---------- $ 2,848/mo.

G. Transmission System Maintenance/per month:

1. Transmission Site — Costs

Maintenance for the entire transmission system -------------------	*

*included in transmission media cost per month

2. Remote Receiving Site/per site — Costs

Maintenance for the entire receiving system ----------------------	*

*included in transmission media cost per month

H. Transmission Media/per month:

1. Point-to-point transmission to 1 Remote Receiving Site

For 1 Site --------------------------	$ 960/mo.*

*does not include equipment costs (modems)

I. Pre-press (includes stripping and plates):

Cost of stripping (all prepress)	per issue	$16,690
Cost of plates -----------------	per issue	17,300
	Total ---	$33,990*

*based on an 80 page news-weekly issue

J. Total System Costs:

Table 2: System 2 - Total System Costs

1. System Components:

Transmission Site --------------------	$1,345,000
1 Remote Receiving Site --------------	$ 295,000
Total System Components -------	$1,640,000

2. Transmission Components:

Transmission Site --------------------	$ 90,000
1 Remote Receiving Site --------------	$ 90,000
Total Transmission Components ------	$ 180,000

3. Error Checking Components:

Transmission Site -------------------	$	5,000+
1 Remote Receiving Site ------------	$	5,000+
Total Error Checking Components -----	$	10,000+

+ approximation based on available data.

TOTAL COMPONENTS -----	$1,680,000	

4. System Data Storage:

Transmission site -------------------	$	52,000
1 Remote Receiving Site -------------	$	26,000
Total System Storage ------	$	78,000

5. Error Checking Service/per month:

Transmission to 1 Remote Receiving Site -------------	$	** /mo.

** included in transmission media costs.

6. System Component Maintenance/per month:

Transmission site -------------------	$	10,150/mo.
1 Remote Receiving Site -------------	$	2,850/mo.
Total System Component Maintenance -	$	13,000/mo.

7. Transmission System Maintenance/per month

Transmission site -------------------	$	** /mo.
1 Remote Receiving site -------------	$	** /mo.
Total Transmission System Maintenance --	$	** /mo.

** included in transmission media costs.

TOTAL SYSTEM MAINTENANCE ----	$	13,000/mo.

8. Transmission Media/per month

Transmission to 1 Remote Receiving Site ------------	$	960/mo.

9. Pre-press:

Stripping & Plates/per issue -------	$	34,000*

*based on an 80 page news-weekly issue

IV - System 3: Pixel Density-Map

A. System Components:

1. Transmission Site

	Costs
Input color scanner	$ 395,000
Preview VDT (includes file manager & storage)	$ 700,000
Front-end typesetting system (includes the Raster Image Processor)	$ 90,000
Data compressor	$ 120,000
Total	$1,305,000

2. Remote Receiving Site/per site

	Costs
Data decompressor	$ 100,000
File Manager	$ 75,000*
Output scanner (color computer)	$ 350,000
Film processor	$ 20,000*
Total	$ 545,000+

*Cost approximated from System 2 data.
+Total approximation based on available data.

B. Transmission Components:

1. Transmission Site

	Costs
Transmission modem	$ 15,000*

*Cost approximated from System 2 data.

2. Remote Receiving Site/per site

	Costs
Receiver modem	$ 15,000*
Approximate cost for a receive Earth Station (depends on the user)	$ 400,000+
Total	$ 415,000+

*Cost approximated from System 2 data.
\+ Total approximation based on available data.

C. Error Checking Components:

1. Transmission Site — Costs

Error checking equipment ------------- $ 18,000*
(includes hardware & software)

*based on data from System 1, cost based on 1 channel.

2. Remote Receiving Site/per site — Costs

Error checking equipment -------------- $ 5,000*
(includes hardware & software)

*Approximate cost for modem from System 1 data.

D. System Data Storage:

1. Transmission Site

	Costs
18 disk packs @ $900 each -----------	$ 16,200
4* drives @ $28,000 each -------------	$112,000
Total ---	$128,200+

* used 4 drives for approximation.
+ approximation based on available data.

2. Remote Receiving Site/per site

	Costs
8 disk packs @ $900 each --------------	$ 7,200
2 drives @ $28,000 each ---------------	$ 56,000
Total ---	$ 63,200

E. Error Checking Service/per month:

1. Transmission to 1 Remote
Receiving Site ------------------------ $ 500/mo.*

*Approximated from data on System 1
for 1 transmission channel.

F. System Component Maintenance/per month:

1. Transmission Site — Costs

Transmission component maintenance ---- $10,000/mo.+
+Approximation based on available data.

2. Remote Receiving Site/per site — Costs

Receive component maintenance ------- $ 5,ØØØ/mo.+
+Approximation based on available data.

G. Transmission System Maintenance/per month:

1. Transmission Site — Costs

Maintenance is built into the Transmission media cost per month.

2. Remote Receiving Site/per site — Costs

Maintenance is built into the Transmission media cost per month.

H. Transmission Media/per month:

1. Broadcast Transmission to 1 Remote Receiving Site, Access T-1 line to Earth Station ---------------------- $ 2,5ØØ/mo.

2. Shared Earth Station (a.k.a. the Hub or transmit terminal) --------- $ 2,521/mo.

3. Space Segment (dedicated) ------------ $ 9,297/mo.
Total --- $14,318/mo.

I. Pre-press (includes stripping & plates):

Pre-press/per issue --------------------- $ 34,ØØØ*+
*based on an 8Ø page news-weekly issue.
+ Approximation based on data from System 2.

J. Total System Costs:

Table 3: System 3 - Total System Costs

1. System Components:

Transmission Site ---------------------	$1,3Ø5,ØØØ
1 Remote Receiving Site ---------------	$ 545,ØØØ
Total System Components -------	$1,85Ø,ØØØ

2. Transmission Components:

Transmission Site ---------------------	$ 15,ØØØ+
1 Remote Receiving Site ---------------	$ 415,ØØØ+
Total Transmission Components ------	$ 43Ø,ØØØ+

3. Error Checking Components:

Transmission Site --------------------	$ 18,ØØØ+
1 Remote Receiving Site -------------	$ 5,ØØØ+
Total Error Checking Components ------	$ 23,ØØØ+
TOTAL COMPONENTS ------	$2,3Ø3,ØØØ+

4. System Data Storage:

Transmission site --------------------	$ 128,2ØØ+
1 Remote Receiving Site -------------	$ 63,2ØØ
Total System Storage ------	$ 191,4ØØ+

5. Error Checking Service/per month:

Transmission to 1 Remote Receiving Site -------------	$ 5ØØ/mo.+

6. System Component Maintenance/per month:

Transmission site -----------------	$ 1Ø,ØØØ/mo.+
1 Remote Receiving Site -----------	$ 5,ØØØ/mo.+
Total System Component Maintenance -	$ 15,ØØØ/mo.+

7. Transmission System Maintenance/per month:

Transmission site -----------------	$ ** /mo.
1 Remote Receiving site -----------	$ ** /mo.
Total Transmission System Maintenance -	$ ** /mo.

** included in transmission media costs.

TOTAL SYSTEM MAINTENANCE ---	$ 15,ØØØ/mo.+

+ approximation based on available data.

8. Transmission Media/per month:

Transmission to 1 Remote Receiving Site -----------	$ 14,318/mo.

9. Pre-Press:

Stripping & Plates/per issue -----	$ 34,ØØØ*+

*based on an 8Ø page news-weekly issue.
+ approximation based on available data.

V - System Costs Comparisons

Table 4: System Costs Comparisons

	System 1	System 2	System 3
SYSTEM COMPONENTS			
Transmission Site --	$ 734,6ØØ	$1,345,ØØØ	$1,3Ø5,ØØØ
1 Receiving Site ---	221,25Ø	295,ØØØ	545,ØØØ+
TRANSMISSION COMPONENTS			
Transmission Site --	$ 435,ØØØ	$ 9Ø,ØØØ	$ 15,ØØØ+
1 Receiving Site --	175,ØØØ	9Ø,ØØØ	415,ØØØ+
ERROR CHECKING COMPONENTS			
Transmission Site --	$ 36,ØØØ	$ 5,ØØØ+	$ 18,ØØØ+
1 Receiving Site ---	5,ØØØ	5,ØØØ+	5,ØØØ+
TOTAL COMPONENTS	$1,6Ø6,85Ø	$1,83Ø,ØØØ+	$2,3Ø3,ØØØ+
SYSTEM STORAGE			
Transmission Site --	*	$ 52,ØØØ	$ 128,2ØØ+
1 Receiving Site ---	*	26,ØØØ	63,2ØØ
TOTAL SYSTEM STORAGE	----	$ 78,ØØØ	$ 191,4ØØ+
TRANSMISSION MEDIA/for 1 receiving site			
Transmission/month -	$ 13,ØØØ	$ 96Ø	$ 14,318
ERROR CHECKING/for 1 receiving site			
Service/month ------	$ 1,ØØØ	$ **	$ 5ØØ+
SYSTEM COMPONENT MAINTENANCE/per month			
Transmission Site --	$ 7ØØ	$ 1Ø,15Ø	$ 1Ø,ØØØ+
1 Receiving Site ---	4ØØ	2,85Ø	5,ØØØ+
TRANSMISSION SYSTEM MAINTENANCE/per month			
Transmission Site --	$ 1,45Ø	$ **	$ **
1 Receiving Site ---	365	**	**
TOTAL SYSTEM MAINTENANCE --	$ 2,915	$ 13,ØØØ	$ 15,ØØØ+

PRE-PRESS/per issue

Stripping & Plates	$ 4,620~	$34,000^	$34,000^

\+ approximation based on available data.
* a limited amount of storage is built into the components of System 1.
** included in transmission media costs.
~ based on 50 - 4/color newspaper pages.
^ based on 80 - 4/color news-weekly pages.

VI - Summary and Evaluation of Total System Costs

All total costs are based on the use of a central transmission site and 1 remote receiving site

A. Total Components:

System 1: ------- $1,606,850

System 2: ------- $1,830,000+

System 3: ------- $2,303,000+

Evaluation: System 3 requires the use of the most expensive system components.

B. Total System Storage:

System 1: ------- not used

System 2: ------- $ 78,000

System 3: ------- $ 191,400+

Evaluation: System 3 requires the most system data storage capacity.

C. Error Checking Service:

System 1: ------ $ 1,000/month

System 2: ------ included in transmission media costs

System 3: ------ $ 500/month+

\+ approximation based on available data.

Evaluation: Based on the available data, System 1 requires the most error checking expense per month for this service.

D. Total System Maintenance:

System 1:	------	$	2,915/month
System 2:	------	$	13,ØØØ/month
System 3:	------	$	15,ØØØ/month+

+ approximation based on available data.

Evaluation: Based on the available data, System 3 requires the most expense per month for this service.

E. Transmission Media:

System 1:	-------	$	13,ØØØ/month
System 2:	------	$	96Ø/month
System 3:	------	$	14,318/month

Evaluation: The present system design for System 3 uses the most expensive transmission lines. System 1 is close to the same cost per month.

System 2 is significantly less expensive for transmission.

F. Pre-Press/per issue

System 1:	------	$	4,62Ø/issue
System 2:	------	$	34,ØØØ/issue
System 3:	------	$	34,ØØØ/issue+

+ approximation based on available data.

Evaluation: Based on the available data, System 1 costs much less per issue for pre-press then the other two systems.

VII - Costs Comparisons for Receive Sites/per site

Table 5: Costs of 1 Remote Receiving Site

	System 1	System 2	System 3
SYSTEM COMPONENTS			
1 Receiving Site --	$ 221,250	$ 295,000	$ 545,000+
TRANSMISSION COMPONENTS			
1 Receiving Site --	175,000	90,000	415,000+
ERROR CHECKING COMPONENTS			
1 Receiving Site --	5,000	5,000+	5,000+
TOTAL COMPONENTS	$ 401,250	$ 390,000+	$ 965,000+
SYSTEM STORAGE			
1 Receiving Site --	*	$ 26,000	$ 63,200
TRANSMISSION MEDIA/for 1 receiving site			
Transmission/month -	$ 13,000	$ 960	$ 14,318
ERROR CHECKING/for 1 receiving site			
Service/month ------	$ 1,000	$ **	$ 500+
SYSTEM COMPONENT MAINTENANCE/per month			
1 Receiving Site ---	$ 400	$ 2,850	$ 5,000+
TRANSMISSION SYSTEM MAINTENANCE/per month			
1 Receiving Site ---	$ 365	$ **	$ **
PRE-PRESS/per issue			
Stripping & Plates -	$ 4,620~	$ 34,000^	$ 34,000^

+ approximation based on available data.
* a limited amount of storage is built into the components of System 1.
** included in transmission media costs.
~ based on 50 - 4/color newspaper pages.
^ based on 80 - 4/color news-weekly pages.

VIII - Multiple Receiving Sites

A. System 1: Page Facsimile

Table 6: System 1 - Multiple Site Costs

Number of Sites	All Components	Storage	Trans Media per month	Error Checking & Maintenance per month
1 ----	$ 4Ø1,25Ø	$ *	$ 13,ØØØ	$ 1,765
5 ----	$ 2,ØØ6,25Ø	$ *	$ 13,ØØØ	$ 8,825
1Ø ----	$ 4,Ø12,5ØØ	$ *	$ 13,ØØØ	$ 17,65Ø
15 ----	$ 6,Ø18,75Ø	$ *	$ 13,ØØØ	$ 26,475
2Ø ----	$ 8,Ø25,ØØØ	$ *	$ 13,ØØØ	$ 35,3ØØ
25 ----	$1Ø,Ø31,25Ø	$ *	$ 13,ØØØ	$ 44,125
3Ø ----	$12,Ø37,5ØØ	$ *	$ 13,ØØØ	$ 52,95Ø

B. System 2: Character-Encoding

Table 7: System 2 - Multiple Site Costs

Number of Sites	All Components	Storage	Trans Media per month	Error Checking & Maintenance per month
1 ----	$ 39Ø,ØØØ	$ 26,ØØØ	$ 96Ø	$ 2,85Ø
5 ----	$ 1,95Ø,ØØØ	$ 13Ø,ØØØ	$ 4,8ØØ	$ 14,25Ø
1Ø ----	$ 3,9ØØ,ØØØ	$ 26Ø,ØØØ	$ 9,6ØØ	$ 28,5ØØ
15 ----	$ 5,85Ø,ØØØ	$ 39Ø,ØØØ	$ 14,4ØØ	$ 42,75Ø
2Ø ----	$ 7,8ØØ,ØØØ	$ 52Ø,ØØØ	$ 19,2ØØ	$ 57,ØØØ
25 ----	$ 9,75Ø,ØØØ	$ 65Ø,ØØØ	$ 24,ØØØ	$ 71,25Ø
3Ø ----	$11,7ØØ,ØØØ	$ 78Ø,ØØØ	$ 28,8ØØ	$ 85,5ØØ

C. System 3: Pixel Density-Map

Table 8: System 3 - Multiple Site Costs

Number of Sites	All Components	Storage	Trans Media per month	Error Checking & Maintenance per month
1 ----	$ 965,000	$ 63,200	$ 14,318	$ 5,500
5 ----	$ 4,825,000	$ 316,000	$ 14,318	$ 27,500
10 ----	$ 9,650,000	$ 632,000	$ 14,318	$ 55,000
15 ----	$14,475,000	$ 948,000	$ 14,318	$ 82,500
20 ----	$19,300,000	$1,264,000	$ 14,318	$ 110,000
25 ----	$24,125,000	$1,580,000	$ 14,318	$ 137,500
30 ----	$28,950,000	$1,896,000	$ 14,318	$ 165,000

D. Multiple Site Comparisons:

Table 9: Multiple Site Costs Comparisons

1. Components:	System 1	System 2	System 3
1 Remote Site ----	$ 401,250	$ 390,000	$ 965,000
5 Remote Sites ----	$ 2,006,250	$ 1,950,000	$ 4,825,000
10 Remote Sites ---	$ 4,012,500	$ 3,900,000	$ 9,650,000
15 Remote Sites ---	$ 6,018,750	$ 5,850,000	$14,475,000
20 Remote Sites ---	$ 8,025,000	$ 7,800,000	$19,300,000
25 Remote Sites ---	$10,031,250	$ 9,750,000	$24,125,000
30 Remote Sites ---	$12,037,500	$11,700,000	$28,950,000

Evaluation: System 2 costs the least for additional remote sites in terms of the components costs required at each receiving site.

System 3 is significantly more expensive than the other two systems for the costs of components required at each receiving site.

2. Data Storage:

	System 1	System 2	System 3
1 Remote Site ----	$ *	$ 26,000	$ 63,200
5 Remote Sites ----	$ *	$ 130,000	$ 316,000
10 Remote Sites ---	$ *	$ 260,000	$ 632,000
15 Remote Sites ---	$ *	$ 390,000	$ 948,000
20 Remote Sites ---	$ *	$ 520,000	$1,264,000
25 Remote Sites ---	$ *	$ 650,000	$1,580,000
30 Remote Sites ---	$ *	$ 780,000	$1,896,000

Evaluation: System 3 requires the most expense for data storage required at each receiving site.

3. Error Checking and Maintenance/per month:

	System 1	System 2	System 3
1 Remote Site ----	$ 1,765	$ 2,850	$ 5,500
5 Remote Sites ----	$ 8,825	$ 14,250	$ 27,500
10 Remote Sites ---	$ 17,650	$ 28,500	$ 55,000
15 Remote Sites ---	$ 26,475	$ 42,750	$ 82,500
20 Remote Sites ---	$ 35,300	$ 57,000	$ 110,000
25 Remote Sites ---	$ 44,125	$ 71,250	$ 137,500
30 Remote Sites ---	$ 52,950	$ 85,500	$ 165,000

Evaluation: System 3 requires the most expense per month for error checking and maintenance service for each receiving site.

4. Transmission Media/per month:

	System 1	System 2	System 3
1 Remote Site ----	$ 13,000	$ 960	$ 14,318
5 Remote Sites ----	$ 13,000	$ 4,800	$ 14,318
10 Remote Sites ---	$ 13,000	$ 9,600	$ 14,318
15 Remote Sites ---	$ 13,000	$ 14,400	$ 14,318
20 Remote Sites ---	$ 13,000	$ 19,200	$ 14,318
25 Remote Sites ---	$ 13,000	$ 24,000	$ 14,318
30 Remote Sites ---	$ 13,000	$ 28,800	$ 14,318

Evaluation: At present System 2 is designed as a point-to-point transmission system. As a result, System 2 is significantly more expensive than the other systems in terms of transmission media costs per month, for additional receiving locations.

COMMUNICATION SYSTEM PERFORMANCE

I - Methodology: System Capacity Analysis

A. Purpose of the Analysis:

For the purposes of this study System Capacity refers to the amount of graphic data, and the transmission time required for transmission by each communication system.

The purpose of this Capacity Analysis is to determine the approximate amount of graphic data, calculated at different line screens using a standard 4/color page, required by each communication system to encode a sample original image for transmission to a remote location. Generally, the higher the line screen the better the reproduction quality of the 4/color subject.

Also analyzed is the length of time required to transmit that standard page by each communication system using different data rate transmission lines.

B. Items Analyzed:

1. **The** Standard Page: For comparison purposes, a standard page was developed by the author, to determine the number of bits needed to encode the same subject by each communication system in the study.

The standard page specifications are as follows:

Size: 8-5/16" x 11-3/16"
Color: Three 4/color subjects
= 65 sq. inches of graphics.
Text: 4Ø lines with an average of 33
text characters per line;
= total of 1,465 characters
= 15 sq. inches of text.

a. Calculations were made, for each system, to determine the approximate amount of bits necessary to encode the standard page, for the following line screens:

1) 85 lines per inch
2) 11Ø lines per inch
3) 133 lines per inch
4) 15Ø lines per inch

2. Transmission Data Rates: The number of bits needed to encode the standard page at each line screen, are used to determine the approximate length of transmission time using 6 different data rate transmission lines.

a. The following are the 6 different transmission data rates used to approximate the transmission time for each system:

1) -- 9,6ØØ bits per second
2) -- 16,8ØØ bits per second
3) -- 56,ØØØ bits per second
4) - 152,6ØØ bits per second
5) - 772,ØØØ bits per second
6) 1,544,ØØØ bits per second

II - Encoding the Standard Page

A. System 1: Page Facsimile

1. Contents of the standard page:

Graphics ------- = 65 square inches.
Text ----------- = 15 square inches.

2. System compression ratios:

Graphics -------- = 5:1
Text ------------ = 15:1

3. Graphic line screens calculations: For calculation purposes the highlight dot size for System 1 is based on 2 pixels per 5% highlight dot. See Appendix F for pixel size calculations at each line screen.

Calculations:

<u>85 lpi</u> = 574,000 pixels per square inch.

65 x 574,000 = <u>37,310,000</u> pixels per color for this page.

<u>110 lpi</u> = 970,800 pixels per square inch.

65 x 970,000 = <u>63,102,000</u> pixels per color for this page.

<u>133 lpi</u> = 1,422,000 pixels per square inch.

65 x 1,422,000 = <u>92,430,000</u> pixels per color for this page.

<u>150 lpi</u> = 1,801,000 pixels per square inch.

65 x 1,801,000 = <u>117,065,000</u> pixels per color for this page.

4. Number of graphics pixels: per color, with <u>5:1</u> data compression ratio:

<u>85 lpi</u> = <u>37,310,000</u> ÷ 5 = 7,462,000 pixels per color for this page.

110 lpi = 63,102,000 ÷ 5 = 12,620,400 pixels per color for this page.

133 lpi = 92,430,000 ÷ 5 = 18,486,000 pixels per color for this page.

150 lpi = 117,065,000 ÷ 5 = 23,413,000 pixels per color for this page.

5. Text calculations:

85 lpi: 15 sq. inches x 574,000 pixels per square inch = 8,610,000 pixels of text for this page.

110 lpi: 15 sq. inches x 970,800 pixels per square inch = 14,562,000 pixels of text for this page.

133 lpi: 15 sq. inches x 1,422,000 pixels per square inch = 21,330,000 pixels of text for this page.

150 lpi: 15 sq. inches x 1,801,000 pixels per square inch = 27,015,000 pixels of text for this page.

6. Number of text pixels: with 15:1 data compression ratio:

85 lpi --- 574,000 pixels of text

110 lpi -- 970,800 pixels of text

133 lpi -- 1,422,000 pixels of text

150 lpi -- 1,801,000 pixels of text

7. Total number of pixels to be transmitted:

Table 10: System 1 - The Standard Page Encoded

	85 lpi	110 lpi	133 lpi	150 lpi
Cyan -----	7,462,000	12,620,400	18,486,000	23,413,000
Magenta --	7,462,000	12,620,400	18,486,000	23,413,000
Yellow ---	7,462,000	12,620,000	18,486,000	23,413,000
Black ----	7,462.000	12,620,000	18,486,000	23,413,000
+ text --	574,000	970,800	1,422,000	1,801,000
Total Pg -	30,422,000	51,452,400	75,366,000	95,453,000

8. Data rate calculations:

Table 11: System 1 - Transmission Data Rates

Line screen		Total bits	9,600 bps		16,800 bps		56,000 bps	
			Sec.	Min.	Sec.	Min.	Sec.	Min.
85	=	30,422,000	3,168	52.8	1,801	30.2	543	9.1
110	=	51,452,400	5,359	89.3	3,062	51.0	918	15.3
133	=	75,366,000	7,850	130.8	4,486	74.7	1,345	22.4
150	=	95,453,000	9,943	165.7	5,682	94.7	1,704	28.4

Line screen		Total bits	152,600 bps		772,000 bps		1,544,000 bps	
			Sec.	Min.	Sec.	Min.	Sec.	Min.
85	=	30,422,000	199	3.32	39	.65	20	.33
110	=	51,452,400	337	5.62	67	1.11	33	.55
133	=	75,366,000	494	8.23	98	1.63	49	.81
150	=	95,453,000	625	10.43	124	2.06	62	1.03

B. System 2: Character-Encoded

1. Contents of the standard page:

4/Color Graphics ----	= 65 square inches.
Text (B&W) ----------	= 15 square inches.

2. System compression ratios:

4/Color Graphics ----	= 4:1
Text ----------------	= none

3. Graphic line screen calculations: based on an average of 9.6 bits per text character and halftone dot.

line screen		pixels		bits		bits/inch		inches		bits per color
85 lpi	=	7,225	x	9.6	=	69,360	x	65	=	4,508,400/page
110 lpi	=	12,100	x	9.6	=	116,160	x	65	=	7,550,400/page
133 lpi	=	17,689	x	9.6	=	169,814	x	65	=	11,037,936/page
150 lpi	=	22,500	x	9.6	=	216,000	x	65	=	14,040,000/page

4. Graphics calculations:

Total graphics bits with all 4 colors:

85 lpi	----	4,508,400	x 4	=	18,033,600	bits per page
110 lpi	----	7,550,400	x 4	=	30,201,600	bits per page
133 lpi	----	11,037,936	x 4	=	44,151,744	bits per page
150 lpi	----	14,040,000	x 4	=	56,160,000	bits per page

5. Text calculations - no data compression:

1,465 characters x 9.6 bits = 14,064 bits/page

6. Total number of bits to be transmitted:

Table 12: System 2 - The Standard Page Encoded

Graphics with compression ratio of 4:1 plus text:						Total bits
85	= 18,033,600	÷ 4 =	4,508,400	+ 14,064	=	4,522,464
110	= 30,201,600	÷ 4 =	7,550,400	+ 14,064	=	7,564,464
133	= 44,151,744	÷ 4 =	11,037,936	+ 14,064	=	11,052,000
150	= 56,160,000	÷ 4 =	14,040,000	+ 14,064	=	14,054,064

7. Data Rate Calculations:

Table 13: System 2 - Transmission Data Rates

Line screen	Total bits	9,600 bps Sec.	9,600 bps Min.	16,800 bps Sec.	16,800 bps Min.	56,000 bps Sec.	56,000 bps Min.
85 =	4,522,464	471	7.9	269	4.5	81	1.3
110 =	7,564,464	788	13.1	450	7.5	135	2.3
133 =	11,052,000	1,151	19.1	658	10.9	197	3.3
150 =	14,054,064	1,464	24.4	836	13.9	251	4.2

Line screen	Total bits	152,600 bps Sec.	152,600 bps Min.	772,000 bps Sec.	772,000 bps Min.	1,544,000 bps Sec.	1,544,000 bps Min.
85 =	4,522,464	30	.59	6	.10	3	.05
110 =	7,564,464	50	.83	10	.16	5	.08
133 =	11,052,000	72	1.20	14	.24	7	.12
150 =	14,054,064	92	1.50	18	.30	9	.15

C. System 3: Pixel Density-Map

1. The contents of the standard page:

4/Color Graphics ---- = 65 square inches.
Text (B&W) --------- = 15 square inches.

2. System compression ratios:

Graphics ------------ = 10:1
Text ---------------- = 4:1

3. Graphic line screen calculations: 300 x 300 lines per inch (lpi) input resolution can be used to output 85 - 175 line screens, at each remote receiving location.

4. Number of graphics pixels: Input resolution of 300 x 300 = 90,000 pixels per square inch.

90,000 pixels x 4 (4 colors) = 360,000 pixels

360,000 x 8 (bits) = 2,880,000 bits per square inch

2,880,000 x 65 square inches = 187,200,000 total bits for the 4/color graphics.

Graphics compressed with a ratio 10:1:

187,200,000 ÷ 10 = 18,720,000 bits

5. Text calculations:

Input resolution of 900 x 900 = 810,000 bits per square inch.

810,000 bits x 15 square inches = 12,150,000 bits

Text compressed with a ratio of 4:1:

12,150,000 ÷ 4 = 3,037,500

6. Total number of bits to be transmitted:

Table 14: System 3 - The Standard Page Encoded

Standard page - total number of bits
(with compression):

Graphics ---	18,720,000
Text --------	3,037,500
Total -	21,757,500

7. Data rate calculations:

Table 15: System - Transmission Data Rates

Transmission data rates: 21,757,500 total bits

9,600 bps		16,800 bps		56,000 bps	
Sec.	Min.	Sec.	Min.	Sec.	Min.
2,266	37.8	1,295	21.6	388	6.4

152,600 bps		772,000 bps		1,544,000 bps	
Sec.	Min.	Sec.	Min.	Sec.	Min.
143	2.4	28.2	.46	14.1	.23

D. System Capacity Comparisons and Evaluations

1. Total Number of Bits Comparison:

These calculations are based on each communication system encoding the same 4/color standard page. All calculations have been made using data compression ratios for each system.

Table 16: Bits Comparisons

Line Screen		System 1	System 2	System 3*
85 lpi	--	30,422,000 bits	4,522,464 bits	21,757,500 bits
110 lpi	--	51,452,400 bits	7,564,464 bits	21,757,500 bits
133 lpi	--	75,366,000 bits	11,052,000 bits	21,757,500 bits
150 lpi	--	95,453,000 bits	14,054,064 bits	21,757,500 bits

* System 3 encodes the same amount of bits for every line screen. The line screens are assigned at the receiving location.

Evaluation: Based on these calculations System 1 is by far the most data intensive system, particularly in the higher line screens. As expected, System 2 encodes with the least amount of bits compared to the other two systems.

2. Transmission Data Rate Comparison

Table 17: Data Rate Comparisons

85 Line Screen	System 1	System 2	System 3
9,600 bps --	52.80 min.	7.90 min.	37.80 min.
16,800 bps --	30.20 min.	4.50 min.	21.60 min.
56,000 bps --	9.10 min.	1.30 min.	6.40 min.
152,600 bps --	3.32 min.	.59 min.	2.40 min.
772,000 bps --	.65 min.	.10 min.	.46 min.
1,544,000 bps --	.33 min.	.05 min.	.23 min.

Evaluation:

System 1: At this line screen System 1 is the most data intensive system and requires the most transmission time with each data rate transmission line. Clearly the faster data rate lines are a requirement for System 1.

System 2: As expected, this system takes the least amount of time to transmit the data.

System 3: This system is somewhat data intensive.

110 Line Screen	System 1	System 2	System 3
9,600 bps --	89.30 min.	13.10 min.	37.80 min.
16,800 bps --	51.00 min.	7.50 min.	21.60 min.
56,000 bps --	15.30 min.	2.30 min.	6.40 min.
152,600 bps --	5.62 min.	.83 min.	2.40 min.
772,000 bps --	1.11 min.	.16 min.	.46 min.
1,544,000 bps --	.55 min.	.08 min	.23 min.

Evaluation:

System 1: At this line screen System 1 is again the most data intensive system and requires the most transmission time with each data rate transmission line.

System 2: As expected, this system takes the least amount of transmission time at any line screen.

System 3: Same transmission time for this line screen as the other line screens chosen, due to the method of encoding the data.

133 Line Screen	System 1	System 2	System 3
9,600 bps --	130.80 min.	19.10 min.	37.80 min.
16,800 bps --	74.70 min.	10.90 min.	21.60 min.
56,000 bps --	22.40 min.	3.30 min.	6.40 min.
152,600 bps --	8.23 min.	1.20 min.	2.40 min.
772,000 bps --	1.63 min.	.24 min.	.46 min.
1,544,000 bps --	.81 min.	.12 min.	.23 min.

Evaluation:

System 1: At the higher line screens, the time limitations of using System 1 at this line screen is clearly evident. At every data rate, System 1 requires an increasing amount of data transmission time.

System 2: At this line screen there are advantages of using System 2.

System 3: Same transmission time for this line screen as the other line screens chosen, due to the method of encoding the data.

150 Line Screen	System 1	System 2	System 3
9,600 bps --	165.70 min.	24.40 min.	37.80 min.
16,800 bps --	94.70 min.	13.90 min.	21.60 min.
56,000 bps --	28.40 min.	4.20 min.	6.40 min.
152,600 bps --	10.43 min.	1.50 min.	2.40 min.
772,000 bps --	2.06 min.	.30 min.	.46 min.
1,544,000 bps --	1.03 min.	.15 min.	.23 min.

Evaluation:

System 1: At this line screen System 1 again requires the longest transmission time using every data rate line.

System 2: Again the least amount of transmission time at this line screen.

System 3: Same transmission time for this line screen as the other line screens chosen, due to the method of encoding the data.

III - System Capacity Conclusions:

1. System 1: Page Facsimile: is clearly the most data intensive and takes the longest transmission time at every line screen.

2. System 2: Character-Encoding: encodes with the least amount of graphic information transmitted and takes the least amount of time at any data rate to transmit the data.

3. System 3: Pixel Density-Map: is the second most data intensive. The same amount of data is encoded for every line screen. Also at every line screen this system will take the second most amount of time to transmit the data.

COMMUNICATION SYSTEM PERFORMANCE

The Quality Analysis - System 1: Page Facsimile

The 4/Color Statistical Analysis

Please refer to Appendix D for a glossary of the Statistical Terms used in this part of the study.

I - Methodology

A. The Purpose of the Statistical Analysis:

Of the three communication systems in this study, Page Facsimile is the only system that directly transmits the original data read by the facsimile scanner at the transmission site. The data received is immediately imaged by a facsimile recorder at place at the receiving site.

The statistical analysis which follows was used as a method to determine the effect, if any, of the transmission system on the data received at the receiving site. Also evaluated was the quality of the 4/color reproduction produced from the received film at the remote printing location at that receiving site.

B. The Subject Analyzed:

The 4/color subject analyzed was taken from the front page of a newspaper supplied by a Page Facsimile system user. The 4/color subject consisted of a variety of highlight, midtone and two different % tint dot areas, all of which were necessary for the 4/color quality analysis.

1. Materials Available:

   a. Original copy of a chosen 4/color subject in the form of a contact print (velox), one for each color transmitted from the transmission site.

   b. Received film of the same 4/color subject in negative film, one for each color of the original transmission from a receiving site.

   c. 4/color press sheet of the same 4/color subject printed from the received film at that remote printing location.

2. Materials Analyzed:

   a. Original copy - The Magenta velox only.

   b. Received film - The Magenta film only.

   c. 4/color press sheet - The Magenta dots only.*

   * A #58 green wratten filter was used to visually separate the magenta dots from the other three process colors.

The process color magenta was chosen for analysis for the following reasons: First; magenta dots are easily identified. Second; magenta dots are among the smallest produced by electronic color scanners to maintain gray balance requirements in the color separation process.

For the purposes of this study it is inferred that the effect, if any, the transmission system has on the magenta transmission will be consistent with the effect on the other three colors transmitted.

C. Procedures:

The items to be measured, i.e. the original prior to transmission, the received film and the press sheet were

registered and stripped with a common pin register system. A mylar master was prepared with the same pin system with the patches to be measured cut out of the master.

On the mylar master, each patch was cut to approximately 1/10th of an inch and bordered with red tape, and labeled for identification. Each item to be analyzed was taped on a light table with the mylar master placed on top of it to isolate those patch areas to be measured.

D. Sample Size:

All sample sizes are based on the central-limit theorem which specifies that "n" is greater than or equal to 30. With samples of this size the sample mean has been found to be approximately normally distributed for analysis. All the samples used for System 1 had an "n" greater than 45 to provide an adequate sample size for statistical analysis.

1. The Sample Patches:

All samples were chosen on the basis of being representative of highlight, midtone and tint areas available from this communication system on the 4/color subject chosen. All highlight and midtone areas were examined and particular sample patch areas were chosen based on the desired characteristics of highlight, midtone and % tint dot areas.

a. Patch Size: Approximately 1/10th of an inch for each patch.

b. Number of Patches: 5

c. Total Number of Patches Analyzed:

5	in the original copy
5	in the received film
5	in the press sheet
15	Total Patches

d. Make up of Patches: Two samples were chosen in two different highlight areas in the 4/color subject. The highlight areas contain the smallest dots.

For the purposes of this study, it has been determined that the highlight areas are essential in assessing the effect, if any, of the transmission system on the smallest dots transmitted.

One sample was chosen in the midtone area to determine the possible effect of the transmission system on the larger midtone dots.

Two tint samples were chosen to determine the possible effect of the transmission system on uniform dot areas.

e. Identification of Patches:

Patch 1A: Highlight Area I

Patch 2A: Midtone Area I

Patch 3A: Highlight Area II

Patch 4A: Tint Area I (20% tint)

Patch 5A: Tint Area II (10% tint)

E. Measurements:

The same exact patch areas were isolated and measured in the following items:

1. The original magenta velox prior to transmission.
2. The received magenta negative film of that original magenta velox from a receiving site.
3. The 4/color press sheet printed from the received film.

All the dots in each sample patch were quantitatively measured as continuous variables, according to size. Each dot size has been measured in mils. 1 mil is equal to 1/1000th of an inch.

The sample patches areas were each individually measured dot for dot on the original, received film and press sheet. Each dot was drawn freehand on 20 squares per inch graph paper, rendering it as closely as possible to the size and shape of each dot in each of the sample patches.

Estimates were made of the dot area, measured in mils, by counting the squares on the graph paper used for each dot. The number of squares for each dot was recorded for each patch. Each total number of squares was divided by 20 to yield the number of mils for each dot area.

Based on the measurements taken on the original, a method of statistical analysis was used to determine the effect, if any, of the transmission system on the film received at the receiving site.

Also analyzed was the effect on the press sheet reproduced from the received film, for the sample page at the printing location served by the receiving site.

For this part of the study, the term effect refers to

the amount of relative image distortion on the size and shape of the halftone dots, from the original through the transmission system to the received film and the final reproduction.

1. Measurement Instrument:

A 5Øx magnifying glass with a 1ØØ mil reticle (1/1Øth of an inch), marked off in 1 mil increments. 1 mil equals 1/1ØØØth of an inch.

2. Photographic enlargement:

A method of photographic enlargement using a microscope, (See Appendix C), was used to photograph as much of each patch as possible, to verify the areas measured. This series of photographs is included in the subjective 4/color analysis section to follows.

F. The Statistical Program:

Once all measurements were completed, data sets for each of the five patches were collected. See Appendix E. A statistical computer software package called MINITAB was used to assist in the preparation of the statistical analysis which follows.

II - System 1: Page Facsimile
The 4/Color Statistical Quality Analysis

A. Analysis of Patch 1A - Highlight Area

Table 18: Statistics - Patch 1A

	Sample Size	Mean	Median	Standard Deviation
Original	57	1.235	1.3ØØ	Ø.75Ø
Received Film	57	3.265	3.5ØØ	1.55Ø
Press Sheet	57	2.894	2.55Ø	1.663

1. Analysis of the Sample Mean:

a. Original: As expected the sample mean in the Original data set indicates that this is a highlight sample patch area with dots averaging 1.2 mils in size.

b. Received Film: The sample mean in the Received Film data set indicates a mean shift from 1.2 in the Original to 3.3 in the Received Film. The mean shift indicates that the transmission system is a possible cause of enlargement in the size of the dots received.

c. Press Sheet: The sample mean in the Press Sheet indicates a mean shift back to a smaller average dot size, closer to the original. It is possible that the printing process compensates for some of the enlargement caused by the transmission system.

2. Analysis of the Sample Standard Deviation:

a. Original: All the data in the Original data set is within 1 standard deviation from the sample mean.

The standard deviation in the original is .75 which indicates a marginal amount of variation in the dot sizes in the Original.

b. Received Film: All the data in the Received Film data set is within 2 standard deviations from the sample mean. The standard deviation in the Received Film is 1.5, indicating a larger variation in the dot sizes received.

c. Press Sheet: All the data in the Press Sheet data set is within 2 standard deviations from the sample mean. The standard deviation in the Press Sheet is 1.7 which indicates a larger variation in the dot sizes in the press sheet. This variation is possibly caused by dot gain on the printing press.

3. Histograms: Patch 1A - Highlight Area I

a. Original

```
            *
            *
            *
            *
        *   *
        *   *
        *   *
    *   *   *
    *   *   *   *
    *   *   *   *
    *   *   *   *
    *   *   *   *
    *   *   *   *
*   *   *   *   *
*   *   *   *   *
*   *   *   *   *   *
*   *   *   *   *   *   *       *
--------------------------------------------------------------------
Ø   .5  1   1.5 2   2.5 3   3.5 4   4.5 5   5.5 6   6.5 7   7.5 8   8.5
```

Figure 7: Original - Patch 1A

Sample Size: 57

	Min	Max
The Range of the Histogram:	Ø.Ø	3.8

Analysis of the Histogram: The histogram shows the higher frequency of dots in the range of .5 to 2.Ø which indicates that this is a highlight sample area.

b. <u>Received Film</u>

```
                            *
                            *
                            *
                            *   *
                            *   *
                            *   *
                            *   *
                *   *       *   *
                *   *   *   *   *   *   *
    *           *   *   *   *   *   *   *
*   *   *   *   *   *   *   *   *   *   *   *       *
*   *   *   *   *   *   *   *   *   *   *   *   *   *
---------------------------------------------------------------------
Ø   .5  1   1.5 2   2.5 3   3.5 4   4.5 5   5.5 6   6.5 7   7.5 8   8.5
```

Figure 8: Received Film - Patch 1A

Sample Size: 57

	Min	Max
The Range of the Histogram:	Ø.Ø	6.6

Analysis of the Histogram: The range of data has changed from Ø - 3.8 in the original to Ø - 6.6 in the received film. Also the data is more spread out with the higher frequency of dots in the 2.Ø to 5.Ø range confirming that the dots have increased in size from the original prior to transmission.

c. <u>Press Sheet</u>

```
               *
               *
               *
               *
               *        *
            *  *  *     *     *
            *  *  *     *     *
         *  *  *  *  *  *     *
*  *     *  *  *  *  *  *     *
*  *  *  *  *  *  *  *  *  *  *
*  *  *  *  *  *  *  *  *  *  *  *     *           *
-----------------------------------------------------
Ø .5  1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 8.5
```

Figure 9: Press Sheet - Patch 1A

Sample Size: 57

	Min	Max
The Range of the Histogram:	.15	8.7

Analysis of the Histogram: The range of data has changed again from Ø - 3.8 in the Original, and Ø - 6.6 in the Received Film to .15 - 8.7 in the Press Sheet. The higher frequency of dots in the 1.Ø to 5.Ø range confirming the mean shift to a smaller average dot size.

B. Analysis of Patch 2A - Midtone Area I

Table 19: Statistics - Patch 2A

	Sample Size	Mean	Median	Standard Deviation
Original	56	9.857	9.150	2.624
Received Film	56	11.079	10.525	2.665
Press Sheet	56	12.582	12.150	2.868

1. Analysis of the Sample Mean:

a. Original: As expected the sample mean in the original data set indicates that this is a midtone sample patch area with dots averaging 9.8 mils in size.

b. Received Film: The sample mean in the Received Film data set indicates a mean shift from 9.8 in the Original to 11.1 in the received film. The mean shift indicates that the transmission system is a possible cause of enlargement in the size of the dots received.

c. Press Sheet: The sample mean in the Press Sheet indicates a further enlargement of the dots in the mid-tone dot area. This enlargement of dot sizes can be attributed to dot gain on press, which has been found to have more of an effect on the midtone dot areas.

2. Analysis of the Sample Standard Deviation:

a. Original: All the data in the Original data set is within 3 standard deviations from the sample mean. The standard deviation in the Original is 2.6 which

indicates a large amount of variation in the dot sizes sizes in the Original. The result is consistent with the patch chosen, containing many different size midtone dots.

b. Received Film: All the data in the Received Film data set is also within 3 standard deviations from the sample mean. The standard deviation in the Received Film is 2.7, which indicates a approximately the same variation that was found in the in the dot sizes in the Original prior to transmission. It is possible that the transmission system has less of an effect on the mid-tone dot areas.

c. Press Sheet: All the data in the Press Sheet data set is also within 3 standard deviations from the sample mean. The standard deviation in the Press Sheet is 2.9, which indicates a slightly larger variation in the dot sizes in the Press Sheet. This result is consistent with the possible dot gain found in the analysis of the sample mean for the Press Sheet.

3. Histograms For Patch 2A - Midtone Area I

a. Original

```
            *
            *
            *
            *
        *   *
        *   *
    *   *   *
    *   *   *
    *   *   *   *           *
    *   *   *   *   *   *   *
*   *   *   *   *   *   *   *       *
*   *   *   *   *   *   *   *   *   *
*   *   *   *   *   *   *   *   *   *   *
---------------------------------------------------------------
6   7   8   9   10  11  12  13  14  15  16  17  18  19  20  21
```

Figure 10: Original - Patch 2A

Sample size: 56

	Min	Max
The Range of the Histogram:	6.2	16.3

Analysis of the Histogram: The histogram shows the higher frequency of dots in the range of 7 to 10, which indicates that this is a midtone sample area.

b. <u>Received Film</u>

```
                                   *
                   *               *
               *   *               *
               *   *               *
           *   *   *   *           *
           *   *   *   *   *       *
           *   *   *   *   *   *   *
           *   *   *   *   *   *   *       *
       *   *   *   *   *   *   *   *       *
   *   *   *   *   *   *   *   *   *   *   *   *
----------------------------------------------------------------
   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21
```

Figure 11: Received Film - Patch 2A

Sample size: 56

	Min	Max
The Range of the Histogram:	6.0	16.8

Analysis of the Histogram: The range of data is approximately the same as it was in the original. However the data is slightly more spread out with more dots in the 13 to 16 range. This indicates that there has been some effect, possibly caused by the transmission system on the size of the dots received when compared to the original prior to transmission.

c. Press Sheet

```
                       *
                       *
                       *       *
                       *       *
                       *       *
                       *       *
                       *       *
               *       *       *
               *   *   *   *   *
               *   *   *   *   *
               *   *   *   *   *   *   *
  *   *   *    *   *   *   *   *   *   *                   *
  *   *   *    *   *   *   *   *   *   *   *   *           *
------------------------------------------------------------
6 7   8   9   1Ø  11  12  13  14  15  16  17  18  19  2Ø  21
```

Figure 12: Press Sheet - Patch 2A

Sample size: 56

	Min	Max
The Range of the Histogram:	6.6	21.Ø

Analysis of the Histogram: The range of data has increased significantly from the Original, and the Received Film to 6.6 - 21.Ø in the Press Sheet. The higher frequency of dots is in the 12 - 14 range confirming the possible effect of dot gain on the midtone dot area.

C. Analysis of Patch 3A - Highlight Area II

Table 2Ø: Statistics Patch 3A

	Sample Size	Mean	Median	Standard Deviation
Original	49	Ø.7122	Ø.55ØØ	Ø.6582
Received Film	49	1.3Ø4Ø	1.15ØØ	Ø.862Ø
Press Sheet	49	2.656Ø	2.5ØØØ	1.959Ø

1. Analysis of the Sample Mean:

a. Original: As expected the sample mean in the original data set indicates that this is a highlight sample patch area with dots averaging .71 mils in size.

b. Received Film: The sample mean in the Received Film data set indicates a mean shift from .71 in the Original to 1.3 in the received film. The mean shift indicates that the transmission system is a possible cause of enlargement in the size of the dots received.

c. Press Sheet: In this highlight area the sample mean in the Press Sheet indicates a further mean shift to a larger average dot size from the Original prior to transmission. In this case, the printing system did not compensate for some of the enlargement caused by the transmission system.

2. Analysis of the Sample Standard Deviation:

a. Original: All the data in the Original data set is within 1 standard deviation from the sample mean. The standard deviation in the Original is .65 which indicates a marginal amount of variation in the dot sizes in the Original.

b. Received Film: All the data in the Received Film data set is also within 1 standard deviation from the sample mean. The standard deviation in the Received Film is .86 which indicates a slightly larger variation in the dot sizes in the Received Film. This increase in the standard deviation from the Original confirms that the transmission system is a possible cause of enlargement of the highlight dots.

c. Press Sheet: All the data in the Press Sheet data set is within 2 SD's from the sample mean. The standard deviation in the Press Sheet is 1.9, which indicates a larger variation in the dot sizes in the Press Sheet. This variation is possibly caused by dot gain on the printing press.

3. Histograms For Patch 3A - Highlight Area II

a. <u>Original</u>

```
    *
    *
    *
    *
    *
    *   *
    *   *
    *   *
    *   *
    *   *
    *   *
    *   *
*   *   *
*   *   *
*   *   *
*   *   *
*   *   *   *
*   *   *   *
*   *   *   *
*   *   *   *       *       *
--------------------------------------------------------
Ø  .5   1  1.5  2  2.5  3  3.5  4  4.5  5  5.5  6  6.5  7
```

Figure 13: Original - Patch 3A

Sample size: 49

	Min	Max
The Range of the Histogram:	Ø.Ø	3.7

Analysis of the Histogram: As expected the range of the histogram indicates that this is a highlight area with the highest frequency of dots in the Ø - 1.5 range.

b. Received Film

```
        *
        *       *
        *       *
        *       *
    *   *       *
    *   *       *
    *   *       *
    *   *   *   *
    *   *   *   *
    *   *   *   *
    *   *   *   *
    *   *   *   *
*   *   *   *   *
*   *   *   *   *   *   *               *
---------------------------------------------------------
Ø  .5   1  1.5  2  2.5  3  3.5  4  4.5  5  5.5  6  6.5  7
```

Figure 14: Received Film - Patch 3A

Sample size: 49

	Min	Max
The Range of the Histogram:	Ø.2	5.Ø

Analysis of the Histogram: The range of data has changed from Ø - 3.7 in the Original to .2 - 5.Ø in the Received Film. Also, the data is slightly more spread out with the higher frequency of dots in the .5 to 2.Ø range, confirming that the dots have increased in size from the Original prior to transmission.

c. Press Sheet

```
                         *
     *                   *
     *                   *    *
     *         *         *    *
     *    *    *         *    *    *                                  *
     *    *    *    *    *    *    *    *                             *
     *    *    *    *    *    *    *    *                   *         *
*    *    *    *    *    *    *    *    *         *         *         *
-----------------------------------------------------------------------
Ø    .5   1    1.5  2    2.5  3    3.5  4    4.5  5    5.5  6    6.5  7
```

Figure 15: Press Sheet - Patch 3A

Sample size: 49

	Min	Max
The Range of the Histogram:	.15	7.35

Analysis of the Histogram: The range has increased in the Press Sheet to .15 - 7.35 indicating a shift to a larger dot size in the Press Sheet. However, there is still more frequency in the .5 - 3 range indicating little effect on the highlight dots from the printing process.

D. Analysis of Patch 4A - Tint Area I

Table 21: Statistics - Patch 4A

	Sample Size	Mean	Median	Standard Deviation
Original	49	5.9837	6.0000	0.1143
Received Film	49	7.5082	7.5500	0.6823
Press Sheet	49	10.0400	10.1500	0.9970

1. Analysis of the Sample Mean:

a. Original: As expected the sample mean in the Original data set indicates that this is a tint sample patch area with larger dots averaging 5.9 mils in size.

b. Received Film: The sample mean in the Received Film data set indicates a mean shift from 5.9 in the Original to 7.5 in the received film. The mean shift indicates that the transmission system is a possible cause of enlargement in the size of the dots received.

c. Press Sheet: The sample mean in the Press Sheet is 10.0, indicating a shift to a larger average dot in the uniform tint area. Since this is larger tint area it is expected that possible dot gain is the cause of of further enlargement of the dots from the original prior to transmission.

2. Analysis of the Sample Standard Deviation:

a. Original: All the data in the Original data set set is within 1 standard variation from the sample mean. The standard deviation in the original is .11 which indicates almost no variation in the dot sizes in the Original. This result is expected since this is a uniform dot size area.

b. Received Film: All the data in the Received Film data set is also within 1 standard deviation from the sample mean. The standard deviation in the Received Film is .68, which indicates a larger variation in the dot sizes in the Received Film. There is strong evidence here that the transmission system is the cause of the enlargement of the dots from the Original prior to transmission.

c. Press Sheet: All the data in the Press Sheet data set is also within 1 standard deviation from the sample mean. The standard deviation in the Press Sheet is .99, which indicates a larger variation in the dot sizes in the Press Sheet. Since this is a larger tint area, this increased variation is possibly caused by the dot gain on the printing press.

3. Histograms For Patch 4A - Tint Area I

a. Original

```
     A
     L
     L

     O
     T
     H
     E
     R

     D
     A
     T
     A

     P
     O
     I
     N
     T
 *   S
-------------------------------------------------------------
5.5  6  6.5  7  7.5  8  8.5  9  9.5  1Ø  1Ø.5  11  11.5
```

Figure 16: Original - Patch 4A

Sample size: 49

	Min	Max
The Range of the Histogram:	5.2	6.Ø

Analysis of the Histogram: The range of the histogram indicates that this is uniform tint area, with only one data point differing from the other data in the data set. All other data is exactly the same size.

b. <u>Received Film</u>

```
                      *
                      *    *
                 *    *    *
                 *    *    *
                 *    *    *
                 *    *    *
       *    *    *    *    *    *
       *    *    *    *    *    *
       *    *    *    *    *    *    *
       *    *    *    *    *    *    *
  *    *    *    *    *    *    *    *
-----------------------------------------------------------------
 5.5   6   6.5   7   7.5   8   8.5   9   9.5  1Ø  1Ø.5  11  11.5
```

Figure 17: Received Film - Patch 4A

Sample size: 49

	Min	Max
The Range of the Histogram:	5.75	8.85

Analysis of the Histogram: The range of the histogram indicates a spread of data with the frequency of dots in the 6 - 9 range. This confirms the strong evidence that the transmission system is responsible for the effect on the dot size and variance from the original uniform dot size areas prior to transmission.

c. <u>Press Sheet</u>

```
                                 *
                                 *             *
                                 *             *
                                 *             *
                                 *         *   *
                                 *    *    *   *
                                 *    *    *   *
                                 *    *    *   *
                                 *    *    *   *
                                 *    *    *   *
                                 *    *    *   *
             *           *   *   *    *    *   *
             *           *   *   *    *    *   *    *
-------------------------------------------------------
5.5  6  6.5  7  7.5  8  8.5  9  9.5  1Ø  1Ø.5  11  11.5
```

Figure 18: Press Sheet - Patch 4A

Sample size: 49

	Min	Max
The Range of the Histogram:	7.2	11.65

Analysis of the Histogram: The range of data has increased significantly in the Press Sheet. The frequency of data is now in the 9.5 - 11 range confirming the possible effect of dot gain on press. This result was expected since this is a large tint dot area.

E. Analysis of Patch 5A - Tint Area II

Table 22: Statistics - Patch 5A

	Sample Size	Mean	Median	Standard Deviation
Original	62	3.8000	3.8000	0.0000
Received Film	62	4.3387	4.3000	0.5136
Press Sheet	62	7.1000	7.1000	0.0000

1. Analysis of the Sample Mean:

a. Original: As expected the sample mean in the Original data set indicates that this is a uniform sample tint patch area with dots averaging 3.8 mils in size.

b. Received Film: The sample mean in the Received Film data set indicates a mean shift from 3.8 in the Original to 4.3 in the received film. The mean shift indicates that the transmission system is a possible cause of enlargement in the size of the dots received.

c. Press Sheet: The sample mean of 7.1 in the Press Sheet indicates a shift to a larger average dot size. This mean shift indicates that the printing system has caused additional enlargement of the dots in the tint area.

2. Analysis of the Sample Standard Deviation:

a. Original: There is no standard deviation in the Original data set because all dots in this smaller tint area are exactly the same size.

b. Received Film: All the data in the Received Film data set is within 1 standard deviation from the sample mean. The standard deviation in the Received Film is .5, which indicates a variation in the dot sizes in the Received Film. Again there is strong evidence of the effect of the transmission system from the original prior to transmission.

c. Press Sheet: There is no standard deviation in the Press Sheet data set. It is possible that in a smaller tint area the effects of dot gain are less. The result is a uniform dot size in this tint area in the press sheet.

3. Histograms For Patch 5A - Tint Area II

a. Original

```
                  A
                  L
                  L

                  D
                  A
                  T
                  A

                  P
                  O
                  I
                  N
                  T
                  S
-----------------------------------------------------
2.5    3    3.5   4    4.5    5    5.5    6    6.5    7    7.5
```

Figure 19: Original - Patch 5A

Sample size: 62

	Min	Max
The Range of the Histogram:	3.8	3.8

Analysis of the Histogram: As expected, all data points measure exactly the same size.

b. <u>Received Film</u>

```
                         *
                         *
                         *
                         *
                         *
                         *
                         *
                   *     *
                   *     *
                   *     *
                   *     *
                   *     *
                   *     *
                   *     *
             *     *     *     *
             *     *     *     *
             *     *     *     *
             *     *     *     *     *
             *     *     *     *     *
       *     *     *     *     *     *
       *     *     *     *     *     *
       *     *     *     *     *     *     *
---------------------------------------------------------------
2.5    3    3.5    4    4.5    5    5.5    6    6.5    7    7.5
```

Figure 2Ø: Received Film - Patch 5A

Sample size: 62

	Min	Max
The Range of the Histogram:	3.1	5.55

Analysis of the Histogram: The range of the histogram is now 3.1 - 5.55 indicating the possible effect of the transmission system on the dots in the Received Film.

c. Press Sheet

```
                                                A
                                                L
                                                L

                                                D
                                                A
                                                T
                                                A

                                                P
                                                O
                                                I
                                                N
                                                T
                                                S
----------------------------------------------------
2.5  3   3.5   4   4.5   5   5.5   6   6.5   7   7.5
```

Figure 21: Press Sheet - Patch 5A

Sample size: 62

	Min	Max
The Range of the Histogram:	7.1	7.1

Analysis of the Histogram: As expected all data points are located on the same measure indicating once more that this smaller tint area is a uniform dot area.

III - System 1: Page Facsimile
The Subjective 4/Color Analysis

A. Methodology

The subjective analysis which follows is the method used in conjunction with the statistical 4/color analysis to determine the and reproduction capability of this communication system.

The subjective analysis consisted of photographing the same sample five patch areas that were measured and statistically analyzed in the previous section, and conducting a subjective quality analysis of each patch from the enlarged photographs. Each patch was photographed with a magnification of 53.4 times its original size.

In this part of the study the photographs were used for the subjective analysis of the 4/color quality, to verify the areas measured and statistically analyzed and for visual demonstration.

Figure 22: Original - Patch 1A

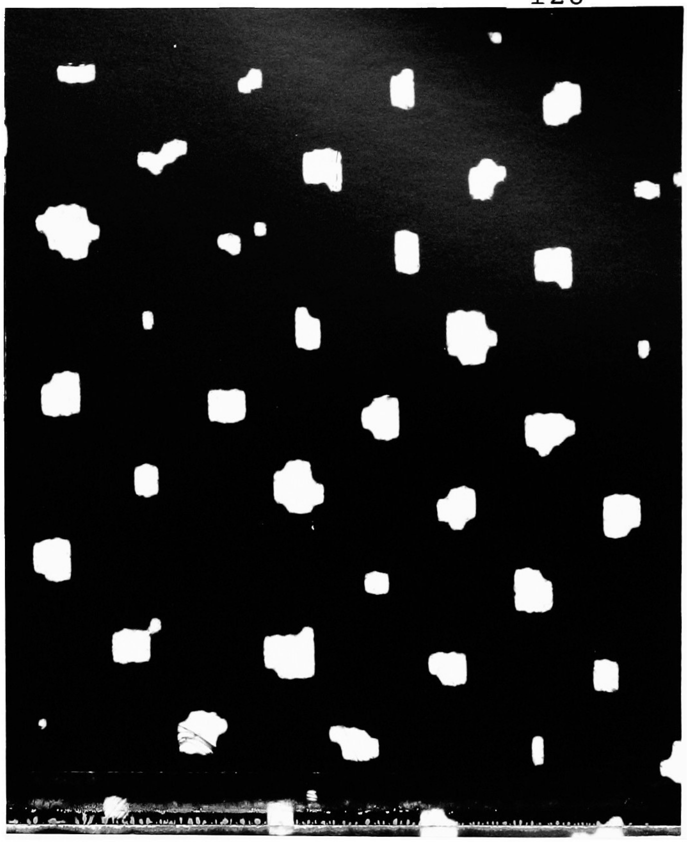


Figure 23: Received Film - Patch 1A

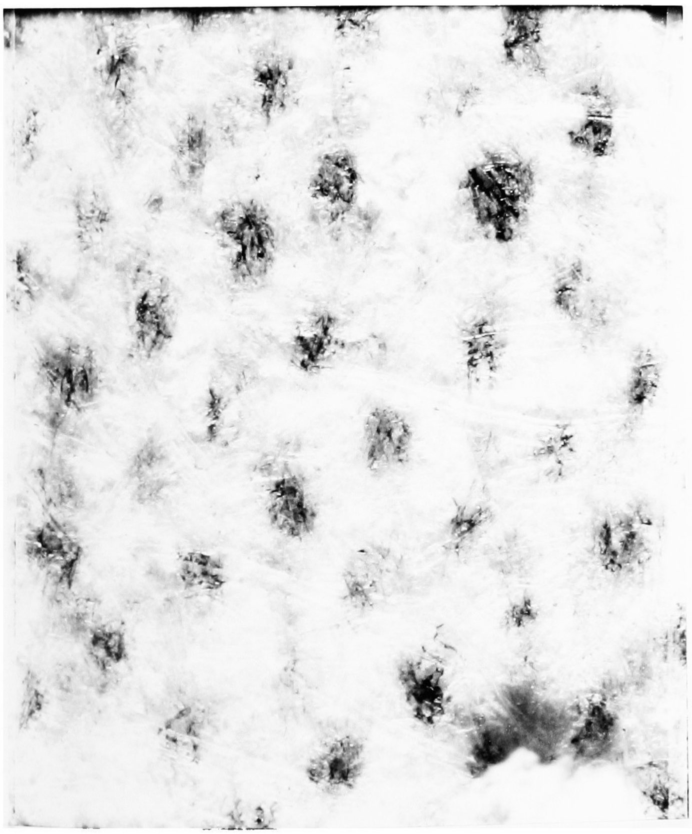


Figure 24: Press Sheet - Patch 1A

System 1: Page Facsimile

1. Subjective Analysis of Patch 1A - Highlight Area I

Figure 22: consists of a dot area with many different highlight dot sizes.

Figure 23: the negative film shows the distortion of the original dots in size and shape caused by the transmission system on the highlight dots received. As expected, the scan frequency has caused a noticeable stair-stepping effect on the dots received.

Figure 24: shows a limited amount of dot gain on press, as expected.

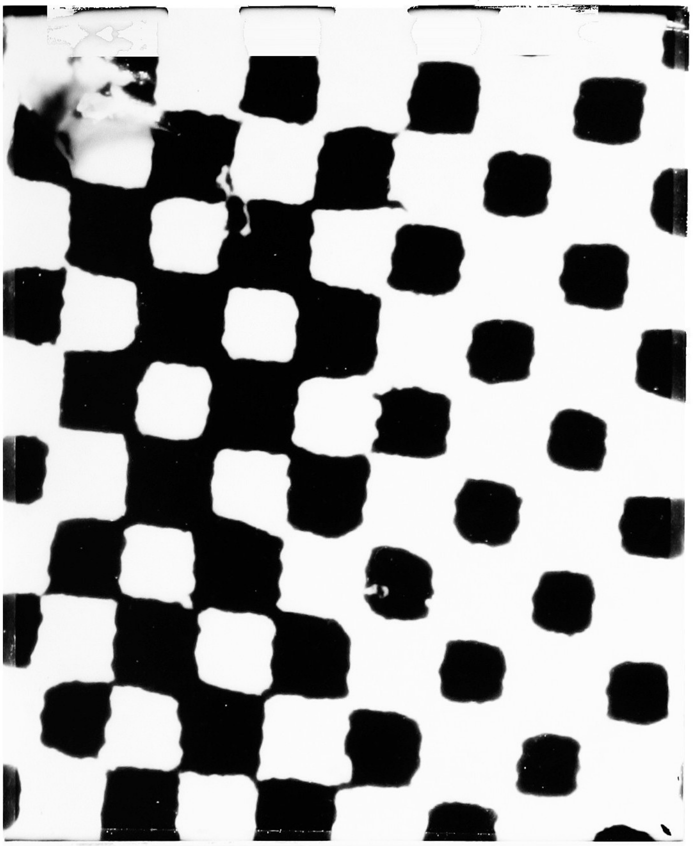


Figure 25: Original - Patch 2A

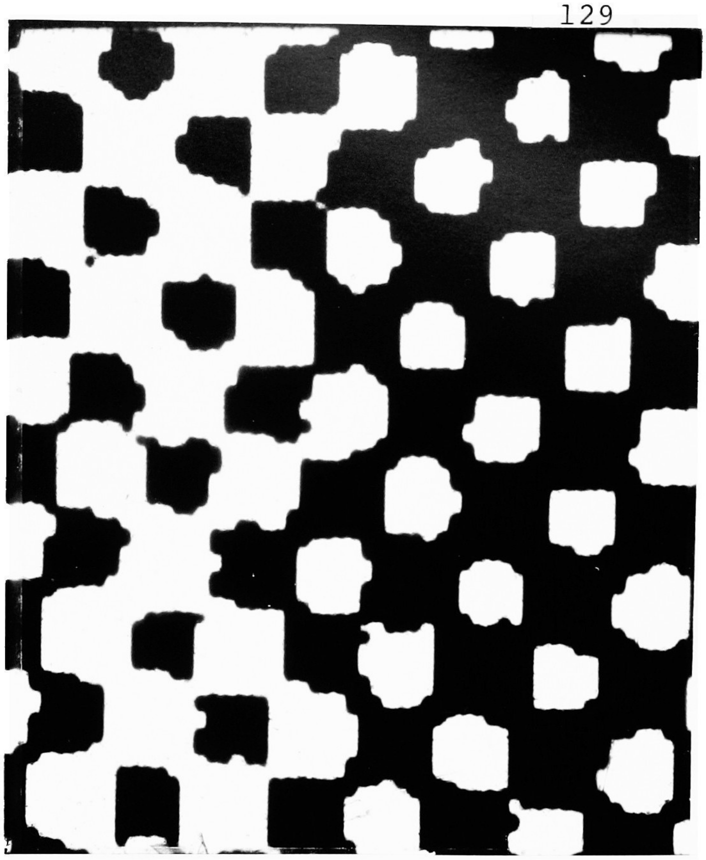


Figure 26: Received Film - Patch 2A

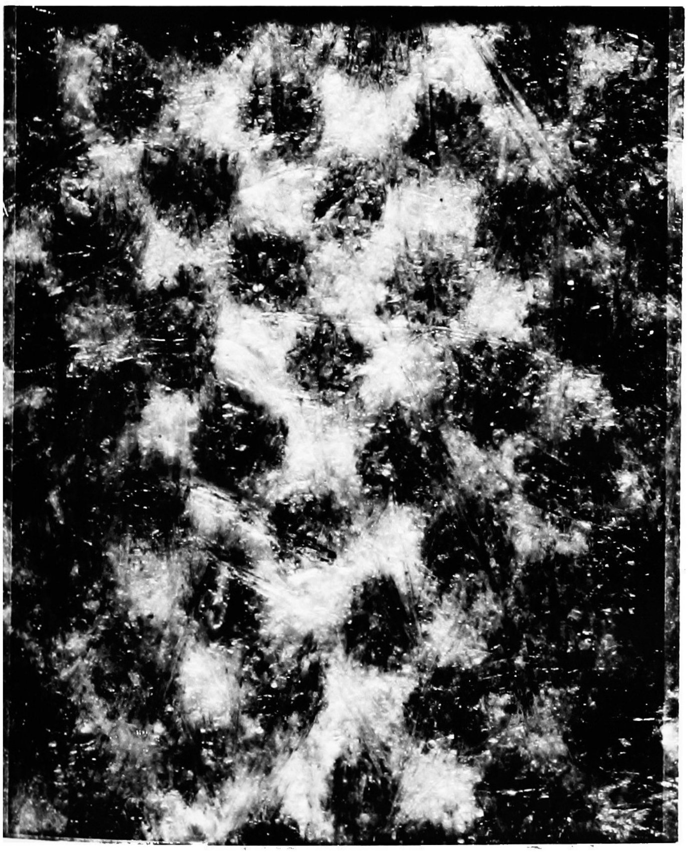


Figure 27: Press Sheet - Patch 2A

System 1: Page Facsimile

2. Subjective Analysis of Patch 2A - Midtone Area I

Figure 25: consists of a dot area with many different mid-tone dot areas.

Figure 26: the negative film shows less distortion caused by the transmission system on the midtone dots received.

Figure 27: shows more dot gain on press, as expected in the midtone area.

Figure 28: Original - Patch 3A

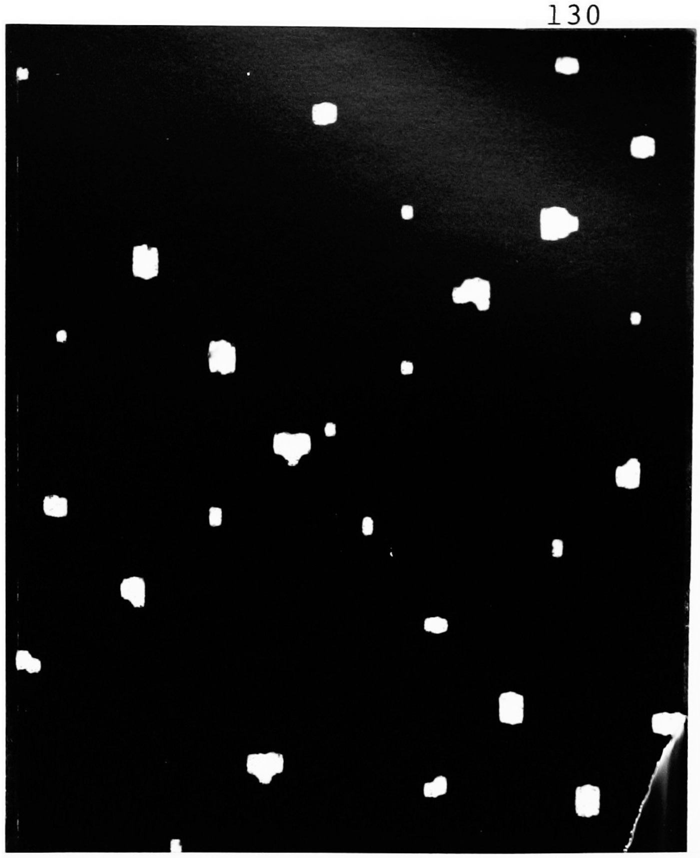


Figure 29: Received Film - Patch 3A

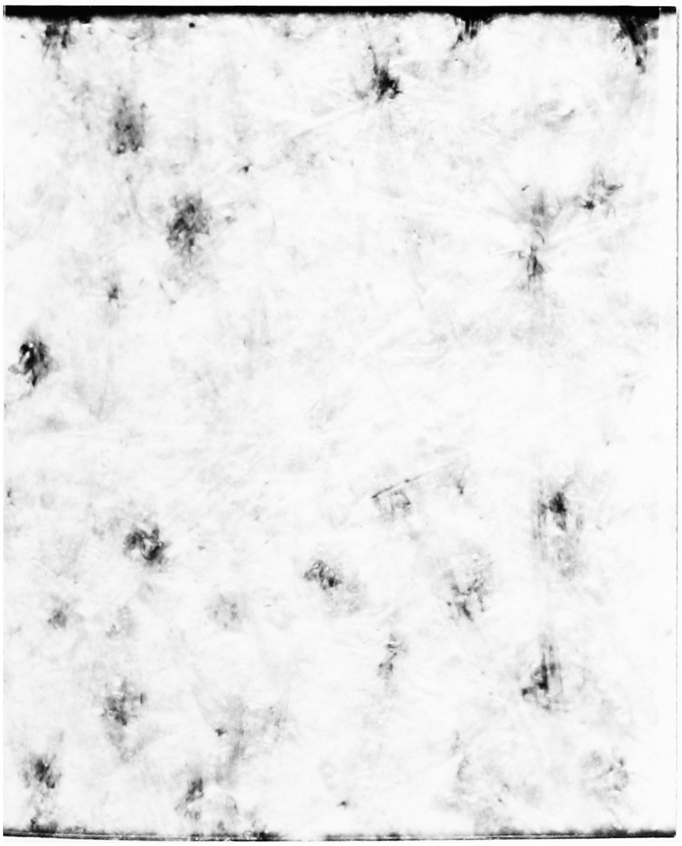


Figure 30: Press Sheet - Patch 3A

System 1: Page Facsimile

3. Subjective Analysis of Patch 3A - Highlight Area II

Figure 28: consists of a dot area with smaller halftone dots.

Figure 29: the negative film shows more distortion caused by the transmission system on the smaller highlight dots. The dots have been squared off as in **Figure 23,** and again the scan frequency of the scanning device at the transmission site is evident.

Figure 30: illustrates the limitations of this communication system to reproduce small dots. As in **Figures 24 and 27,** many of this system's quality limitations are often caused by the type of paper required for newspapers.

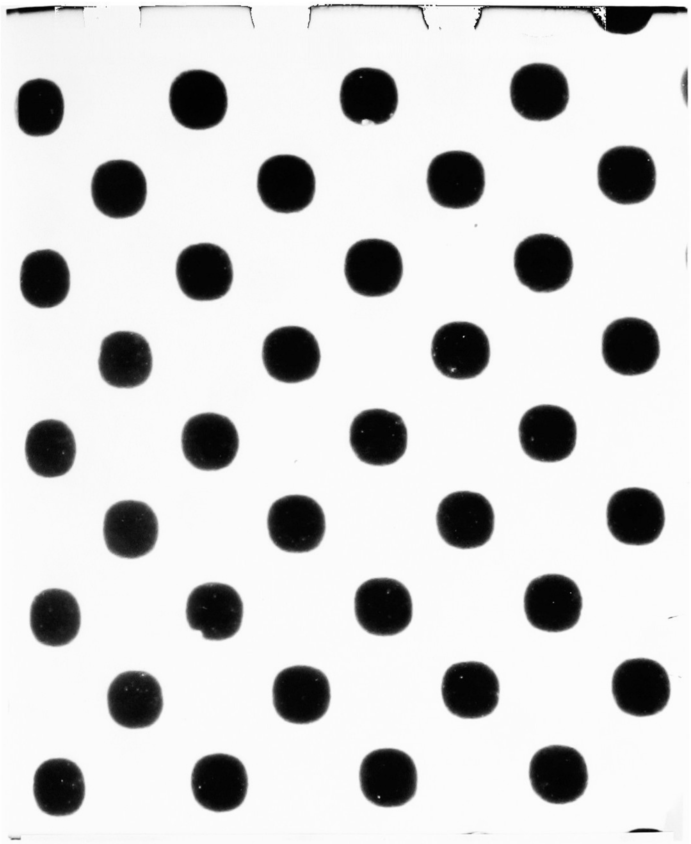


Figure 31: Original - Patch 4A

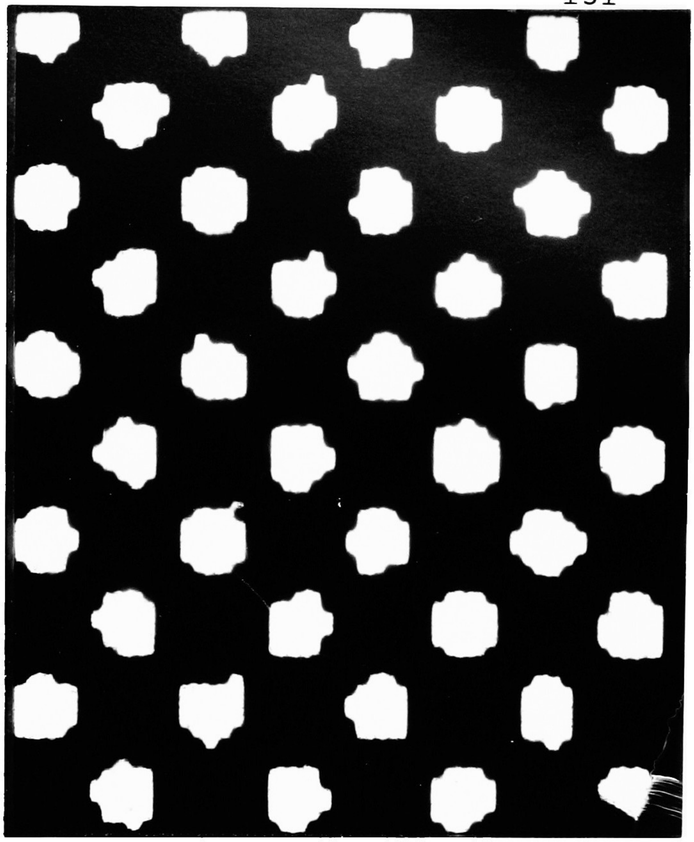


Figure 32: Received Film - Patch 4A

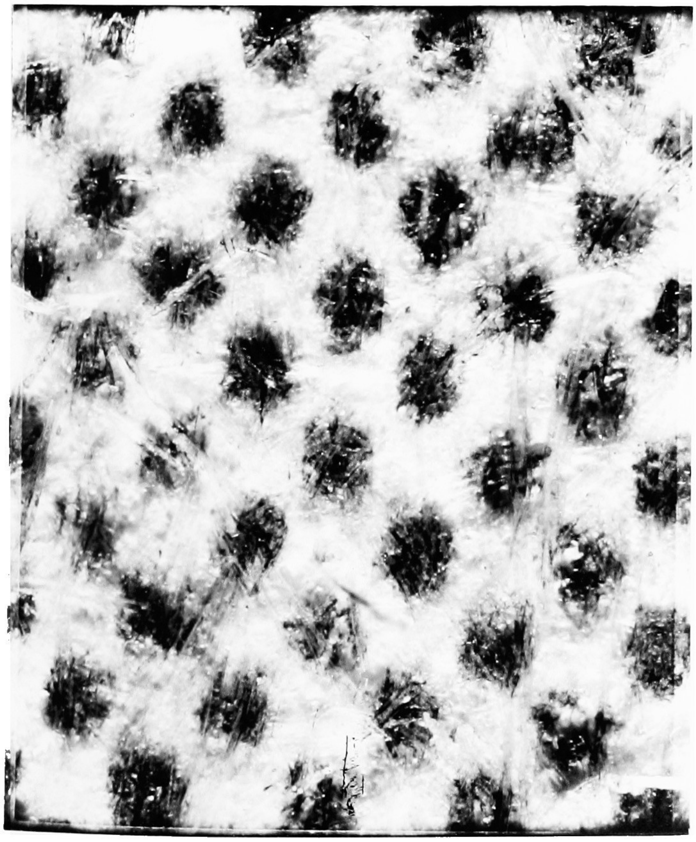


Figure 33: Press Sheet - Patch 4A

System 1: Page Facsimile

4. Subjective Analysis of Patch 4A - Tint Area I

Figure 31: consists of a uniform tint patch area. All the dots are the same size.

Figure 32: the negative film shows a significant amount of distortion caused by the transmission system on a uniform dot size area. There are many different dot shapes and sizes in the Received Film. There is also evidence of a possible syncronization problem in the scanning device used, causing more distorted dots.

Figure 33: shows a significant amount of dot gain, as expected in this tint area. The printing process has smoothed out the dots to a predominantly round shape.

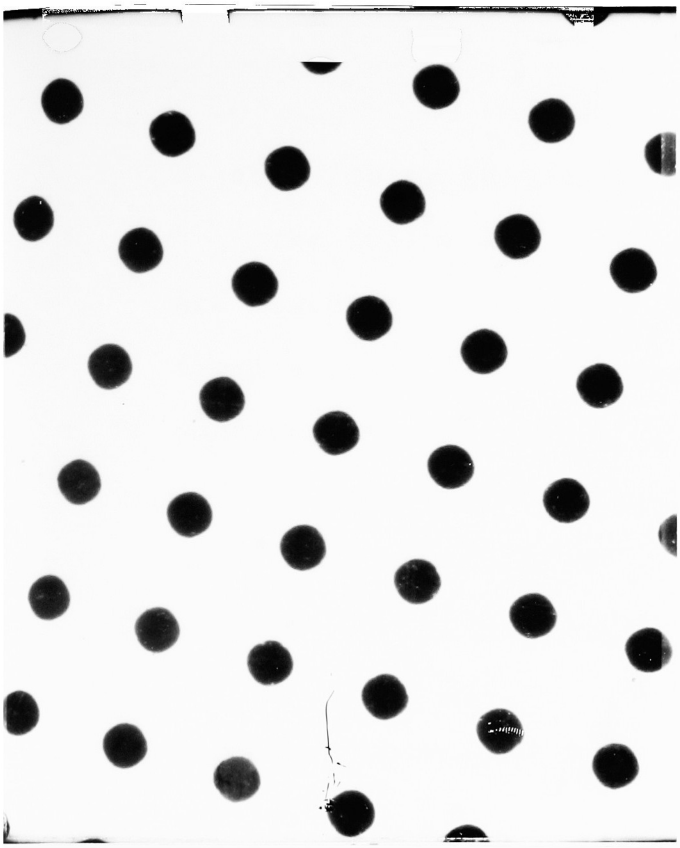


Figure 34: Original - Patch 5A

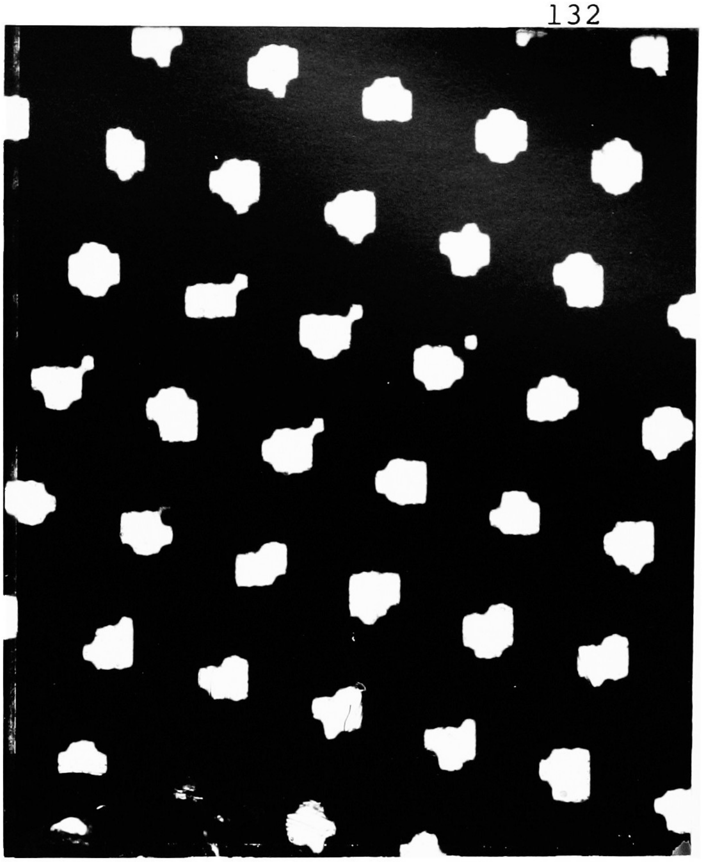


Figure 35: Received Film - Patch 5A

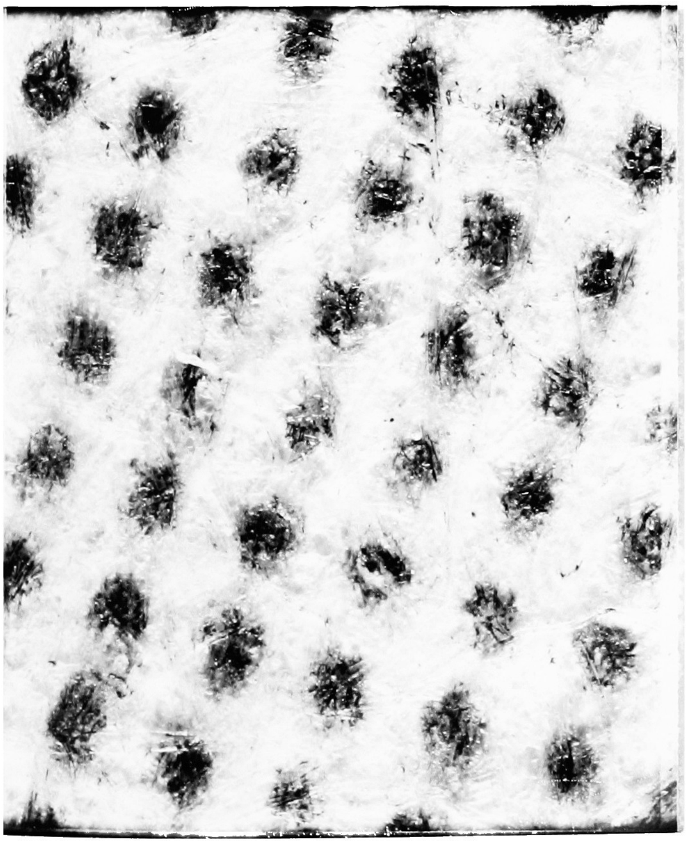


Figure 36: Press Sheet - Patch 5A

System 1: Page Facsimile

5. Subjective Analysis of Patch 5A - Tint Area II

Figure 34: consists of a uniform tint patch area with smaller dots than in **Figure 31**. All the dots are the same size.

Figure 35: shows more dot distortion caused by the transmission system on this uniform dot size area.

Figure 36: shows a minimal amount of dot gain in this tint area. The dots have once again been smoothed out by the printing process, to a round shape. The shape and size is approximately the same for each dot.

B. The 4/color Quality Evaluation:

The follow evaluations for System 1: Page Facsimile are based on a compilation of the results of the statistical 4/color analysis, and the subjective 4/color analysis conducted for this part of the study.

1. **Patches 1A & 3A:** The highlight dot areas were found to be more distorted by the transmission system and less effected by the printing process.

2. **Patch 2A:** The midtone dot area was found to be less distorted by the transmission system and more effected by the printing process.

3. **Patch 4A:** The larger tint dot area was found to be less distorted by the transmission system and more effected by the printing process.

4. **Patch 5A:** The smaller tint dot area was found to be more distorted by the transmission system and less effected by the printing process.

5. **Conclusions:** The 4/color capability of the Page Facsimile System is found to be poor, particularly in the reproduction of highlight areas on the newsprint stock used. However, with the limited quality expectations of the newspaper industry, this system meets the 4/color quality requirements for editorial and advertising pages.

System 2: CHARACTER-ENCODING & System 3: PIXEL DENSITY-MAP

The Subjective 4/Color Analysis

IV - Methodology

A. Purpose

The subjective analysis which follows was the method used to evaluate the 4/color reproduction capability of each communication system.

The subjective analysis for each system consisted of visually choosing sample patch areas photographing them and conducting an analysis of each patch from the enlarged photographs.

In this part of the study the photographs were used for the subjective analysis of the 4/color quality, and to verify the areas analyzed and for visual demonstration.

B. Materials Analyzed:

Two 4/color pages were analyzed, one for each communication system, by users of both System 2: Character-Encoding and System 3: Pixel Density-Map. A number of highlight and midtone sample patches were analyzed. Each 4/color page supplied was part of an actual issue transmitted, received and printed by that system user. A subjective quality analysis was conducted.

The 4/color subject analyzed for each system was taken from a lead story page supplied by current users of each

communication system. Each 4/color subject consisted of a variety of highlight and midtone areas, which were determined to be necessary for the 4/color quality analysis.

1. Materials Available:

a. Original copy of a chosen 4/color subject in the form of a pre-press 4/color proof, from the transmission site.

b. Received film of the same 4/color subject in film, one for each color of the transmission for that page. (System 2 supplied positive film, and System 3 supplied negative film.)

c. 4/color press sheet of the same 4/color subject printed from the received film at that remote printing location.

2. Materials Used:

1. Original copy - The Magenta dots only.*

2. Received film - the Magenta positive film only.

3. 4/color press sheet - The Magenta dots only.*

* A #58 green wratten filter was used to visually separate the magenta dots from the other three process colors.

C. Procedures

The items to be analyzed i.e. the Original prior to transmission, the Received Film and the press sheet were registered and stripped with a common pin register system. A mylar master was prepared with the same pin system with the patches to be analyzed cut out of the master. On the mylar

master each patch was cut out to approximately 1/10th of an inch and bordered with red tape and labeled for identification. Each item to be analyzed was taped on a light table with the mylar master registered to it to isolate those patch areas to be analyzed.

The process color Magenta was again chosen for analysis for each communication system.

D. Sample Size:

Two samples, one highlight and one midtone, were determined to be representative of the 4/color subject area under analysis for each communication system.

1. The Sample Patches:

The sample patches were chosen on the basis of being representative of highlight and midtone areas available for each communication system on the 4/color subject chosen. All highlight and midtone areas in the original were examined and particular patch areas were chosen based on the desired characteristics of highlight and midtone dot areas.

The same exact patch areas were isolated, photographed and subjectively analyzed.

a. Patch Size: Approximately 1/10th of an inch for each patch.

b. Number of Patches: 2

c. Total Number of Patches Analyzed: 6

2 in the original copy
2 in the received film
2 in the press sheet
6 Total Patches

d. Make Up of the Samples:

1) One highlight area was chosen to assess the 4/color capability of each transmission system.

2) One midtone area was chosen to assess the 4/color capability of each transmission system on the on the larger midtone dots.

e. Identification of Patches:

System 2: Character-Encoding

Patch 1B - Highlight Area

Patch 2B - Midtone Area

System 3: Pixel Density-Map

Patch 1C - Highlight Area

Patch 2C - Midtone Area

E. Photographic Enlargement:

A method of photographic enlargement using a microscope, (See Appendix C), was used to photograph each patch for analysis purposes.

System 2: Character-Encoding
The 4/Color Quality Analysis

Of the three communication systems in this study the Character-Encoded system is the only system that converts all the original data to ASCII codes for the text, and 8 bit byte codes for the graphics. The codes for all the text and graphics to the receiving site. The byte codes for the graphics are imaged from fonts of halftone dots stored in the intelligent photo imager at the receiving site.

The purpose of the 4/color quality analysis was to evaluate the reproduction capability of this communication system. It was known in advance that the photo imager used in this system had quality limitations. Because of the the CRT used in the receiving photo imager soft dots are created at the output location. There are a limited amount of dot sizes when compared to the sizes in the original. Also only whole dots could be created from the local halftone font.

All of these factors lead to potential 4/color quality limitations using this communication system, with the strongest effect in the highlight areas. The extent of these inherent limitations on the final reproduction copy was the emphasis of this part of the study.

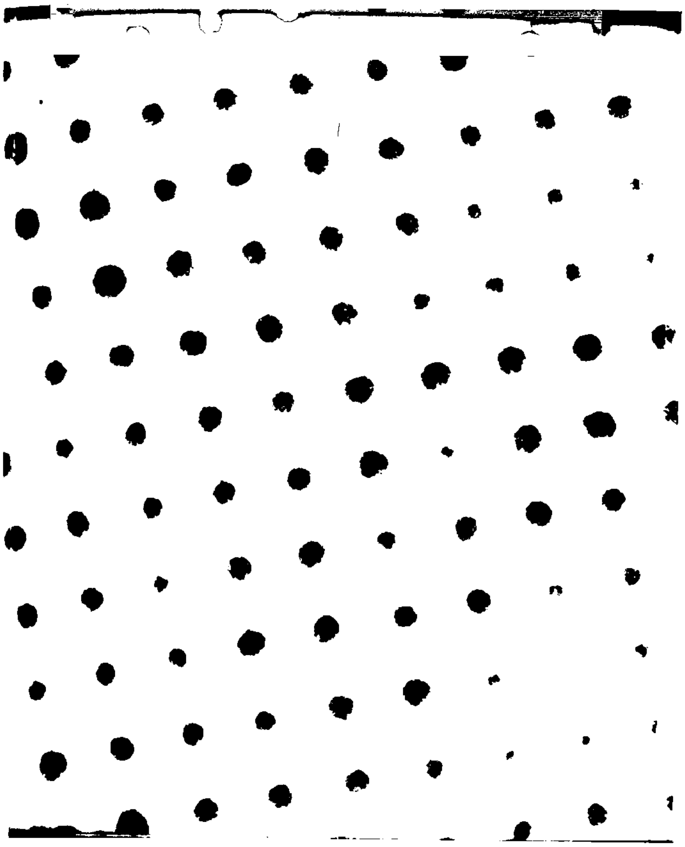


Figure 37: Original - Patch 1B

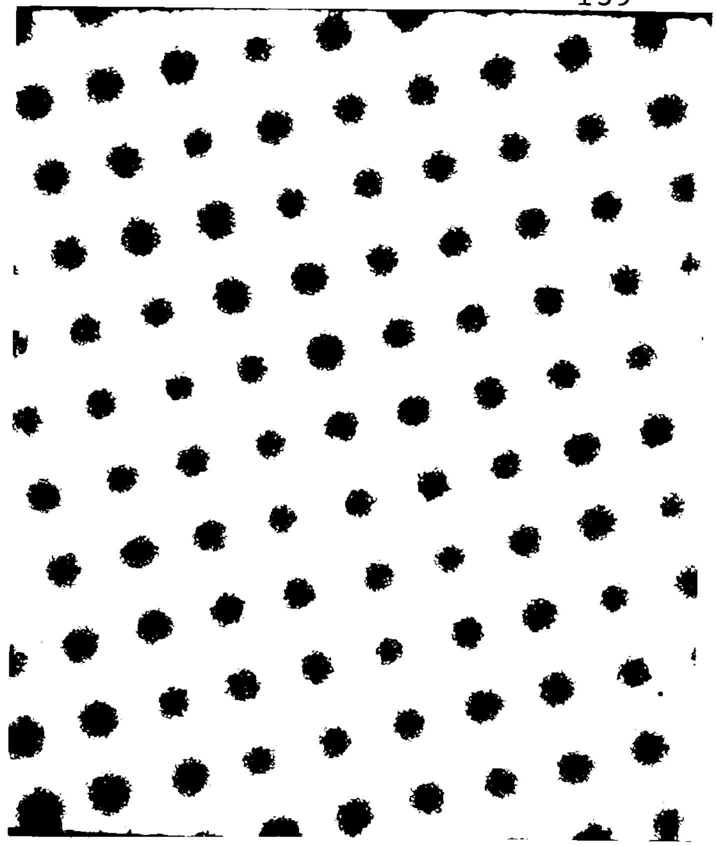


Figure 38: Received Film - Patch 1B

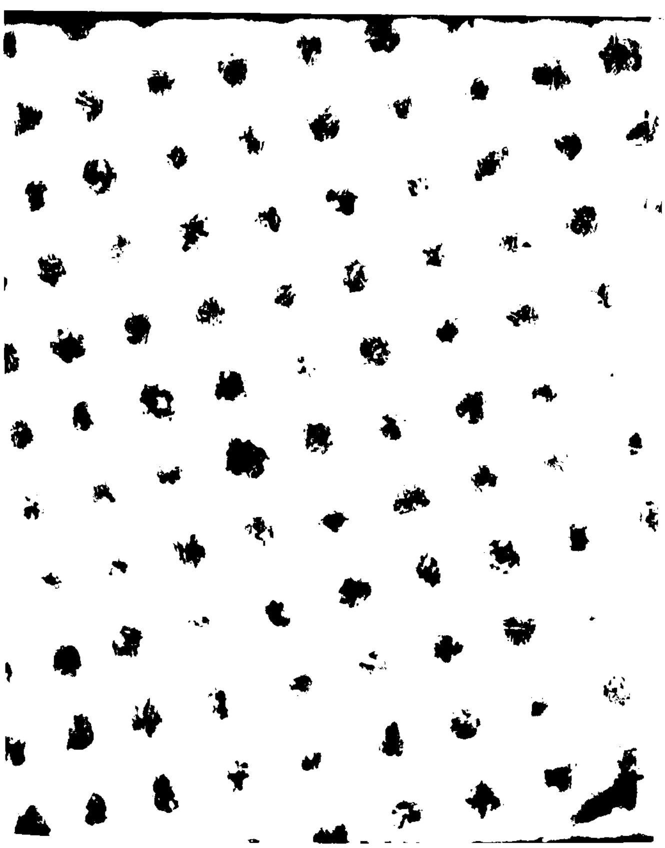


Figure 39: Press Sheet - Patch 1B

System 2: Character-Encoding

1. Subjective Analysis of Patch 1B - Highlight Area

Figure 37: consists of many different highlight dot sizes.

Figure 38: the positive film shows soft dots, with excessive fringe, created by the receiving photo imager. There is a limited amount of dot sizes when compared to the original dots. None of the dots in the received film are as small as in the original.

Figure 39: shows minimal dot gain on press. A better grade of paper was used for this sample. It is possible that when the Received Film was contacted for plates, the dots were sharpened to produce a hard dot.

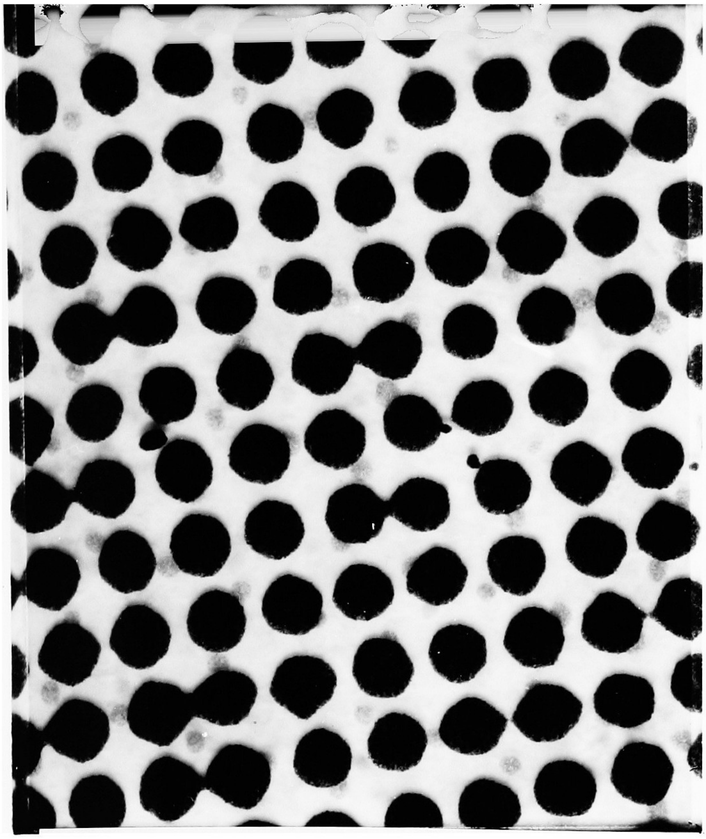


Figure 4Ø: Original - Patch 2B

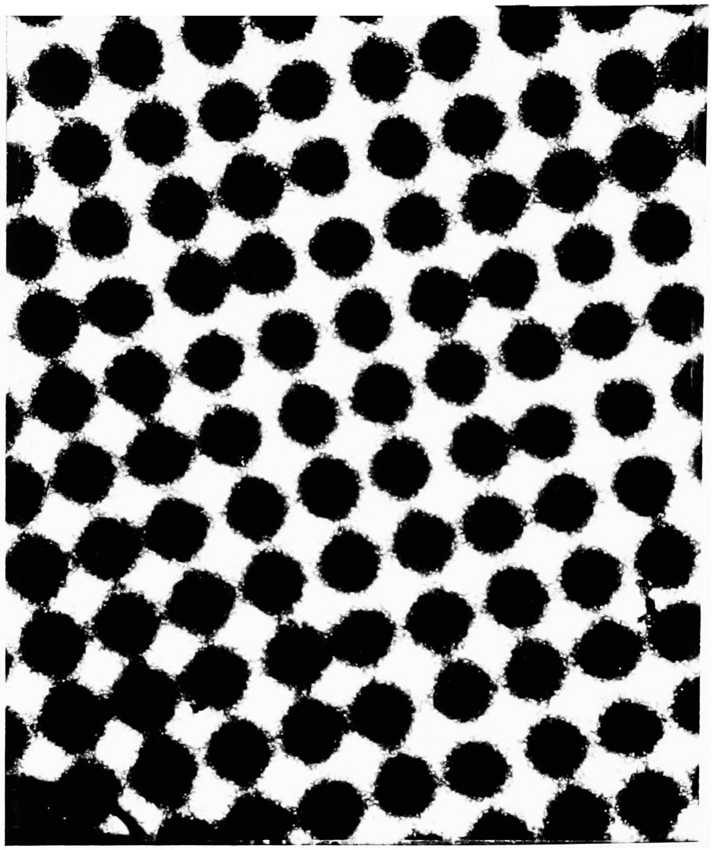


Figure 41: Received Film - Patch 2B

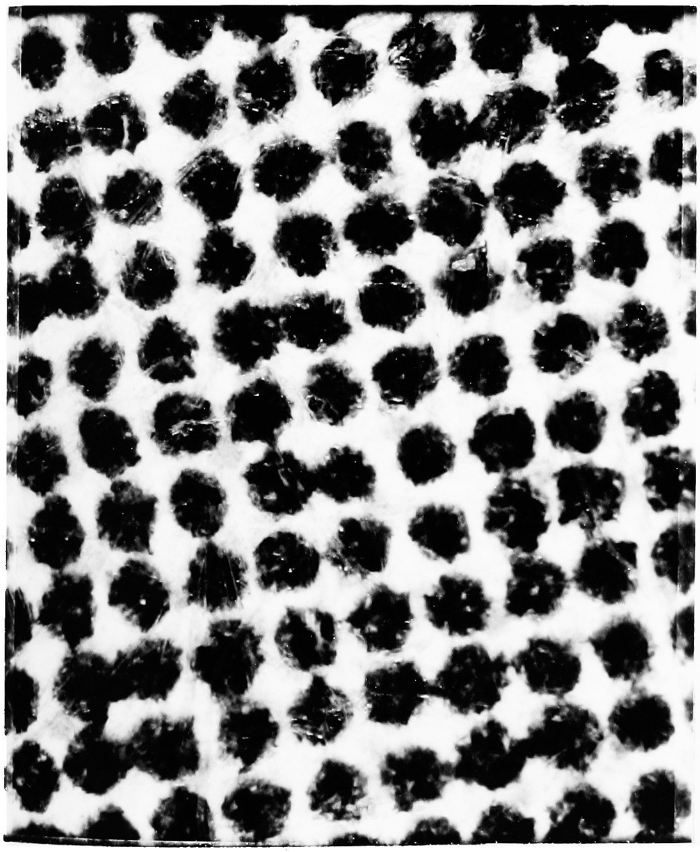


Figure 42: Press Sheet - Patch 2B

System 2: Character-Encoding

2. Subjective Analysis of Patch 2B - Midtone Area

Figure 4Ø: shows a fairly uniform midtone dot area.

Figure 41: the positive film again shows the limitation of the receiving photo imager in creating soft dots. There are a limited amount of midtone dot sizes when compared to the original.

Figure 42: again shows a minimal amount of dot gain on press.

System 2: Character-Encoding

The 4/Color Quality Evaluation:

1. **Patch 1B:** The highlight area in the received film exhibits the limitations of the photo imager at the receiving location. There are only a limited amount of halftone dot sizes in this system, usually 256 different sizes. Only full size dots are stored in the halftone font in the photo imager.

2. **Patch 2B:** The midtone area in the received film exhibits the same limitations in dot size and shape as the highlight dots in patch 1.

3. **Conclusions:** From the 4/color patches analyzed for this communication system it has been found that the CRT in the photo imager produces soft dots in the received film. There is also a limitation in the number of sizes of the dots created from the ASCII codes received. Creating only full dots limits the 4/color capability in this communiication system.

There is less of an effect from dot gain in the printing process used with this system. The soft dots can be compensated for in contacting the film to hard dots for platemaking. Also a better grade of paper is used for this type of magazine.

The overall 4/color capability of this system is adequate for 4/color editorial pages. However due to the

nature of creating the halftone dots at the receiving location the quality is not considered to be good enough for 4/color advertising applications.

System 3: Pixel Density-Map
The 4/Color Quality Analysis

The Purpose of the Analysis:

Of the three communication systems in this study the Pixel Density-Map system is the only communication system that scans the original graphics and transmits the density values to the receiving site. The density values are converted to halftone dots by the color computer in the output photo imager located at the receiving site.

The purpose of this 4/color analysis was to evaluate the reproduction capability of this communication system. It was expected that this system should have the best results from a 4/color quality standpoint. The reason being that the output part of a scanner is located at the receiving site.

The 4/color quality limitations in this system are primarily based on the output screening specification for each printing location.

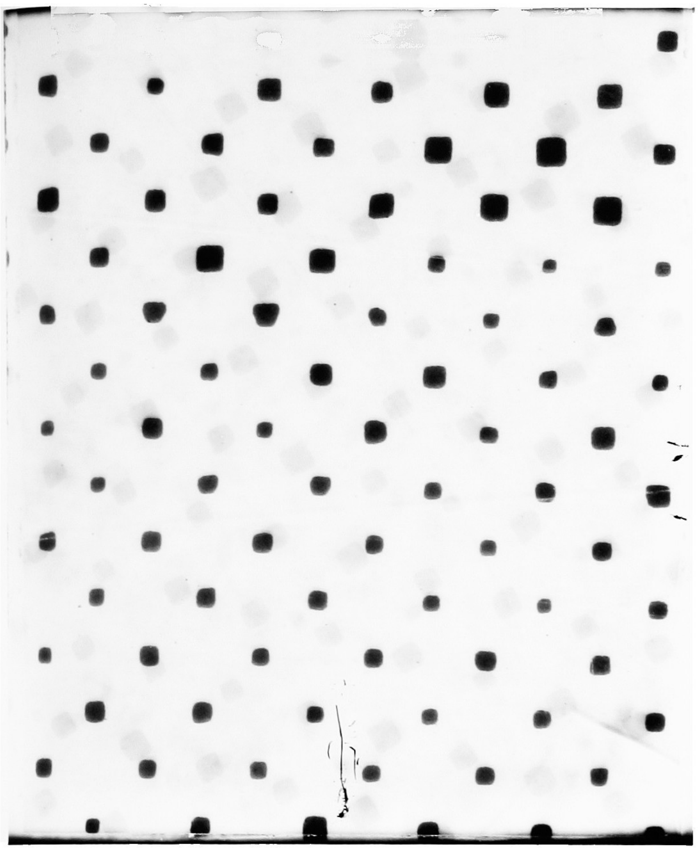


Figure 43: Original - Patch 1C

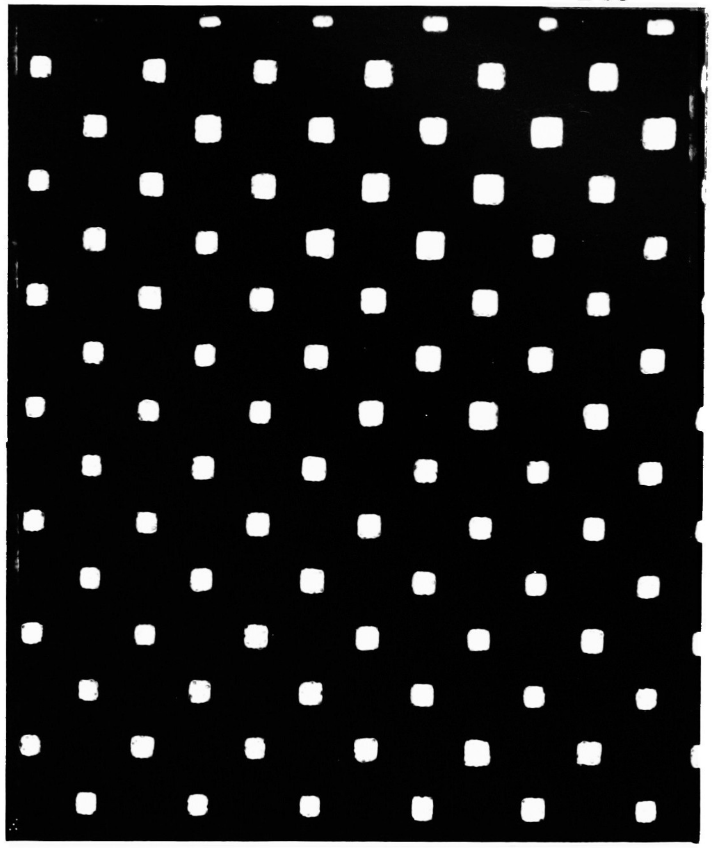


Figure 44: Received Film - Patch 1C

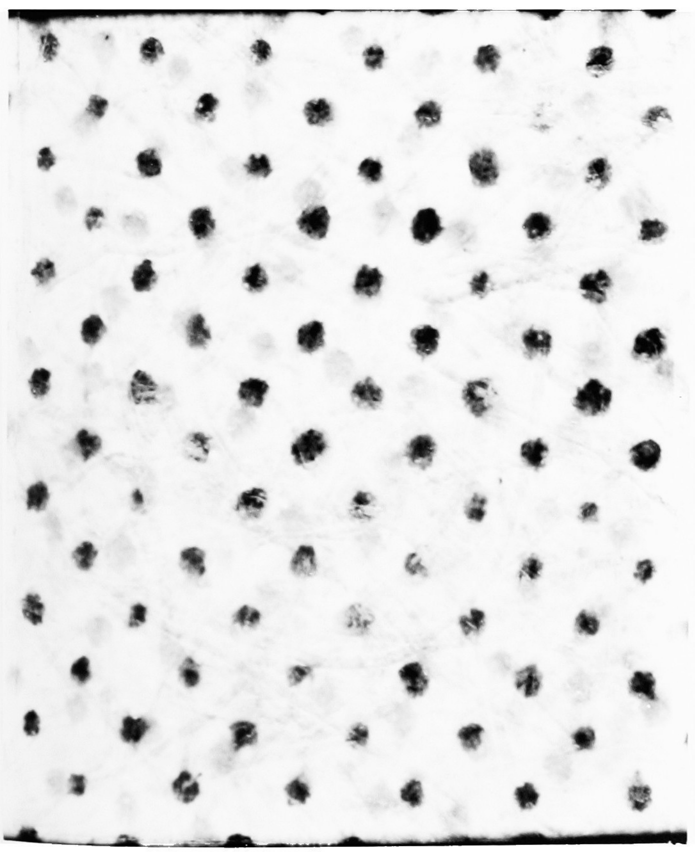


Figure 45: Press Sheet - Patch 1C

System 3: Pixel Density-Map

1. Subjective Analysis of Patch 1C - Highlight Area

Figure 43: consists of many different dots in the highlight area.

Figure 44: the negative film does not have as many different dot sizes as the original. It is possible that this limitation could be caused by the screening requirement specified for this remote printing location.

Figure 45: shows the square dots in the film now have a rounded shape, probably caused by the smoothing effect of the printing process. There is a minimal amount of dot gain due to the better grade of paper used.

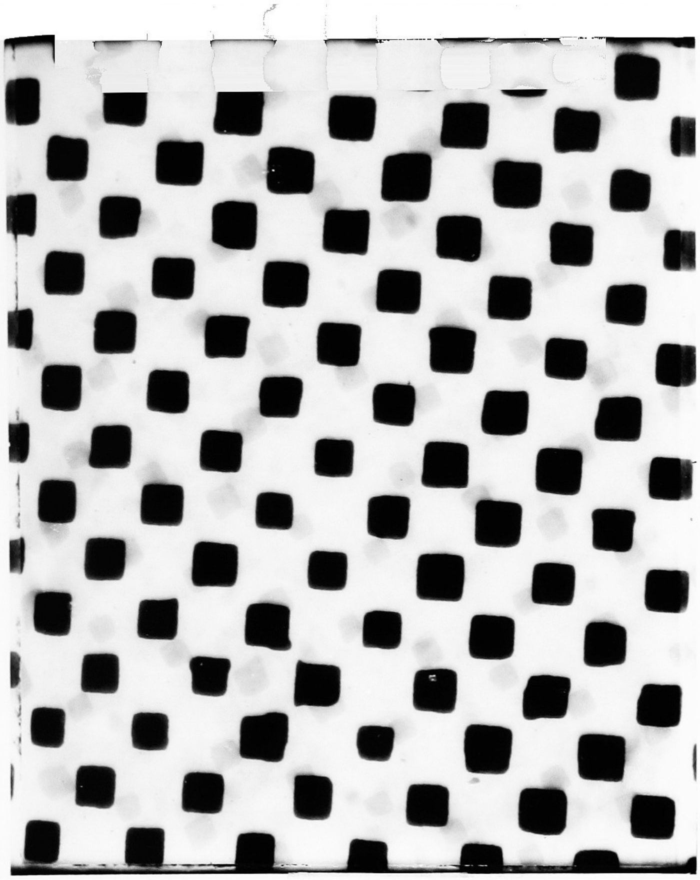


Figure 46: Original - Patch 2C

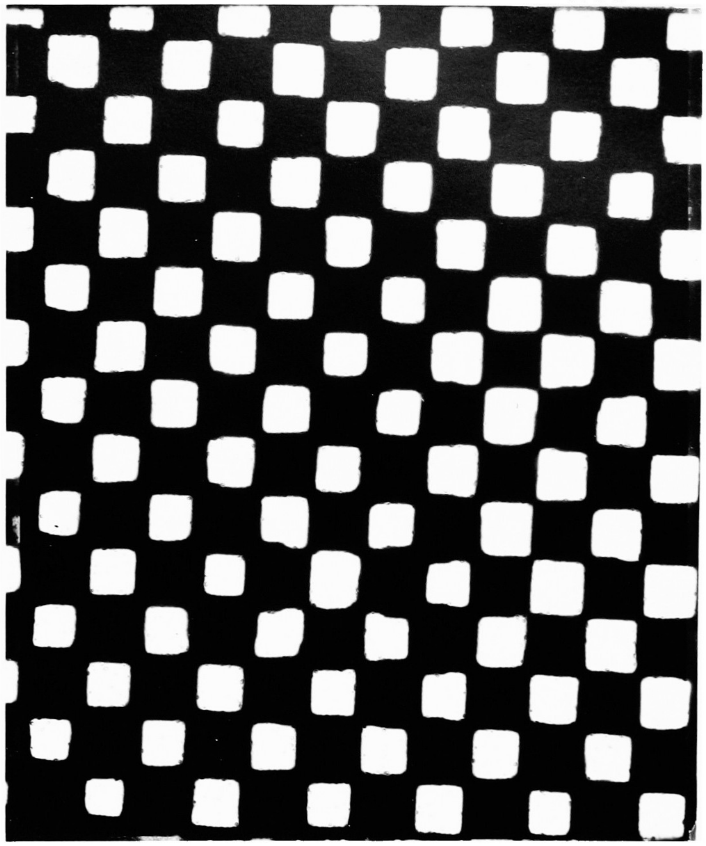


Figure 47: Received Film - Patch 2C

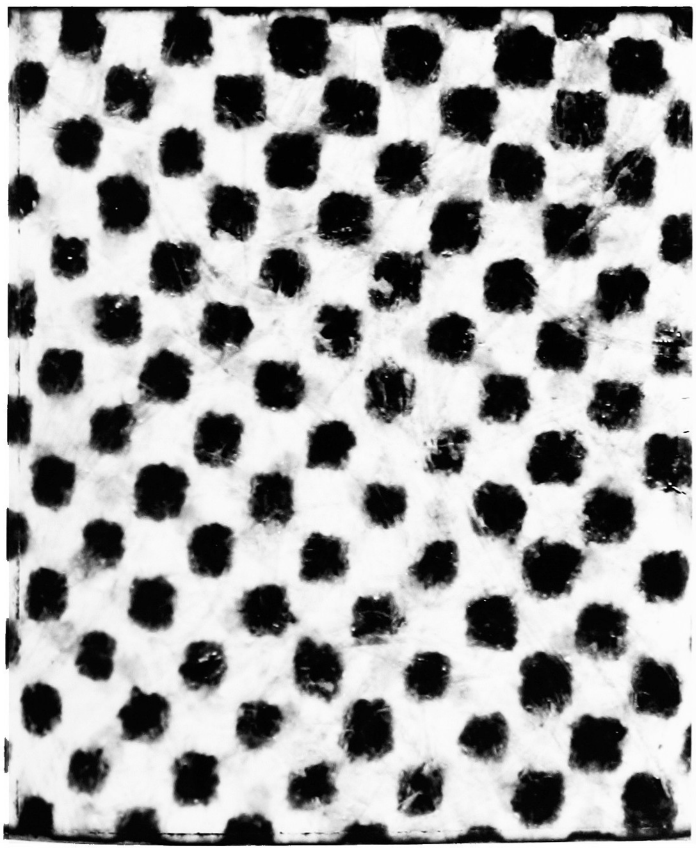


Figure 48: Press Sheet - Patch 2C

System 3: Pixel Density-Map

2. Subjective Analysis of Patch 2C - Midtone Area

Figure 46: consists of many different dot sizes in the midtone area.

Figure 47: the positive film contains dots of a slightly different size than the original. This could be caused by the screening requirement specified for this printing location.

Figure 48: exhibits a certain amount of rounding off of the square dots in the film. More dot gain is evident in the midtone dot area.

System 3: Pixel Density-Map

The 4/Color Quality Evaluation

1. **Patch 1C:** As in the original hard dots are output in the received film. The highlight area in the received film exhibits the dot size limitations imposed by the screening requirement specified at the receiving location.

2. **Patch 2C:** The midtone area also consists of hard dots in the received film. However the screening limitations are not as evident in the midtone dot area.

3. Conclusions: This system has the greatest potential from a 4/color quality standpoint. From the patches analyzed, hard dots are created in the receiving photo imager. As for the limitations in highlight dot sizes seen in patch 1, the screening requirement can be specified to as a higher line screen. A higher line screen creates smaller dot sizes in the highlight areas. Line screens of up to 175 lpi are possible with this communication system.

There is less of an effect from dot gain in the printing process used with this system. A better grade of paper is used for this type of magazine.

The overall 4/color capability of this system is excellent for both 4/color editorial and advertising pages.

The Subjective Text Quality Analysis
All Three Communication Systems

V - Methodology

A. Purpose

The subjective analysis consisted of visually choosing sample letters, one serif, the other sans serif, photographing them and conducting an analysis of each letter from the enlarged photographs.

In this part of the study the photographs were used for the subjective analysis of the type quality, to verify the areas analyzed and for visual demonstration.

From materials supplied by a users of each communication system number of sample type areas were enlarged photographically and subjectively analyzed for each system.

B. The Subject Analyzed:

The text material analyzed was taken from live text pages supplied by users of each communication system. The text material consisted of a variety of fonts and type sizes, all of which were necessary for the text analysis.

1. The Serif Type: Lower case serif type, i.e. "i" & "it" were chosen because of the number of serifs on the letters and the dot above the letter "i".

2. The Sans Serif Type: Upper case sans serif type, i.e. "A", "K" and "S" were chosen because these letters have a number of angles in the letter, useful in the analysis of the transmission system.

C. Materials Supplied and Used:

1. System 1: Page Facsimile

a. Original copy of a text area in the form of a black velox, from the transmission site.

b. Received film of the text area in negative film, from a receiving site.

c. Press sheet of the same text area printed from the received film at the remote location.

2. System 2: Character-Encoding &
System 3: Pixel Density-Map

a. Original copy of the text areas from the transmission site for each system are in the form of a pre-press proof for System 2 and positive film for System 3.

b. Received film of the text area in film, from a receiving site for each system. (System 2 supplied positive film, System 3 supplied negative film.)

c. Press Sheet of the same text printed from the received film at the remote location for each communication system.

D. Sample Size:

Two samples were determined to be representative of the text matter area under analysis for each system.

The sample patches were chosen on the basis of being representative of the text available from each communication system on the text material supplied. All text areas were examined and particular sample type patch areas were chosen based on the desired characteristics of font and type size.

1. Sample Patches

a. Number of patches: 2

b. Make up of the samples:

Type style: Serif Type - lower case
Sans Serif Type - upper case

c. Identification of Areas:

1) System 1: Page Facsimile

Patch 6A: The serif letter "i"

Patch 7A: The sans serif letter "A"

2) System 2: Character-Encoding

Patch 3B: The italic serif letters "it"

Patch 4B: The sans serif letter "K"

3) System 3: Pixel Density-Map

Patch 3C: The italic serif letter "i"

Patch 4C: the sans serif letter "S"

E. Photographic enlargement:

A method of photographic enlargement using a microscope (See Appendix C) was used. Each photograph contains as much of each letter as possible with the magnification chosen.

System 1: Page Facsimile

The Purpose of the Text Analysis

As previously discussed in the 4/color statistical quality analysis, Page Facsimile is the only communication system in the study that directly transmits the original data read by the facsimile scanner at the transmission site. The data received is immediately imaged by a facsimile recorder at place at the receiving site.

The subjective analysis which follows was used as a method to determine the effect, if any, of the transmission system used in Page Facsimile, on the type received at the receiving site.

For this part of the study, the term effect refers to the amount of relative image distortion on the type. The type density, type shape and edge quality will be analyzed and evaluated for each letter.

Also evaluated was the quality of the reproduction produced from the received film at the remote printing location at that receiving site.

For the purposes of this study it is inferred that the effect, if any, the transmission system has on these sample type patch areas will also be found to be consistent with a similar effect on other text matter transmitted.

Figure 49: Original - Patch 6A

Figure 5Ø: Received Film - Patch 6A

Figure 51: Press Sheet - Patch 6A

System 1: Page Facsimile

1. Subjective Analysis of Patch 6A: The Serif Type "i"

Figure 49: this letter prior to transmission exhibits a sharp edge and good definition of the serifs. The type density in the original is good.

Figure 5Ø: the negative film for this letter exhibits the jaggies caused by the scan frequency used. There is some distortion on the straight part of the letter. This effect indicates a possible synchronization problem in the scanning device used. Type density is good in the film.

Figure 51: the press sheet shows some dot gain in the printed letter on the newsprint stock used. Even with the smoothing of the printing process, the distortion caused by the synchronization problem is evident.

Figure 52: Original - Patch 7A

Figure 53: Received Film - Patch 7A

Figure 54: Press Sheet - Patch 7A

System 1: Page Facsimile

2. Subjective Analysis of Patch 7A: Sans Serif Type "A"

Figure 52: this letter exhibits a sharp edge and good type density.

Figure 53: the negative film for this letter exhibits the jaggies caused by the scan frequency used. Again there is some distortion caused by the synchronization problem in the scanning device.

Figure 54: this letter shows some dot gain on the newsprint stock used. The smoothing of the printing process is seen. There is less distortion in this letter caused by the synchroni-zation problem in the scanning device.

System 1: Page Facsimile

The Text Quality Evaluation:

1. Patches 6A & 7A: The original type in this system is photographed, as is the entire page, and contacted to a velox print prior to transmission. As a result, the type shape and density can be manipulated in the velox by exposure and development. The type prior to transmission is made sharp in the velox with none of the jaggies normally seen in original type created by the CRT used in the front-end typesetting system.

The transmission system does have a great deal of effect on the edge quality and density of the type. Jaggies are easily seen in all the type in the received film. This stair-step effect is caused by the scan frequency used at the transmission site and to some extent by the amount of data compression used for transmission. This is seen clearly in the received film, particularly in Patch 7A: the "A".

What is seen in the press sheet is a significant amount of dot gain from the printing process used. The newsprint paper used contributes greatly to the dot gain seen on the press sheet.

Conclusions: The smoothing effect caused by the printing process makes the type quality for this system acceptable based on the limited quality expectations of the newspaper industry.

The Text Quality Analysis

System 2: Character-Encoding

The Purpose of the Text Analysis

As previously discussed in the 4/color quality analysis, the Character-Encoding system is the only communication system in the study that converts the original type into ASCII character codes and transmits these codes via a transmission link from the transmission site. The codes received are locally generated into the approproate fonts by an intelligent photo imager at place at the receiving site.

The subjective analysis which follows was used as a method to determine the type quality capability of this communication system on the type received at the receiving site. Also evaluated was the quality of the reproduction produced from the received film at the remote printing location at that receiving site.

The basis for analysis for this part of the study is the amount of relative image distortion on the type. Type density, type shape and edge quality will be analyzed and evaluated for each letter.

For the purposes of this study it is inferred that the quality analysis of this communication system has on these sample type patch areas will also be found to be consistent with a similar effect on other type transmitted.

Figure 55: Original - Patch 3B

Figure 56: Received Film - Patch 3B

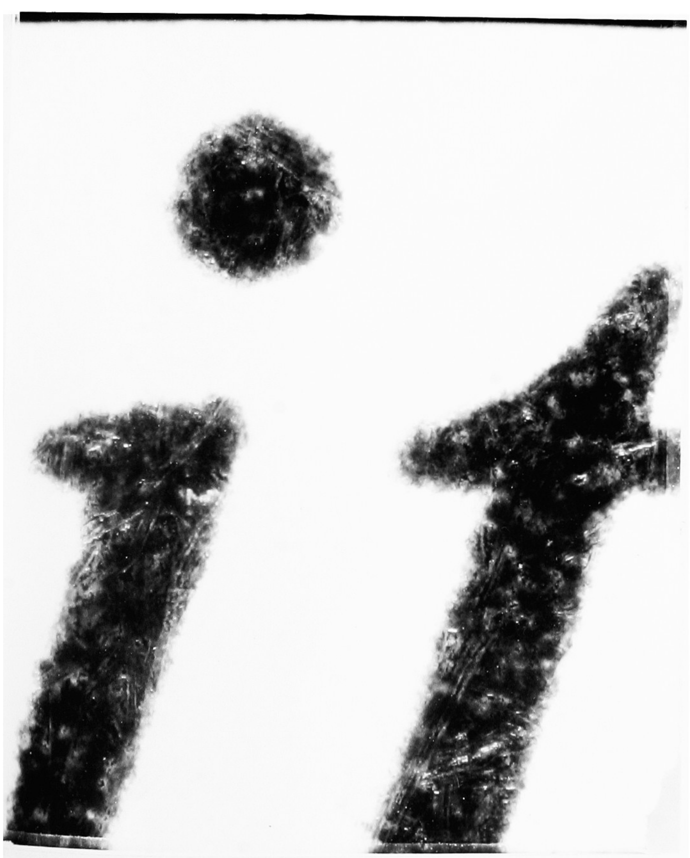


Figure 57: Press Sheet - Patch 3B

System 2: Character-Encoding

1. Subjective Analysis of Patch 3B: Italic Serif Type "it"

Figure 55: these letters have a sharp edge and very good definition of the serifs, in the pre-press proof used for analysis. The type density is good.

Figure 56: the positive film for these letters exhibit the soft edges that were seen in the halftone dots created by the receiving photo imager. The type density is fair.

Figure 57: these letters show a minimal amount of dot gain as was also evident in the press sheet analysis for the halftone dots in the 4/color analysis.

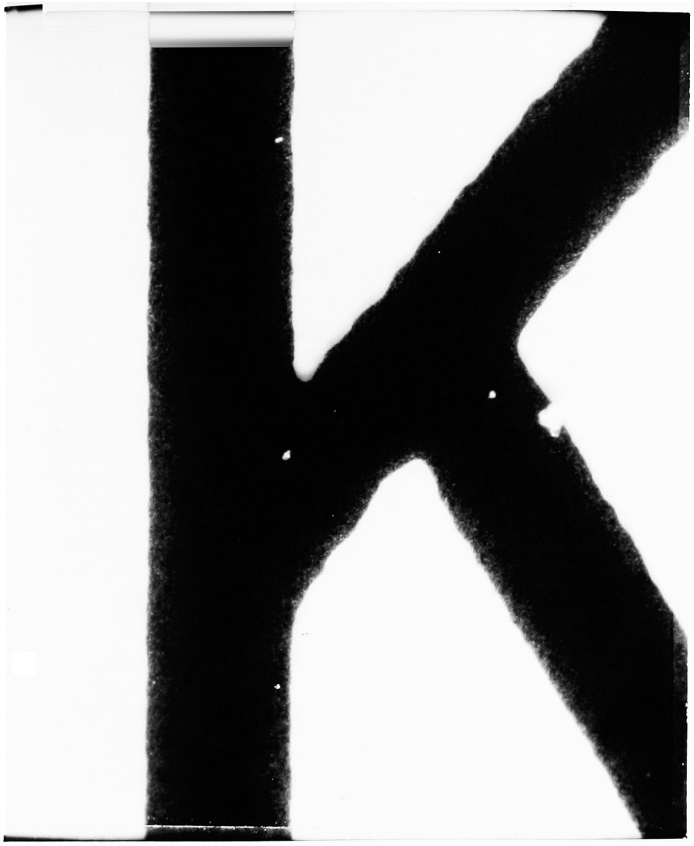


Figure 58: Original - Patch 4B

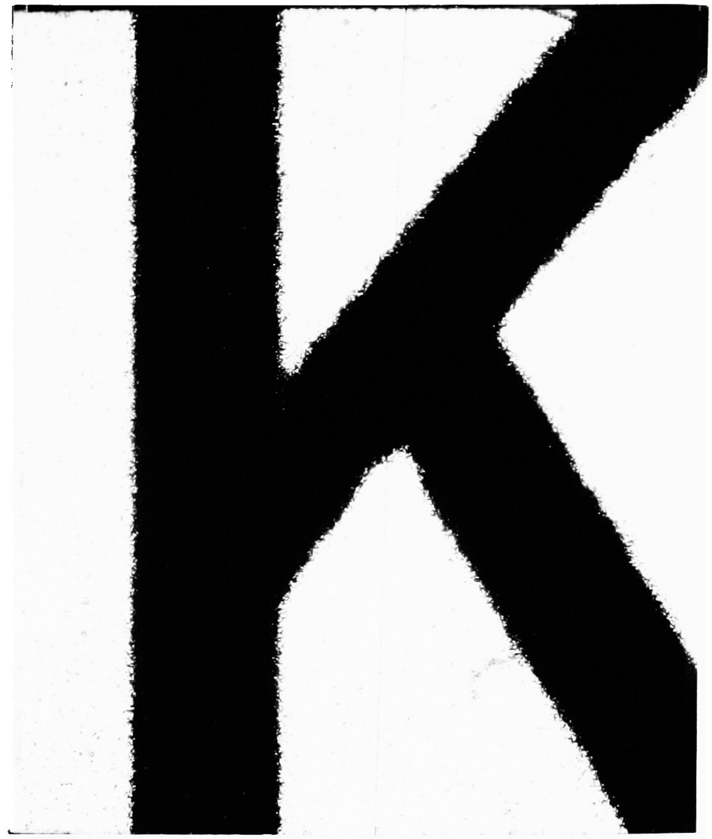


Figure 59: Received Film - Patch 4B

Figure 6Ø: Press Sheet - Patch 4B

System 2: Character-Encoding

2. Subjective Analysis of Patch 4B: Sans Serif Type "K"

Figure 58: this letter has a sharp edge and good type density in the pre-press proof used for analysis.

Figure 59: the positive film for this letter exhibits the soft edges as in Patch 3B. A noticeable jaggy effect is evident in the angles of the letter, caused by the CRT in the receiving photo imager being used.

Figure 6Ø: this letter shows a minimal amount of dot gain on the paper used. Again the smoothing effect of the printing process is seen.

System 2: Character-Encoding

The Text Quality Evaluation:

1. Patch 3B: The original supplied is a pre-press proof which has sharp edges and fair type density. The received film shows the soft edge that was seen in the halftone dots. There is some noticeable dot gain in the press patch, filling in the serif areas.

2. Patch 4B: The larger sans serif letter shows a soft jagged edge in the angles of the letter. Less dot gain in evident in the press patch.

3. Conclusions: The type in this system is locally generated by the receiving photo imager. Based on the analysis of the two sample patches the type is the best from an overall quality standpoint. The soft edges on the type seem to have a minimal effect on the type in the final reproduction.

The type produced in this communication system is extremely good and meets the quality requirements of a weekly magazine.

The Text Quality Analysis

System 3: Pixel Density-Map

The Purpose of the Text Analysis

As previously discussed in the 4/color quality analysis, the Pixel Density-Map system is the only communication system in the study that converts the original data into density values and transmits these densities via a transmission link at the transmission site.

The text in this system is raster image processed and it is the raster data that is transmitted for each letter. The receiving imager draws the letters from the raster data received.

The subjective analysis which follows was used as a method to evaluate the text quality of this communication system on the type received at the remote site. Also evaluated was the quality of the reproduction produced from the received film at the remote printing location at that site.

What will be analyzed for this part of the study is the amount of relative image distortion on the type. Type density, type shape and edge quality will be analyzed and evaluated for each sample letter.

For the purposes of this study it is inferred that the quality effect that this communication system has on these sample type patch areas will be consistent with a similar effect on other type transmitted.

Figure 61: Original - Patch 3C

Figure 62: Received Film - Patch 3C

Figure 63: Press Sheet - Patch 3C

System 3: Pixel Density-Map

1. Subjective Analysis of Patch 3C: Italic Serif Type "i"

Figure 61: this letter has a jagged edge caused by the raster processing, but good definition of the serifs. The type density is good.

Figure 62: the negative film for this letter also has a jagged edge, but there appears to be more definition in the letter. Type density is good.

Figure 63: this letter shows a minimal amount of dot gain and there is a definite smoothing effect from the printing process. The jagged edges still appear in the printed copy.

Figure 64: Original - Patch 4C

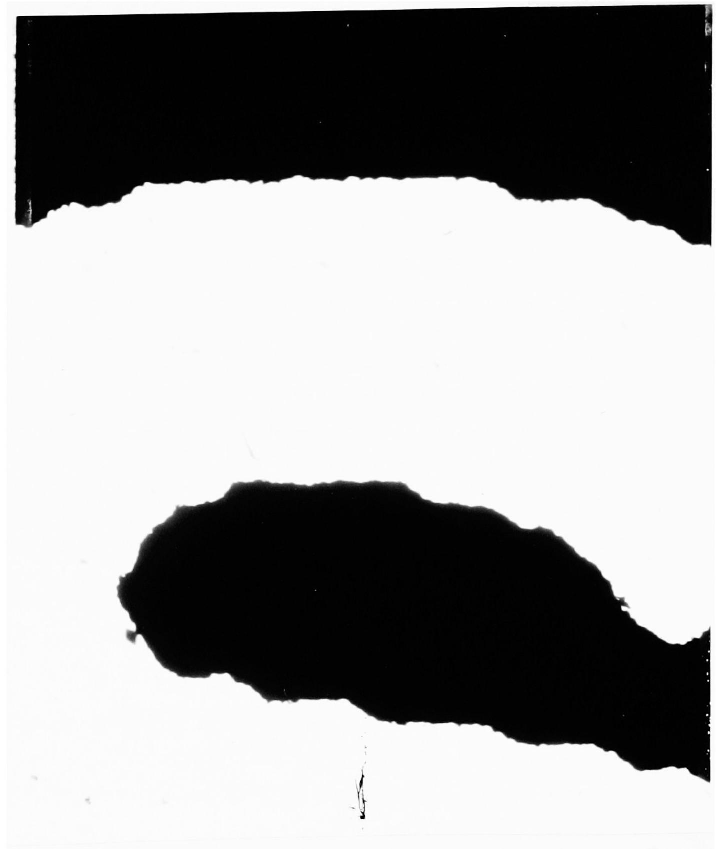


Figure 65: Received Film - Patch 4C

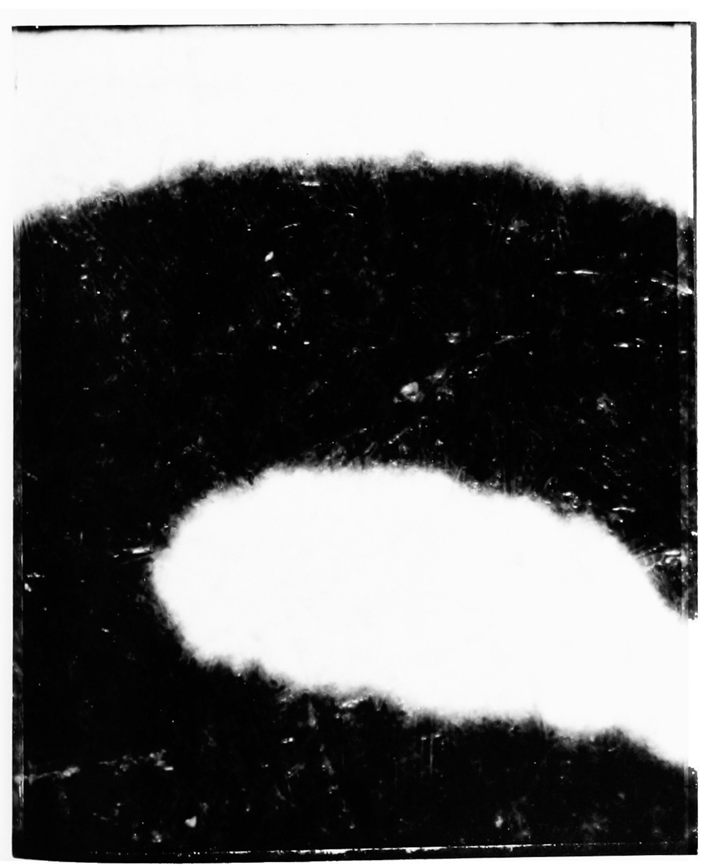


Figure 66: Press Sheet - Patch 4C

System 3: Pixel Density-Map

2. Subjective Analysis of Patch 4C: Sans Serif Type "S"

Figure 64: this letter has a more noticeable jagged edge caused by the Raster Imager Processor. The type density is good.

Figure 65: the negative film for this letter also shows a more noticeable jagged edge. The type density is good.

Figure 66: this letter shows a minimal amount of dot gain, however there is less of a smoothing effect on the larger type. The jagged edges still appear in the printed copy.

System 3: Pixel Density-Map

The Text Quality Evaluation

1. Patch 3C: The original supplied was positive film from the transmission site. The effect of the raster image processor is evident in the ragged edges of the serif type. There is minimal dot gain evident in the press sheet for this patch. The printing process has smoothed out the ragged edges to a certain extent.

2. Patch 4C: The larger sans serif type shows more of a ragged edge quality in the angles of the letter. The printing process seems to have less of a smoothing effect on this letter.

3. Conclusions: The type in this system is raster image processed prior to transmission. This accounts for the jaggies in the original type. Based on the analysis of the two sample patches the type is adequate from an overall quality standpoint. The ragged edges on the type do have a significant effect on the type quality in the final reproduction.

Generally the type produced in this communication system is good and meets the quality requirements of a weekly magazine.

CHAPTER V

OVERALL SYSTEM EVALUATIONS

The following are the overall evaluations and conclusions regarding the three electronic communication systems in the study.

COST EVALUATION

Table 18: Overall System Cost Evaluations

Fixed Cost Evaluation	System 1	System 2	System 3
Components ------------	3	2	1
Storage ---------------	Not Used	2	1
Transmission/month ----	2	3	1
Error Checking/month --	1	*	2
Maintenance/month -----	3	2	1
Variable Cost Evaluation			
Pre-press/issue -------	3	1	1**
Multiple Sites -----------	2	3#	1

Cost ratings used: 1 - Most Expensive
2 - Second Most Expensive
3 - Least Expensive

* included in transmission media costs for this system.
** same costs used for this system as in System 2.
\# System 2 is the least expensive with the exception of the costs for transmission media for multiple remote sites, because of point-to-point transmission.

PERFORMANCE EVALUATIONS

Table 19: Overall System Performance Evaluations

Capacity Evaluation	System 1	System 2	System 3
Number of bits /standard page ------	1	3	2

Ratings used: 1 - Most Data Intensive
2 - Second Most Data Intensive
3 - Least Data Intensive

Data Evaluation	System 1	System 2	System 3
Data Compression Text Ratio* -------	15:1	Not needed	4:1
Data Compression Graphics Ratio* ---	5:1	4:1	10:1

*Based on information from representative systems.

Transmission Evaluation	System 1	System 2*	System 3
Transmission Mode --	Broadcast	Point-to -Point	Broadcast

*This system can be designed for broadcast transmission, if desired.

Data Rate Evaluation	System 1	System 2	System 3
Transmission rate /bits per second ----	3	1	2

Ratings used: 1 - Least Transmission Time
2 - Second Most Transmission Time
3 - Most Transmission Time

Quality Evaluation	System 1	System 2	System 3
4/color subject ----	Adequate	Adequate	Best
Type subject -------	Adequate	Best	Good

CONCLUSIONS

System 1: Page Facsimile

1. Cost Advantages:

Of the three systems in the study, the costs of the transmitting and receiving components used for the Page Facsimile system are the least expensive. If multiple receiving sites are required, pages can be transmitted in a broadcast mode, saving in transmission costs.

2. Cost Disadvantages:

Even with data compression techniques, the method of encoding the images for Page Facsimile remains the most data intensive. These systems require expensive broad bandwidth communication lines to process the data volume.

3. Performance Advantages:

Relatively high data compression ratios of 15:1 in the text and 5:1 in the graphics can be used because of image redundancy in the Page Facsimile system.

Quality levels for 4/color pages and text material are found to be adequate for newspapers or other publications printed on newsprint.

4. Performance Disadvantages:

In Page Facsimile all the graphics are screened prior to transmission. In effect, the velox copy that is scanned for transmission is a second generation photograph of the original. All 4/color graphics are scanned and screened, contacted to a print and photographed.

Also, in the preparation of the page, all text and graphics are positioned together on the page mechanical. If there are text changes, the entire page preparation process must be repeated. In some cases a retransmission of this page must be done.

Generally, data storage capabilities are not built into this system design. This necessitates immediate transmission and reception of data.

5. Overall Evaluation:

At present, Page Facsimile systems are the only systems in use that operate with a full communication system design. As a result, this system can offer the user the advantage of transmitting the entire publication, including all 4/color editorial pages and 4/color advertising.

The quality levels of Page Facsimile systems are best suited to newspaper applications, where material from many sources - text, line art, halftones, and advertising often appear on the same page.

Generally this kind of publication is printed on a coarse stock requiring lower line screen rulings. The Page Facsimile system performs best at transmissions of 85 line screens. At the higher line screens required for other types of publications, the Page Facsimile system becomes increasingly expensive to operate because of the amount of data required to encode the original. This system is by far the most data intensive system in the study.

CONCLUSIONS

System 2: Character-Encoding

1. Cost Advantages:

Due to the method of encoding the graphic information, Character-Encoding systems can be operated with the less expensive, narrower bandwidth transmission lines. There are sizable savings in transmission costs with this communication system design.

2. Cost Disadvantages:

The Character-Encoding system requires the use of expensive, intelligent photo imagers at the transmission site and at every remote receiving location. Since all the fonts are locally stored at each receving location, more data storage is also a requirement of this system.

If a large number of multiple sites are desired by the user the present method of point-to-point transmission to each of these receiving locations becomes economically prohibitive.

3. Performance Advantages:

The Character-Encoding offers the user the best text quality possible at the receiving location. All the fonts are locally generated at each receiving location.

Data compression is already built into this system by the method of encoding the data. An additional data compression ratio of 4:1 in the graphics can be achieved.

Some bandwidth reduction is possible through the use of specially designed transmission modems.

4. Performance Disadvantages

In Character-Encoding all the graphics are screened prior to transmission. Transmitting screened data is a quality limitation in this system, particularly since a 133 line screen is at the present time the upper limit.

As in System 1, System 2 also merges the text and graphics prior to transmission. If there are any changes in the text the entire 4/color page must be reprocessed. In some cases a text change necessitates a retransmission of the entire 4/color page to each receiving location.

Character-Encoding systems lack the flexibility of transmitting different typefaces. All fonts, for a particular user must be locally stored and on-line at the receiving location.

The quality levels of Character-Encoding are found to be generally adequate for 4/color editorial pages. However at present, it is evident that the color transmission system design has not met the higher quality requirements of 4/color advertising.

5. Overall Evaluations:

Of the three communication systems in the study the Character-Encoding system is the least data intensive. The user can expect sizable savings in transmission costs with this system.

There exist inherent 4/color quality limitations with the Character-Encoding system, due to the limitations of dot sizes and line screens that can transmitted and imaged at the receiving location. As a result the Character-Encoding system is best suited to publications that are generally text oriented. It is clear from the findings of this study that for this system to continue in use another means of transmitting 4/color must be developed for it to remain competitive with the other two communication systems.

CONCLUSIONS

System 3: Pixel Density-Map

1. Cost Advantages

Generally it is the finding of this study that there are no cost advantages for users of the Pixel Density-Map communication system.

2. Cost Disadvantages

The present system design used for the Pixel Density-Map requires the most expensive and sophisticated components including data storage, at the transmission site as well as at each receiving location.

Also, since this system is data intensive in the method of encoding the graphic information, expensive broad bandwidth transmission lines are required for transmission.

3. Performance Advantages:

Type and graphics are merged at the receiving location. This is the only system in the study that transmits the text and graphics separately. This is a significant advantage in this system since it allows the earlier transmission of color graphics leaving text transmissions to later closing publication schedules.

If multiple receiving sites are required, pages can be transmitted in a broadcast mode, offering a significant savings in transmission costs.

At present, this system is the best from a reproduction

quality standpoint. The 4/color quality levels achieved are the best for advertising and editorial pages, equal to another "original."

Continuous tone densities are transmitted. A screen ruling range of 85 - 175 lines per inch is determined at the receiving location. Also halftone dot sizes for highlight, midtone and shadow can be chosen at each receiving location to optimize quality for press conditions.

4. Performance Disadvantages:

The same amount of data is generated for any line screen required at the remote receiving location. As a result, if the line screens in the lower ranges of 85 lpi are desired by the user, more data is transmitted than is necessary for each page to the receiving locations.

Even with the data compression ratios for text at 4:1 and 10:1 for graphics, the encoding method used is still very data intensive. With the present system design the most expensive broad bandwidth lines are a necessity.

At present all text is raster image processed prior to transmission. Ripping the type is time consuming and depending on the scan frequency used in the RIP, there is a noticeable jaggy effect seen in the text imaged at the remote receiving locations.

5. Overall Evaluation

It is clear that the Pixel Density-Map system is still in a development stage. However, it is the finding of this study that there is great future potential with this communication system.

The Pixel Density-Map system is the best transmission system for 4/color. Eventually this system will evolve into a full communication system design, necessary for the transmission of all pages in the publication. However, an improvement in the method of encoding and transmitting the text is necessary for this communication system to reach its full quality potential.

RECOMMENDATIONS FOR FURTHER STUDY

Based on the findings of the study, the following are recommendations for further study in the area of electronic communications in the printing and publishing industry.

Recommendation I:

An analysis of an original 4/color transparency prior to scanning for each communicaton system. After scanning, an analysis of the film output at the transmission site prior to transmission. After transmission, a quality evaluation of the film received at a remote site with a full press sheet analysis conducted.

Recommendation II:

The design and future use of a new electronic graphic communication system for the printing and publishing industry.

This system would combine character-encoding the text (System 2) with transmitting density values for the 4/color graphics (System 3).

The author would be required to develop a functional system description and the design of the system components, data storage, transmission media, and maintenance required to implement this new system design. Also required is a determination and evaluation of the cost and performance levels potential of this new communication system.

LITERATURE

"Composition Takes to the Sky",
Graphic Arts Monthly, April 1983

"Electronic Communications in Printing and Publishing",
by Joseph DeLorenzo. 1984 Course notes, Rochester
Institute of Technology.

"The Concept of Frequency in Linear System Analysis",
by Jack M. Manley.
1981 IEEE Communications Magazine

"Page Facsimile In The Eighties",
by Richard E. Amtower.
1981 TAGA Proceedings

"PPI - TECH" - A Technical Newsletter,
published by Publisher's Phototype Inc.
Volume 1, Number 1 - June 10, 1985

"The Technology Behind USA Today",
published by Gannett Corp.
December 5, 1985

"Transmitting Data by Satellite Calls for Special Signal
Handling", by Harvey T. Hindin.
Electronics Magazine - March 29, 1979

GENERAL READINGS

Communications Standard Dictionary, by Martin H. Weil. New York: Van Nostrand Reinhold Co.

Communication Systems, by Simon Haykin. Copyright 1978, John Wiley & Sons NY.

Data Communications, A Users Guide, by Kenneth Sherman. Copyright 1981 by Reston Publishing Company Inc.

Data Communications Dictionary, by Charles J. Sippl. New York: Van Nostrand Reinhold Co. Paper.

Digital and Data Communications, by Vincent F. Alisouskas and Wayne Tomasi. Copyright 1985, Prentice Hall.

Electronic Communication Systems, by George Kennedy. Copyright 1970 McGraw-Hill Publishing Co., Inc.

Introduction to Communication Science and Systems, by John R. Pierce and Edward C. Posner. Copyright 1980, Plenum Press NY.

Information Transmission, Modulation and Noise, by Mischa Schwartz. Copyright 1980, 1970, 1959 by McGraw-Hill, Inc.

Introductory Statistics, by Neil Weiss and Matthew Hassett. Copyright 1982, Addison-Wesley Publishing Company, Inc.

The Netweaver's Sourcebook - A Guide to Micro Networking and Communications, by Dean Gengle. Copyright 1984, Addison-Wesley Publishing Company, Inc.

The Random House Dictionary of New Information Technology. Edited by A. J. Meadows, M. Gordon, and A. Singleton. New York: Vintage Books. Paper.

Signals - The Telephone and Beyond, by John R. Pierce. Copyright 1981, W. H. Freeman and Company

Statistics, by D. Freedman, R. Pisani and R. Purves. Copyright 1980, W.W. Norton & Company, Inc.

Telecommunications And The Computer - 2nd Edition, by James Martin. Copyright 1976, Prentice Hall.

Telecommunication Transmission Handbook - 2nd Edition, by Roger L. Freemman. Copyright 1981, John Wiley & Sons NY.

APPENDIX A

Basic Electronic Communication Concepts

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Basic Electronic Communication Concepts

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A) THE CONCEPT OF INFORMATION

1) Information Theory

"If information is to conveyed, we must presumably have sounds or, more generally, signals changing unpredictably with time."[1]

For information or the message to be communicated, the signals themselves must change in an unpredictable way. For example, "A continuous trilling of one note conveys no information to you. If the note is varied in a manner that you can interpret, however the "signal" begins to convey meaning and information."[2]

2) Information Signal Processing

Of critical importance is how the information signal is transmitted, received and whether it is received correctly. "In most communication work, information transmission is closely related to the modulation or time variation of a particular sinusoidal signal called a carrier."[3]

Modulation is a technique which modifies the form of an electrical signal so the signal can carry information on some form of communications media. The signal which carries the information signal is called the carrier. Modulation of the carrier will change the signal at the transmitting end in a predetermined way, prior to transmission, so the information signal can be correctly detected at the receiver.

A carrier wave is a sinusoidal wave. Sine waves are

periodic and predictable waves, an important factor in the transfer of data from the transmitter to the receiver. A sine wave can be described by three numbers; the frequency, the number of times the sine wave peaks per second, measured in hertz or cycles per second; the peak amplitude of the sine wave above its average height, measured in volts; and the phase of the sine wave, which indicates exactly when the wave peaks, measured by the phase angle of the signal.

The frequency, the rate of signal wave change, determines the information content or how much information is communicated within a certain amount of time. The faster the desired data rate the higher the frequency.

The information signal is called a baseband signal. A baseband signal is a low frequency nonperiodic signal. The higher frequency carrier wave is modulated by the baseband signal to a high frequency for more efficient transmission.

Once the transmission is completed, and the signals are received at the destination, the baseband signal is demodulated from the carrier wave, back to the original information signal.

There are two types of baseband signals, digital and analog. A digital signal is a two discrete level state signal, called binary, i.e. on or off bits. An analog signal changes in a nondiscrete manner, i.e. a smooth transitioning to different voltage levels, or amplitudes.

In an electronic communication system either digital

or analog signals are used. The type of signal generated depends on the input of the system, and the method of transmission. A digital signal is simpler because of its binary nature. The newer, and generally higher speed transmission systems use fully digital lines. The communication systems that utilize voice grade telephone lines can only transmit analog signals through the line. Therefore, if the source signal is digital, it must be converted to an analog signal by particular forms of modulation.

3) Signal Modulation Techniques

There are different methods used for modulation. These methods are Amplitude Modulation, Frequency Modulation and Pulse Code Modulation.

Amplitude Modulation, called AM, is a method of transmitting an analog signal by use of a band of high frequency components. "In AM, a constant voltage is added to the signal voltage to produce a voltage that is always positive so that in the receiver the signal can be recovered easily."[4] A carrier wave is used to multiply the sum of the constant voltage and the signal voltage to produce the high frequency transmitted signal.

Frequency Modulation, called FM, is a method which changes the frequency of the carrier wave. In FM the carrier signal has a fixed power. "A FM signal is a high-frequency radio wave whose frequency varies in accordance with the amplitude of the baseband signal."[5]

FM offers the user three advantages. The first advantage is an improvement in the signal-to-noise ratio. An improvement in the signal-to-noise ratio decreases the amount of distortion in the transmission system and lowers the number of transmission errors at the receiving location. However, with FM a wider bandwidth is required to keep the different frequencies used from interfering with each other.

The second advantage of using FM is that it has a constant amplitude. As a result the transmitter can be operated at full power and efficiency.

The third advantage of using FM is referred to as the capture phenomenon. If two FM signals reach a receiver at the same time the stronger signal captures the receiver, the weaker signal is not heard.

Pulse Code Modulation, called PCM, is a modulation method designed for use with high speed digital transmission lines. PCM is used if the source signal is analog and must be converted to a digital signal for use with digital transmission systems. PCM is done by sampling the original analog signal, quantizing the signal to certain voltage levels and then binary encoding the signals into a digital form. "In PCM, binary numbers transmitted as on and off pulses represent the waveform of the signal."[6]

An advantage of PCM is that it produces a digital signal which can be continually regenerated throughout the transmission system. Regeneration is necessary in the use

of all long distance transmission systems.

The use of PCM requires more system bandwidth, as FM does. "PCM makes it possible to get a better signal-to-noise ratio by using more bandwidth. The more pulses (digits) we transmit per second, the more bandwidth we need to transmit them, but the more accurately we represent the signal."[7]

B) THE ELECTRONIC COMMUNICATION SYSTEM

1) General Definition

An electronic communication system is defined in the following way:

"A complete communication system will include a transmitter, a transmission medium over which the information is transmitted, and a receiver which produces as its output a recognizable replica of the input information."[8]

2) System Components

The Transmitter: The transmitter filters and modulates the signals prior to transmission.

The Modem: Computers communicate with each other using a series of off and on pulses, which are called digital signals or binary digits (bits). Traditional analog telephone lines, called voice grade lines, cannot carry digital signals. These lines transmit only sounds or analog signals. If an analog telephone line is used for transmission then the digital signals must be converted to analog signals

before they reach the telephone line. Once transmission is completed and the signals are received, the analog signals must be converted back into digital signals. These conversions are called Modulating and Demodulating the signals. The device used is called a MODEM.

The Transmission Medium: The transmission medium, or channel, is the communication path over which the signals are transmitted. The medium can be comprised of a single channel or a combination of any of the following: coaxial cable, telephone wires, microwave, fiber optics or satellite links. As the signals traverse any transmission medium they become distorted; noise and interfering signals are added to the signals in the medium. The amount of distortion depends on the medium chosen.

The Receiver: The receiver is configured through the use of filters and demodulators to correctly interpret the signals as received at the desired destination.

The Communications Port: The port is the connection of the users communication computer to the communications network computer. Because of the distance between the computer locations it is not cost effective to run a cable directly between the two computers. A telephone line is often used to bridge the gap between the two computers.

The Electronic Transmission System: The electronic transmission system can be a single network or comprise a combination of systems. These systems use various mediums

including telephone lines, coaxial cable, fiber optics, microwave, satellite links and others. These systems can be owned by the user or leased from a common carrier who supplies these services.

Satellite Communication Systems: A satellite communication system is generally comprised of earth stations, terrestrial stations, and a communication satellite.

"An earth station is a radio facility located on the earth's surface which communicates with satellites (or other space vehicles). In general terms an earth station has come to mean a radio station operating with other stations on the earth via an orbiting satellite relay."[9]

A terrestrial station is a radio facility on the surface of the earth operating directly with other similar facilities on the earth's surface. This allows communication between the transmission site and the receiving site.

The transmission earth station, called a hub, provides the uplink to the communication satellite. The uplink is the link from the earth station to the satellite.

Communication earth stations operate with synchronuous earth satellites. These satellites orbit the earth with a period of 24 hours. They appear to be stationary over a particular geographic location on earth. The altitude of a synchronous satellite is 22,300 miles above the surface of the earth.

The channel or medium in satellite transmission is the

earth's atmosphere. The signals must pass through the air just as all radio waves do. To reach the communication satellite 22,300 miles away, the signals are transmitted at assigned transmission freqencies. The frequencies used for satellite communication are within a certain range of transmission frequencies called the earth-space window.

The earth-space window is the band of frequencies that are used for broadband communication where the signals will suffer minimum attenuation (signal loss) and where the inherent noise level is least. "Generally the optimum earth-space window is between 1,000 and 10,000 MHZ. In the 1,000-10,000 MHZ window, four bands, each 500 MHZ wide, have been assigned for use with communication satellites."[10]

As in any other transmission media used there is a certain amount of channel loss. In satellite systems this phenomena is called path loss. To minimize path loss, the signals must be of sufficient strength to reach the communication satellite. Upon reaching their destination in space, the satellite transponder regenerates the signals, preparing them for retransmission via the downlink. The downlink is the link between the satellite and the earth.

The downlink is considered to be the limiting factor on earth station design. "The uplink may take advantage of powerful earth station transmitters, high-gain narrow-beam antennas with little likelihood of interference with other services. On the other hand, the downlink is severly limited

in radiated power owing to the possibility of interfering with terrestrial services."[11]

To compensate for these limitations, it is the downlink around which receiving earth stations are designed.

Receiving earth stations are categorized by what is called a Figure of Merit G/T. This designation is used to describe the capability of an earth station to receive a signal from a satellite.

Signals are prepared for satellite transmission in the following way: Prior to transmission to the satellite the signals must be up-converted through the use of local oscillators which are used to convert the slower baseband signal frequencies to the higher frequencies necessary for transmission through the atmosphere. The signals are then power amplified and passed to an antenna for transmission.

When the signals reach the satellite transponder, which is a radio frequency repeater, the signals are regenerated and radiated back towards the earth.

The receiving earth station accepts the downlink signal through an antenna and low noise amplifies it to recover the original signal. Local oscillators are used to down-convert the signals to frequencies that can be processed by the receiving communication system.

C) ELECTRONIC COMMUNICATION SYSTEM CAPACITY

1) System Capacity

System capacity is directly related to the users needs for communicating information. These needs include the transmission data rate needed to get information from one place to another in a reasonable amount of time, and the method of transmission to the remote receiving sites. "All portions of the transmitter and receiver, as well as the physical channel, contribute to the capacity."[12]

The transmission data rate is determined by the method of encoding the information in the orignal. The more data a system generates the faster the transmission data rate required for transmission to take place in a reasonable amount of time. Clearly if the amount of user information that must be transmitted in a given time increases then, so must the system capacity.

The physical channel is the transmission medium itself. In telephone line and coaxial cable transmission the medium is the lines or the cable used. In microwave or satellite transmission the medium is the air space.

Physical channel capacity determines the maximum transmission rate of signals over the medium. The medium chosen is should be matched to the desired transmission rate.

2) Bandwidth Capacity

Bandwidth is another major factor to be considered in the determination of system capacity. "An electric signal can be represented as a sum of sine waves of different frequencies. The bandwidth of the signal is the range of frequencies that must be used to represent all these sine waves."[13]

Every transmission system has a bandwidth or is band limited in the range of frequencies that are designed to pass through that system. The bandwidth is expressed in frequency and is measured in hertz of cycles per second. Bits per second (bps) is a measure of the data rate which can be transmitted through the bandwidth of a particular transmission system.

The system bandwidth is a measure of the frequencies that will pass through that transmission system. For example, if frequency components ranging from Ø to 5,ØØØ hertz are band limited to represent all the signals transmitted, the system bandwidth is 5,ØØØ hertz.

There is an important inverse relationship between pulse width, or duration, and the system bandwidth. In its simplest terms the bandwidth, called a baud in this special case, is the inverse of the shortest pulse in a signal or bit stream. If the shortest pulse can pass through the bandwidth of a system, then all other pulses in that signal will pass.

The inverse relationship is expressed as follows:

Pulse width is τ

Bandwidth is B

$$B = \frac{1}{\tau} \qquad \tau = \frac{1}{B}$$

Since an inverse relationship exists between system bandwidth and signal pulse width, it follows that the smaller the pulse widths the broader the bandwidth required. If the user desires to send data quickly, then more signals or pulses must be compacted into a given time period. Shorter pulse widths increase system bandwidth requirements.

There are important differences between broad bandwidth and narrow bandwidth systems. Generally in any communication system, the choice of bandwidth requirements generates a great deal of the transmission expense.

To meet the needs of the new communication technologies being developed, current users of narrow bandwidth systems are now faced with the necessity to upgrade present systems to broader bandwidth systems. Generally narrow bandwidth systems transmit data from 9,600 bits per second to 56,000 bits per second.

A well known user of a narrow bandwidth communication system is Publisher's Phototype Inc. (PPI) in Carlstadt, New Jersey.[14]

Currently, PPI transmits "Newsweek" magazine to eight remote printing facilities each week. This company is at

present considering an upgrade to a broader bandwidth communication system design.

In a technical newsletter published by PPI, some of the factors involved in the decision to upgrade its present communication system are discussed by John Werner, PPI's Director of New Product Development.[15]

Mr. Werner states:

> "Generally broad band communications means "T-1" or 1.544 million bits per second, or 16Ø times faster than the 9,6ØØ bits per second system transmission rates. The reason for the need for increased speed is the new color scanner and data manipulation technologies being developed by Scitex and other companies work at 1ØØØ lpi (lines per inch) or higher resolutions."

> "At a resolution of 1ØØØ lpi, one inch square yields 1 million or more pixels per square inch, compared to 18,ØØØ halftone dots per square inch, at the 133 line screen. The systems with increased volumes of data thus require faster data transmission systems to accomodate the greater throughput. There is also a need for greatly expanded data storage capacity in the computer systems in use."

For Publisher's Phototype Inc. these are some of the many factors which must be considered in this eventual transition from narrow bandwidth to a broad bandwidth communication system.

Other factors include, suitable data compression options and the speed of the transmission and receiving computer equipment. Speed is an important consideration since many computer systems cannot transfer data internally from disk at "T-1" (1.544 million bits per second) speeds. The operation speed of many of these computer systems will

have to be upgraded. Speeds at half of "T-1" are more realistic at present, running at around .768 million bits per second in terms of matching disk transfer speeds.[16]

In the design of all electronic communication systems the efficient match between bit rate and the bandwidth required is difficult to achieve, because of the economic factors involved. Currently three basic system designs are used. These designs are:

a) Design 1 <u>Broad Bandwidth Systems With Simple Playout Photo Imagers</u>

b) Design 2 <u>Narrow Bandwidth Systems With Intelligent Photo Imagers</u>

c) Design 3 <u>Broad Bandwidth Systems With Intelligent Photo Imagers</u>

In any transmission system design chosen there are other capacity factors along with system bandwidth which are considered. Specifically, the sophistication of the controllers and other computer hardware, including storage requirments in place at the transmission and receiving site needed to monitor the desired information data throughput.

Generally, the level of sophistication required by any communication system is determined by the users data rate needs. If the user desires to transmit data quickly, then the levels of system sophistication, and expense, must rise to meet this increased demand.

a) Design 1 Broad Bandwidth Systems With Simple Playout Photo Imagers

If the user generates large amounts of data and needs to send this data in a reasonable amount of time, this leads to the choice of a broad bandwidth system.

Broad bandwidth systems are relatively more expensive from a transmission standpoint. These systems, particularly those used for Page Facsimile, require higher speed data transmitters, which generate high bit per second transmission rates. To send data quickly, higher speed broad bandwidth transmission lines are required.

When higher bit rates are generated, much more data must be transmitted. Higher bit rates can be handled in two ways.

The first way is "real time" transmission, i.e. immediate transmission and reception of the data, generally used by Page Facsimile systems. The second way is "delayed time" transmission, i.e. the user can determine the transmission rate and time of transmission.

"Delayed time" transmission systems require relatively more overall system sophistication, specifically in terms of extensive buffer storage and the intelligence of the photo imagers used. The concept of "delayed time" transmission will be discussed further in the next two system designs.

Most Page Facsimile communication systems do not have the storage capacity built into them, or the sophisticated

photo imagers required to process handle all the data being transmitted for a "delayed time" mode. Although there is a limited amount of buffer storage on both ends of the Page Facsimile system, it usually becomes necessary for all the data to be played out immediately, in "real time" by the receiving playout imager.

This type of playout imager, called a "dumb" imager, simply takes the signal received, element by element, and images it.

The major design advantage for broad bandwidth systems that use simple playout imagers, such as Page Facsimile communication systems, is that they use relatively less expensive transmission and receiving components, and do not require the use of extensive data storage capacity.

However, Design 1 systems do require the use of expensive broad bandwidth transmission lines for the immediate transmission of data. The disadvantage in these systems is that they do not offer the flexibility of variable transmission rates or variable transmission time schedules.

b) Design 2 Narrow Bandwidth Systems With Intelligent Photo Imagers

If slow data rate transmitters are part of the system design, then the user can choose a narrow bandwidth communication system. Narrow bandwidth lines are relatively much less expensive from a transmission standpoint. Slow transmitters create larger signal pulse widths.

However, if the user decides to increase the data rate, i.e. goes to smaller pulse widths, then the transmission bandwidth must increase accordingly.

It is physically impossible for small pulse widths, i.e. fast data rates to be transmitted, without major signal distortion, over narrow bandwidth lines.

In terms of system capacity, narrow bandwidth systems are generally slower, than the broad bandwidth systems. In a narrow bandwidth system it takes more time to transmit data from one location to another. The important factor for the user to consider is based on a determination of reasonable transmission times, for the data rate generated.

A major factor to be considered by Design 2 users, particularly for those who encode their data with symbolic codes for transmission as in Character-Encoding systems, is the requirement for more intelligent and expensive imaging equipment at the transmitting and receiving ends of the communication system.

The Character-Encoding system requires the use of an intelligent imager at every remote receiving site. These intelligent photo imagers become expensive because of the increased need for computing power required by the system. Moreover identical units must be in place at all the remote locations being served by the transmission system.

Another factor to be considered in this system design is the amount of internal computer storage capacity required

for image formation, at both ends of the electronic communication system. Off-line and on-line computer storage must also increase, significantly adding to the total system cost. However, the Design 2 system does offer the flexibility of variable transmission rates and variable transmission time schedules.

With this system design the user must consider the break-even point between the savings in cost of the narrow bandwidth transmission lines, and the increased cost for the more sophisticated imaging equipment, and the storage needed to process the data.

c) Design 3 Broad Bandwidth Systems With Intelligent Photo Imagers

Design 3 systems use both broad bandwidth lines and intelligent photo imagers on both ends of the communication system. These systems generally use a method of encoding the original continuous tone data into pixels, and raster image process the text material.

Pixel Density-Map are the systems used for Design 3. Design 3 systems encode every bit of type and graphic information in the original as does Design 1. The difference is that Design 3 encoding is done by assigning density values, or gray levels, to each pixel. It is the density levels that are transmitted. Encoding the data in this manner creates an intensive amount of data to be transmitted and received by this communication system.

The transmission site imager is in effect the input part of an electronic color scanner. The imager at the receiving location is the output part of the color scanner. Each receiving location served by the transmitter must have this sophisticated component design in place.

To maintain reasonable transmission times, the large amount of data to be transmitted in this communication system necessitates a system design which will process smaller and smaller pulses. Broad bandwidth lines and more sophisticated controllers and imagers, at the transmission and each receiving site, must be used to process the increased data flow.

As in Design 2 it is necessary for Design 3 systems to have extensive internal computer data storage capacity built into the system, to handle the required data throughput.

Some of the major factors to consider in Design 3 systems are the costs of the broad bandwidth transmission lines and the level of component sophistication of the photo imagers required at each receiving location served by the transmitter. As in Design 2, this system also offers the flexibility of variable transmission rates and variable transmission time schedules.

3) Point-to-Point Transmission

An important aspect of the transmission system design is a consideration of the different ways of transmitting the

data from the transmission site and receiving the data at the remote receiving locations. Point-to-point transmission is a system that sends data to each remote receiving site individually, on a one-to-one basis.

4) Broadcast Transmission

Broadcast transmission is also known as point-to-multi-point transmission. It is a transmission system that sends the data only once, with each remote receiving location system configured to receive its part of the transmission.

The choice of using either point-to-point or broadcast transmission must be made by users of each communication system. The expense of the transmission lines is usually the major deciding factor. Generally for communication systems that use multiple receive sites, broadcast transmission is chosen.

D) LIMITATIONS IN ALL COMMUNICATION SYSTEMS

In any electronic communication system there are inherent limitations in the amount of information that can transmitted. These limitations are caused by the physical systems used.

1) System Bandwidth

The bandwidth of a system determines the range of frequencies that can be transmitted and received. As discussed in section C) 2) above, every transmission system is

band limited. If expense is a factor there is always a limitation on system bandwidth.

2) Thermal Noise

Noise is another important physical limitation. The noise generally encountered in a communication system is thermal noise. Thermal noise is generated by all objects whose temperatures are above zero degrees Kelvin, -273.15 degrees Celsius. Any object with molecular motion generates noise. The stars, the ground, the trees, all generate different levels of noise. Noise is everywhere in the system, including the transmission medium and is a source of distortion of the original signal.

Noise is always introduced to some extent in a transmission system. The critical factor is the signal-to-noise ratio established. If properly designed the system will maximize the signal-to-noise ratio. To accomplish this, the signal power must be proportional to the noise power added to the signal.

3) Signal Power

Signal power is another physical limitation in all communication systems. Signal strength cannot be increased as much as necessary to overcome the thermal noise because of the power limitations in the transmitter components.

Signal power levels must be adequate for the transmitted signals to be detected correctly at the receiving

location. Generally in the broader bandwidth communication systems, noise levels rise as the bandwidth becomes wider.

4) Error Rate Tolerance

Every transmission system has a certain error rate tolerance designed into the system. The error rate for a transmission system represents the transmission rate tolerable, based on a prescribed probability of error. The error rate of any communication system must be predetermined by the user and designed into the system.

E) WAYS TO MINIMIZE THE LIMITATIONS

There are equipment and methods used to minimize the effects of the physical limitations on any transmission system.

1) Electric Filters

Filters are used extensively for the purpose of minimizing many physical system limitations. "A device that is essential to...all communication, is the electric filter. A filter responds to, or passes, some chosen range of frequencies and rejects all others."[17]

There are three types of filters used. These are high-pass, band-pass and low-pass filters. Depending on the frequency cut-off designed into it, a filter will pass only those frequencies above, below or within a certain range of the frequency cut-off. High-pass filters are used for the

transmission of higher frequency signals. "Band-pass filters are used to pass almost equally all frequencies lying in some range or bandwidth. Low-pass filters are used in recovering the baseband frequency from an AM or FM signal."[18]

2) **Data Compression**

Another way to minimize the physical limitations of a transmission system is through data compression techniques. The use of data compression allows more information to be conveyed during a certain amount of time.

A data compression technique widely used is <u>run length encoding</u>. "Run length encoding reduces horizontal image redundancy by transmitting only the number of white picture elements or black picture elements in a sequential run, rather than transmitting each individual white or each individual black."[19]

Other methods of data compression used include <u>multiple run length encoding</u>. These methods can operate in a dual line mode or in blocks of data. In this form of data compression the system reads more than one line at a time and comparisons are made regarding the amount of image redundancy from one line to the next.

Data compression is based on ratios of original data to compressed data, and depends on the complexity of the original scanned image. The ratio is an average of the amount of compression taking place. For example, more data compression

will take place in a constant tonal area, like blue sky than in a high detail area such as lace in a dress. Compression ratios used for graphics are rarely above 10:1.

In contrast to graphic images, type has a great deal of vertical and horizontal image redundancy. Compression ratios of 28:1 are possible for text matter.

The data compression ratios chosen are usually predetermined by the user. The ratio decision is based on how much degradation can be seen, if any, in the reproduction and the kind of paper, or other substrate, the image will be transferred to. Empirical studies are often conducted to see the results of different compression ratios on a sample reproduction.

It is important to note that if data is compressed on the transmission end of the communication system, there must be a means at the receiving end to decompress the data back to its original form.

3) Multiplexing

Multiplexing is a widely use method of minimizing the physical limitations of a transmission system. The word multiplex refers to multiple users. "A multiplexer takes multiple low-speed lines and combines their individual data transmission volume requirments in such a way that a specific grouping of them can be transmitted on a single higher speed line."[20]

There are two basic techniques used in multiplexing: Frequency Division Multiplexing, called FDM, and Time Division Multiplexing, called TDM.

FDM is an analog technique in which a frequency guard band separates each channel from the adjacent one. The primary use of FDM is to combine low-speed signals onto single voice grade lines for transmission to a common site.

TDM is a digital technique used for both low- and high-speed lines. "Its theory of operation is that the digital bits will share the time available on a high-speed line, so each of the low-speed incoming channels will have a dedicated portion of the high-speed outgoing line assigned to it."[21]

The overall effect of multiplexing is that it allows multiple use over the same lines, decreasing the overall costs and the amount of lines needed for transmission.

At present both FDM and TDM techniques are still in use. However with the increasing use of digital transmission systems, TDM is predominantly used.

Appendix A - Footnotes

1
Information, Transmission, Modulation and Noise,
by Mischa Schwartz. Copyright 198Ø, McGraw-Hill, Inc.
Page 9

2
Ibid. Page 9

3
Ibid. Page 1

4
SIGNALS The Telephone and Beyond, by John R. Pierce.
Copyright 1981, W. H. Freeman & Company.
Page 35

5
Ibid. Page 65

6
Ibid. Page 68

7
Ibid. Page 7Ø

8
Information, Transmission, Modulation and Noise,
by Mischa Schwartz. Copyright 198Ø, McGraw-Hill, Inc.
Page 1

9
Telecommunication Transmission Handbook - 2nd Edition,
by Roger L Freeman. Copyright 1981, John Wiley & Sons.
Page 289

1Ø
Ibid. Page 291

11
Ibid. Page 292

12
Information, Transmission, Modualtion and Noise,
by Mischa Schwartz. Copyright 198Ø, McGraw-Hill, Inc.
Page 7

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13
SIGNALS The Telephone and Beyond, by John R. Pierce.
Copyright 1981, W. H. Freeman & Company.
Page 69

14
Publisher's Phototype International Inc. is a recognized leader in the field of publication transmission systems.

15
PPI Technical Newsletter - June 10, 1985 issue.

16
Ibid.

17
SIGNALS The Telephone and Beyond, by John R. Pierce.
Copyright 1981, W. H. Freeman & Company.
Page 58

18
Ibid. Page 73

19
"Page Facsimile In The Eighties", by Richard E. Amtower.
1981 TAGA Proceedings.
Page 264

20
SIGNALS The Telephone and Beyond, by John R. Pierce.
Copyright 1981, W. H. Freeman & Company.
Page 72

21
DATA COMMUNICATIONS: A Users Guide, by Kenneth Sherman.
Copyright 1981, Reston Publishing Company Inc.
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APPENDIX B

A Glossary of Electronic Terms

This glossary is intended to provide the user with a basic vocabulary reference. Items have been selected on the basis of most common use in telecommunications, networks and the associated concepts found in this study. There are several dictionaries available which can also serve as useful in acquiring more of the necessary basic terminology of data communications. Among them:

The Random House Dictionary of New Information Technology: Edited by A. J. Meadows, M. Gordon, and A. Singleton. New York: Vintage Books. Paper.

Sippl, Charles J. Data Communications Dictionary. New York: Van Nostrand Reinhold Co. Paper.

Weik, Martin H., D.Sc. Communications Standard Dictionary. New York: Van Nostrand Reinhold Co.

Note: Words in capitals inside definitions are themselves entries in the glossary.

Ack - The name of a control CHARACTER transmitted by a receiver to acknowledge or affirm that a SIGNAL or group of signals such as a block of characters sent by a transmitter has been received.

Amplitude Modulation - AM - Denotes a continuously running sequence where the DEMODULATOR (see MODULATE) puts out zeros and ones (on and off bits) in direct relation to the amplitude (height) of the signals it receives over a telephone line. A specific frequency represents a 1 BIT when it is of a higher amplitude, and the same frequency at a different point in time, and at a lower amplitude represents a Ø BIT.

Analog Signal - An electrical signal consisting of a continuous range of voltages (amplitudes) or frequency values. An analog signal changes in a nondiscrete manner, i.e. using voltages to represent the numerical data.

ARQ - Automatic Request for Repetition. A character sequence that causes an automatic retransmission (transparent to the user) of a SIGNAL in which an ERROR has been detected.

ASCII - American Standard Code for Information Interchange. A data communications code set developed by ANSI (American National Standards Institute). Only seven bits (128 possible combinations) are needed to specify a particular CHARACTER. An eighth bit is sometimes used for PARITY, hence ASCII is sometimes referred to as an eight-bit code.

Asynchronous Transmission - A DATA COMMUNICATIONS mode in which the timing of the SIGNAL being sent is not critical. In asynchronous transmission there is no clocking signal. In this mode, each transmitted character includes a start bit and may also include one or more stop bits. Thus, accurate reception of the data does not depend on precision timing between the transmitting unit and the receiving unit.

Attenuation - The reduction in the strength of the SIGNAL due to either a dissipative element or signal spreading.

Bandwidth - The frequency range of a CHANNEL. The smaller its bandwidth, the less information can be carried on a given channel. The bandwidth may be for a single or a collection of signals. It is expressed in Hertz (Hz) or cycles per second (cps). Importantly there is an inverse relationship between pulse width, or duration, and the bandwidth i.e. the bandwidth of a signal is based on the shortest pulse in that signal. If the shortest pulse can pass through the system then all other pulses will pass.

Bandwidth Reduction - A means of reducing BANDWIDTH requirements by creating levels of data within the signal transmitted.

Baseband Signal - The information which is to be MODULATED onto the CARRIER SIGNAL. The frequency band occupied by information-bearing signals before they are combined with a carrier in the modulation process.

Baud - A data communication rate and often used interchangeably with bits per second (bps) for low-speed data. Baud is defined as the number of signal level changes per second, regardless of the information content of those signals. If each signal change represents a single bit, then the baud rate is the same as the number of bits per second. However, in some coding schemes, one signal change can represent two or more bits. In such cases, the baud rate will not exactly equal the number of bits per second transmitted.

Bit - Binary digit contraction. The smallest unit of data communications information, used to develop code representations of characters. The two binary digits are Ø and 1.

Bit Rate - The rate at which bits are transmitted over a communications CHANNEL. The bit rate should not be confused with the data signaling rate (baud) which measures the rate of signal changes being transmitted.

Bit Stream - Refers to a continuous series of bits being transmitted on a TRANSMISSION LINE.

Byte - (As in ASCII code sets) - Some set of contiguous bits which make up a discrete item of information. Most common bytes are 6 or 8 bits long. The byte is commonly used as a unit of measurement for various computer characteristics, such as the amount of memory storage available.

Carrier Signal - An ANALOG SIGNAL at some fixed amplitude and frequency which is then combined with a BASEBAND SIGNAL to produce an output signal suitable for transmission.

Channel - A pathway or connection between two or more points through which signals are transmitted. The pathway may be cable, wire, radio signals, sound signals, light signals, or any combination of these.

Character - A single letter, number, or other symbol.

Coaxial Cable - A cable composed of an insulated central conducting wire wrapped in another cylindrical conducting wire. The entire unit is usually wrapped in another insulating layer and an outer protective layer.

Common Carrier - An organization or business providing commmunications services to the general public at rates set by approval of the FCC (Federal Communications Commission).

Data Communications - The transfer of DIGITAL SIGNALS through various electromagnetic CHANNELS: telephone lines, satellites, microwaves, fiber optic cable, etc.

Data Compression - The technique which provides for the transmission of fewer data bits without the loss of information. The receiving location expands, or decompresses, the received data bits into the original bit sequence.

Digital Signal - An electrical signal that consists of discrete variations in voltage or duration. In computers and data communications, only two states need to be defined, i.e. on or off, in order to transmit digital information.

Error Detection - In digital communications, the process of finding and correcting transmission errors that may have been introduced by NOISE in the CHANNEL.

Frequency Division Multiplexing - FDM - A MULTIPLEXING technique where a data line BANDWIDTH is divided into different frequency subchannels used to share a data line between several user terminals.

Frequency Modulation - FM - A method of transmitting digital information on an analog line by changing the carrier frequency to different values.

Frequency Shift Keying - FSK - A form of modulation (see MODULATE) used in low-speed MODEMS in which different frequencies are used to represent Øs and 1s of digital data.

Gain - The inverse of ATTENUATION. The gain, expressed in dB (decibels) is the amplification of the signal by a device.

Guard Band - In telecommunications, an unused band of frequencies between two adjacent CHANNELS providing a safety margin to prevent adjacent frequencies from interfering with each other.

Handshaking - In telecommunications and data communications, the initial exchange of signals between two devices. This exchange helps the two systems prepare for the transmissions that follow.

Hertz - The unit used to measure FREQUENCY. Also described as cycles per second.

Modem - Modulator-demodulator. A device that changes DIGITAL SIGNALS into a form that can be transmitted over a telecommunications CHANNEL and back again. Most modems convert digital signals to analog and vice versa although there are other kinds of modems used for special applications.

Modulate - The impressing of information, called the BASEBAND SIGNAL, on any electromagnetic signal, called the CARRIER SIGNAL. Information is added to carrier signals by using one or more of the three basic aspects of a carrier (SINE) wave: its amplitude, its frequency, or its phase angle.

Multiplexing - In telecommunications and data communications, methods for transmitting many signals over a single CHANNEL and reconverting them into separate signals at the receiving end. See FREQUENCY DIVISION (FDM) and TIME DIVISION MULTIPLEXING (TDM).

Noise - Extraneous signals generated in amplifiers or attenuators. The cause of ERROR (distortion) in all communication systems.

Parity - Usually called character parity, a technique of adding an overhead BIT to a character code to provide error-checking capability.

Pixel - A picture element contraction used to describe an area of a continuous tone photographic image.

Phase Modulation - PM - A method of combining digital type information onto a line-carrying signal by variation of the phase relationship of the signal.

Pulse Modulation - The modulation (see MODULATE) of the characteristics of a series of pulses in one of several ways to represent the BASEBAND SIGNAL. Typical methods involve modifying the amplitude (PAM), width of duration (PDM), or position (PPM). The most commmon pulse modulation technique in telephone systems is pulse code modulation (PCM). In PCM, the information signals are sampled at regular intervals and a series of pulses in coded form are transmitted, representing the amplitude of the information signal at that time.

Signal(s) - Physical phenomena used to convey data, such as electrical pulses, sounds, light, etc.

Signal-to-Noise Ratio (S/N) - The power ratio of the desired signal to the noise accumulated in the transmission system from its original source through to the final point of measurement at the receiving location.

Sine Waves - Signals of unvarying frequency or amplitude. The CARRIER SIGNAL used in MODEMS uses sine waves of specified frequencies, measured in HERTZ.

Synchronous Transmission - A DATA COMMUNICATIONS mode in which each string of BITs that make up a CHARACTER (BYTE) is transmitted in accordance with a timing signal - in synchronization. A timing marker signals the beginning of a given character, and the bits are transmitted in strictly timed intervals.

Telecommunication(s) - Any communication via electrical or electromagnetic media. Telecommunications generally refers to radio, television, telegraph, telephone, and digital systems.

Throughput - The number of units of data (bits, bytes, blocks, etc.) that pass through all or part of a given information system when the system is working to its fullest capacity. Throughput is usually expressed as units per given time interval, such as bits per second (bps) or block per second, etc.

Time Division Multiplexing - TDM - A method of multiple access (See MULTIPLEXING) in that the entire BANDWIDTH is time divided among many users. Each user transmits a short burst of information and the receiver is synchronized to receive those signals.

Transmission Lines - The media used for the transmission of data. See CHANNEL.

Transponder - The equipment, also called a radio frequency repeater, located on a telecommunications satellite that regenerates and relays the earth signals received and retransmits those signals to other earth stations.

Voice Grade Line - Traditional telephone lines that connect most of the telephones used for person-to-person conversations. Voice grade lines permit the transmission of sound frequencies between 300 and 3,400 hertz. In order to transmit digital data on voice grade lines, the data must be converted into signals that can be handled by voice grade lines. This is done using MODEMS.

APPENDIX C

Photographic Procedures

General Information

Photographic equipment used:

1) Nikon Optiphot Microscope with 5Ø Watt Quartz-Halogen Lamp in Attached Lamphouse.

2) Nikon Microflex PFX Photographic Attachment with Large Format Adaptor.

Magnification: 53.4 times the original, throughout.

Materials: Polaroid 55/PN Film.

Size: 4" x 5"

Preparation of material to be photographed:

All patches were mounted on 3" x 1" glass slides.

Reflective copy was mounted on the glass slides over a base of opague film to prevent any show through.

Identification method:

All prints and film for each system were identified through the use of a punch coding system.

Procedures:

Transmission Copy: All halftones & linework

Exposure Time: 1/15 second.

Light Source: 5Ø Watt Quartz-Halogen Lamp operated at 7 Volts.

Reflective Copy: Black & White and Linework

Exposure Time: 2 flashes.

Light Source: Small electrical flash, unknown strength, placed about 2" from subject and about 45 degree angle to the subject.

Reflective Copy: 4/color

Filter: Two Wratten #58 Green filters, super-imposed to photograph the magenta dots only.

Exposure Time: 16 flashes.

Light Source: Same as for B&W Reflective Copy.

Development:

Development of positive prints:

Standard Polaroid method: extended by 10 seconds for a total development time of 30 seconds.

Development of negatives:

Development Solution: Sodium Sulfite Bath.

Development Time: Variable; at least 1 minute of agitation. Negatives can stay in solution up to 24 hours or longer if necessary.

Wash Time: 5 minute wash with 68 - 75 degree fahrenheit water temperature.

Rinse: 1 minute detergent rinse with Photo-flo added to water bath.

Drying: Air dry negatives overnight.

Stripping Procedures:

All negatives were grouped by System per patch and stripped together with original, film and press patch per flat.

Contacting Procedures:

All flats were contacted emulsion down to Kodak Versatec contact paper to create positive contact prints.

Exposure time: 12.5 units on Olix light table with exposure integrator.

Development: standard photographic development in Rapid Access Chemistry.

APPENDIX D

A Glossary Of Statistical Terminology

This glossary is intended to provide the reader with the basic statistical terms used in this study. Items have been selected on the basis of most common use and the associated concepts discussed in Chapter IV, the Statistical Analysis for System 1: Page Facsimile.

Note: Words in capitals inside definitions are themselves entries in the glossary.

Average: The average of a list of numbers equals their sum, divided by how many there are. See MEAN.

Central Limit Theorem: In relation to sample size, called "n", this theorem states that as long as "n" is greater than or equal to 30 the SAMPLE MEAN is approximately normally distributed (see NORMAL DISTRIBUTION) no matter what the POPULATION looks like.

Central Tendency: The different kinds of averages (see AVERAGE) used to describe where the center, or most typical value, of a set of data lies. These averages are called the MEAN, MEDIAN and the MODE.

Continuous Variable: Any VARIABLE quantatively (see QUANTITATIVE VARIABLE) measured on a continuous scale.

Data: The information collected and analyzed.

Data Set: The DATA collected and analyzed in a particular SAMPLE. The sample size or number of data in a data set is called "n".

Frequency Histogram: A method of summarizing DATA through the use of a graph consisting of marks and limits used for such topics as probability theory and the NORMAL DISTRIBUTION.

Inferential Statistics: A statistical method of making an inference (an educated guess) about the POPULATION based on information obtained from a SAMPLE of the populationn.

Mean: The most commonly used measure of CENTRAL TENDENCY. The mean is considered the AVERAGE of the data. The mean is found by adding all the data and dividing that total by "n".

$$\text{Mean} = \frac{\text{sum of data}}{\text{number of pieces of data}}$$

Measure of Dispersion: A number used to show how much variation there is in a DATA SET. Measures include the RANGE and the STANDARD DEVIATION.

Median: The dividing line between the top half and bottom half of DATA. In percentile terms the median divides the data into a top 50% and a bottom 50%

Mode: The value that appears most often in the DATA SET.

Normal Distribution: Almost all of the DATA in any DATA SET will lie within three standard deviations (see STANDARD DEVIATION) measured off on either side of the MEAN as follows:

68% of the data within 1 Standard Deviation from the MEAN
95% of the data within 2 Standard Deviations from the MEAN
99% of the data within 3 Standard Deviations from the MEAN

Population: The set of items or DATA under consideration.

Quantitative Variable: A numerical description, such as size, assigned to a variable calculated from individual measurement of that variable.

Range: A MEASURE OF DISPERSION in a DATA SET in which the range is calculated by subtracting the smallest value from the largest value.

Sample: That part of the POPULATION from which information is collected and significant inferences (see STATISTICAL INFERENCE) can be made.

Sample mean: The AVERAGE based on a SAMPLE of the POPULATION calculated from the DATA SET.

Standard Deviation (SD): A MEASURE OF DISPERSION in a DATA SET in which the SD is calculated as the difference between each data value and the MEAN. The SD number is used to show how much variation there is in a data set. The more variation there is in a data set, the bigger the SD.

Variable: A characteristic, such as size or weight, which changes from item to item (see DATA) in a study (see DATA SET).

APPENDIX E

Statistical Data

System 1: Page Facsimile

Table 23: Patch 1A - Highlight Area I

Original Data: 57 dots measured in mils

Original	Received Film	Press Sheet
0.40	3.70	3.80
0.60	2.95	2.90
0.85	0.00	4.10
1.35	3.80	2.30
1.85	3.60	2.15
0.35	4.25	1.75
0.80	3.65	3.90
1.80	3.30	1.85
0.20	2.80	0.15
1.55	2.10	2.10
2.60	0.60	1.70
1.40	5.05	5.30
1.30	3.50	4.70
0.50	1.80	1.80
1.40	4.15	5.15
1.90	1.75	0.50
0.30	2.20	3.95
0.00	3.70	0.85
1.40	6.55	2.80
1.05	5.05	4.60
1.35	4.80	3.30
2.50	0.00	2.80
1.60	2.40	2.80
1.70	4.10	2.25
1.75	3.50	4.90
1.90	3.30	4.90
1.55	4.80	4.90
1.05	3.75	0.70
1.80	5.50	1.80
0.75	3.50	6.40
0.20	4.70	3.15
0.60	4.05	2.25
2.05	4.00	1.70
0.30	4.05	2.45
3.80	3.75	2.75
1.60	2.50	2.55
1.65	0.80	3.90
0.90	5.90	2.25
3.20	3.65	1.15
1.40	0.95	0.55

1.25	2.90	2.45
0.25	3.55	1.45
1.10	6.60	8.70
1.40	4.70	5.05
1.10	1.40	2.25
0.55	3.20	2.25
1.80	4.10	1.40
1.75	2.15	3.90
0.35	4.40	3.40
1.00	1.25	0.15
1.35	2.60	3.40
0.10	3.25	3.40
0.85	2.60	0.15
0.75	2.55	3.90
1.15	0.40	2.25

Table 24: Statistics - Patch 1A

	Sample Size	Mean	Median	Standard Deviation
Original	57	1.235	1.300	0.750
Received Film	57	3.265	3.500	1.550
Press Sheet	57	2.894	2.550	1.663

System 1: Page Facsimile

Table 25: Patch 2A - Midtone Area I

Original Data: 56 dots measured in mils

Original	Received Film	Press Sheet
12.50	8.85	15.10
10.75	10.30	10.20
7.30	8.8	7.95
6.65	13.95	10.50
9.15	10.60	10.70
6.95	9.50	12.15
10.30	9.55	12.15
13.30	13.70	11.90
13.40	12.70	13.30
12.10	10.75	13.15
8.60	9.60	14.35
8.90	12.10	11.70
9.85	9.40	10.30
6.40	7.20	11.45
8.75	7.75	13.90
13.00	16.40	12.05
15.10	10.40	13.00
8.85	6.05	16.00
6.20	10.50	17.00
8.65	13.55	13.30
7.50	8.45	8.20
6.35	8.10	12.00
7.80	10.55	11.80
12.30	13.80	13.70
14.30	13.60	11.55
10.90	14.25	9.00
6.80	7.55	9.75
9.05	10.50	14.85
9.15	14.35	11.10
7.70	13.70	6.60
7.60	8.90	10.35
12.30	7.75	10.25
16.35	12.65	15.50
7.95	14.30	13.75
6.90	10.00	10.50
9.20	8.40	13.50
8.20	8.60	21.00
8.55	10.85	15.00
7.80	8.70	10.10
12.20	8.50	11.60
15.00	12.85	13.50

10.40	16.05	13.50
6.95	11.55	13.35
9.70	6.50	11.75
10.30	10.05	12.10
9.15	12.60	21.00
7.70	11.90	12.30
13.75	10.00	9.05
14.85	16.85	13.70
9.20	16.10	13.70
8.25	11.65	13.80
11.25	9.80	11.80
12.60	14.70	6.70
9.00	13.75	15.60
7.20	11.60	18.20
11.10	9.30	14.30

Table 26: Statistics - Patch 2A

	Sample Size	Mean	Median	Standard Deviation
Original	56	9.857	9.150	2.624
Received Film	56	11.079	10.525	2.665
Press Sheet	56	12.582	12.150	2.868

System 1: Page Facsimile

Table 27: Patch 3A - Highlight Area II

Original Data: 49 dots measured in mils

Original	Received Film	Press Sheet
3.70	5.00	7.25
2.40	3.20	7.35
0.45	1.20	2.00
0.00	0.55	2.40
0.40	0.75	2.90
0.95	1.10	7.20
1.60	0.70	7.25
0.40	0.45	5.90
0.25	0.80	5.90
0.55	0.80	0.20
0.55	0.85	4.20
0.10	0.30	0.45
0.80	1.75	0.15
0.65	1.40	0.20
0.15	0.50	0.70
0.30	1.75	2.55
1.05	0.80	1.65
0.35	2.10	0.90
0.75	1.80	0.70
0.05	0.90	0.20
0.50	1.90	2.30
1.00	1.75	1.60
1.15	1.15	2.80
0.55	0.55	1.20
0.25	1.50	3.15
0.15	1.15	1.45
0.80	0.45	0.90
0.30	0.40	2.65
0.30	1.90	2.50
0.40	1.25	2.10
0.25	0.25	3.20
1.35	1.15	3.85
0.75	2.05	0.65
0.15	1.35	4.15
1.70	0.20	3.40
0.65	2.10	0.50
0.25	1.35	1.45
1.05	1.35	1.40
1.10	0.25	3.30
1.45	1.40	2.65
0.25	2.50	3.50

Ø.9Ø	1.9Ø	4.8Ø
Ø.9Ø	1.95	3.2Ø
1.ØØ	Ø.2Ø	2.65
Ø.15	1.15	3.25
Ø.Ø5	1.Ø5	1.95
Ø.35	1.8Ø	1.55
Ø.8Ø	2.15	1.4Ø
Ø.95	1.Ø5	2.6Ø

Table 28: Statistics - Patch 3A

	Sample Size	Mean	Median	Standard Deviation
Original	49	Ø.7122	Ø.55ØØ	Ø.6582
Received Film	49	1.3Ø4Ø	1.15ØØ	Ø.862Ø
Press Sheet	49	2.656Ø	2.5ØØØ	1.959Ø

System 1: Page Facsimile

Table 29: Patch 4 - Tint Area I (20%)

Original Data: 49 dots measured in mils

Original	Received Film	Press Sheet
6.0	6.75	11.65
6.0	7.20	10.90
6.0	7.40	10.60
6.0	7.40	7.20
6.0	8.05	10.50
6.0	7.50	10.15
6.0	6.70	10.50
6.0	8.25	10.50
6.0	8.45	9.40
6.0	6.35	10.90
6.0	7.30	9.40
6.0	8.20	9.40
6.0	7.90	9.40
6.0	6.45	10.90
6.0	8.85	9.40
6.0	7.30	10.15
6.0	6.55	11.20
6.0	8.40	11.20
6.0	8.00	10.50
5.2	7.70	10.15
6.0	7.10	9.40
6.0	7.60	11.20
6.0	7.15	9.00
6.0	8.70	10.15
6.0	5.75	11.20
6.0	7.75	9.40
6.0	7.90	10.15
6.0	7.20	9.40
6.0	8.05	9.40
6.0	7.80	9.40
6.0	6.40	10.15
6.0	7.65	9.40
6.0	7.95	9.40
6.0	8.05	11.20
6.0	7.80	10.50
6.0	7.10	8.35
6.0	7.75	9.40
6.0	7.55	11.20
6.0	6.55	10.50
6.0	6.70	10.50
6.0	6.95	11.20

6.Ø	7.45	8.35
6.Ø	7.35	11.2Ø
6.Ø	8.ØØ	1Ø.5Ø
6.Ø	6.85	1Ø.9Ø
6.Ø	8.65	7.2Ø
6.Ø	7.35	1Ø.15
6.Ø	7.7Ø	1Ø.15
6.Ø	8.4Ø	9.ØØ

Table 3Ø: Statistics - Patch 4A

	Sample Size	Mean	Median	Standard Deviation
Original	49	5.9837	6.ØØØØ	Ø.1143
Received Film	49	7.5Ø82	7.55ØØ	Ø.6823
Press Sheet	49	1Ø.Ø4ØØ	1Ø.15ØØ	Ø.997Ø

System 1: Page Facsimile

Table 31: Patch 5 - Tint Area II (1Ø%)

Original Data: 62 dots measured in mils

Original	Received Film	Press Sheet
3.8	4.25	7.1
3.8	4.15	7.1
3.8	5.Ø5	7.1
3.8	3.8Ø	7.1
3.8	3.65	7.1
3.8	3.9Ø	7.1
3.8	4.3Ø	7.1
3.8	5.25	7.1
3.8	4.5Ø	7.1
3.8	4.35	7.1
3.8	5.25	7.1
3.8	4.7Ø	7.1
3.8	4.4Ø	7.1
3.8	5.55	7.1
3.8	3.8Ø	7.1
3.8	3.15	7.1
3.8	4.Ø5	7.1
3.8	4.4Ø	7.1
3.8	5.45	7.1
3.8	4.25	7.1
3.8	4.5Ø	7.1
3.8	4.5Ø	7.1
3.8	4.3Ø	7.1
3.8	3.85	7.1
3.8	3.95	7.1
3.8	4.4Ø	7.1
3.8	4.85	7.1
3.8	3.7Ø	7.1
3.8	4.15	7.1
3.8	4.65	7.1
3.8	3.5Ø	7.1
3.8	4.3Ø	7.1
3.8	4.35	7.1
3.8	4.35	7.1
3.8	4.2Ø	7.1
3.8	4.4Ø	7.1
3.8	5.25	7.1
3.8	4.6Ø	7.1
3.8	4.15	7.1
3.8	3.9Ø	7.1
3.8	4.45	7.1

3.8	4.3Ø	7.1
3.8	4.3Ø	7.1
3.8	4.7Ø	7.1
3.8	3.3Ø	7.1
3.8	3.95	7.1
3.8	4.25	7.1
3.8	5.3Ø	7.1
3.8	4.65	7.1
3.8	4.75	7.1
3.8	4.95	7.1
3.8	4.95	7.1
3.8	3.4Ø	7.1
3.8	4.75	7.1
3.8	3.85	7.1
3.8	3.85	7.1
3.8	4.45	7.1
3.8	4.2Ø	7.1
3.8	3.9Ø	7.1
3.8	4.3Ø	7.1
3.8	4.35	7.1
3.8	4.Ø5	7.1

Table 32: Statistics - Patch 5A

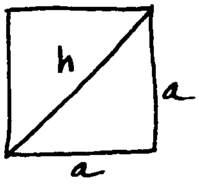
	Sample Size	Mean	Median	Standard Deviation
Original	62	3.8ØØØ	3.8ØØØ	Ø.ØØØØ
Received Film	62	4.3387	4.3ØØØ	Ø.5136
Press Sheet	62	7.1ØØØ	7.1ØØØ	Ø.ØØØØ

APPENDIX F

Formula for Encoding the Standard Page

System 1 - Page Facsimile: for 85, 110, 133 & 150 lpi.

See pages 231-234.



$a = \frac{h}{\sqrt{2}} \qquad h^2 = 2a^2$

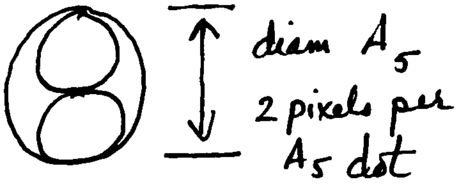
$$\text{hypotenuse} = \frac{1}{\text{line screen frequency (lpi)}}$$

$$\text{Area}_{50\%\text{ dot}} = \frac{h^2}{2}$$

Calculations are based on transmitting a 5% highlight dot - using 2 pixels per dot.

$$\text{Area}_{5\%\text{ dot}} = \frac{A_{50}}{10} \qquad \text{Diameter} = \sqrt{4\ A_5/\pi}$$

$$\text{Pixel diameter} = \frac{\text{diam } A_5}{2}$$



$$\text{Pixel size} = \text{Pixel area}$$

$$\text{Pixel}_{\text{area}} = \frac{\pi\ (\text{Pixel diam})^2}{4}$$

$$\text{Number of Pixels}/\text{sq. inch} = \frac{1}{\text{Pixel size}}$$

System 1 - Encoding the Standard Page

85 line screen - Calculations

$h = \frac{1}{85} = .0118$

$A_{50} = \frac{h^2}{2} = \frac{1.39 \times 10^{-4}}{2} = 6.95 \times 10^{-5}$

$A_5 = \frac{A_{50}}{10} = \frac{6.95 \times 10^{-5}}{10} = 6.9 \times 10^{-6}$ sq. in.

$diam = \sqrt{4\, A_5/\pi} = \sqrt{4(2.21 \times 10^{-6})}$

$= \sqrt{8.86 \times 10^{-6}} = \underline{\underline{2.98 \times 10^{-3}}}$

$a = \frac{h}{\sqrt{2}}$ $\quad h^2 = 2a^2$ $\quad \sqrt{2} = 1.414$

$a = \frac{.0118}{1.414} = 8.34 \times 10^{-3}$

$a^2 = 6.95 \times 10^{-5}$

$h^2 = 2a^2$

$h^2 = 2(6.95 \times 10^{-5})$

$h^2 = \underline{\underline{1.39 \times 10^{-4}}}$

Pixel diam = diam $A_5/2 = \frac{2.98 \times 10^{-3}}{2} = \underline{\underline{1.49 \times 10^{-3} \text{ inches}}}$

Pixel Size = Pixel area

$P_{area} = \frac{\pi (P_{diam})^2}{4} = \frac{3.14159(1.49 \times 10^{-3})^2}{4}$

Pixel Size $= P_{area} = 1.74 \times 10^{-6}$ sq. inches

$\#\ \text{Pixels}/\text{sq. in} = \frac{1}{1.74} \times 10^6 = .5747 \times 10^6$

85 line screen = 574,000 Pixels/sq. inch

System 1 - Encoding the Standard Page

110 line screen - Calculations

$h = \frac{1}{110} = .0009$

$A_{50} = \frac{h^2}{2} = \frac{8.27 \times 10^{-5}}{2} = 4.13 \times 10^{-5}$

$A_5 = \frac{A_{50}}{10} = \frac{4.13 \times 10^{-5}}{10} = 4.13 \times 10^{-6}$ sq in

$\text{diam} = \sqrt{4\ A_5/\pi} = \sqrt{4(1.31 \times 10^{-6})}$

$= \sqrt{5.26 \times 10^{-6}} = \underline{\underline{2.29 \times 10^{-3}}}$

$a = \frac{h}{\sqrt{2}} \qquad h^2 = 2a^2 \qquad \sqrt{2} = 1.414$

$a = \frac{.0009}{1.414} = 6.43 \times 10^{-3}$

$a = 6.43 \times 10^{-3}$

$a^2 = 4.13 \times 10^{-5}$

$h^2 = 2a^2$

$h^2 = 2(4.13 \times 10^{-5})$

$h^2 = \underline{\underline{8.27 \times 10^{-5}}}$

$\text{Pixel diam} = \text{diam } A_5/2 = \frac{2.29 \times 10^{-3}}{2} = \underline{\underline{1.14 \times 10^{-3} \text{ inches}}}$

Pixel size = Pixel area

$P_{area} = \frac{\pi (P_{diam})^2}{4} = \frac{3.1459 (1.14 \times 10^{-3})^2}{4}$

$\text{Pixel Size} = P_{area} = 1.03 \times 10^{-6}$ sq. inches

$\#\ \text{Pixels/sq. in.} = \frac{1}{1.03} \times 10^6 = .9708 \times 10^6$

110 line screen = 970,800 Pixels/sq. inch

System 1 - Encoding the Standard Page

133 line screen - Calculations

$$h = \frac{1}{133} = .0075$$

$$A_{50} = \frac{h^2}{2} = \frac{5.63 \times 10^{-5}}{2} = 2.81 \times 10^{-5}$$

$$A_5 = \frac{A_{50}}{10} = \frac{2.81 \times 10^{-5}}{10} = 2.81 \times 10^{-6} \text{ sq. in}$$

$$\text{diam} = \sqrt{4\,A_5/\pi} = \sqrt{4(8.95 \times 10^{-7})}$$

$$= \sqrt{3.58 \times 10^{-6}} = 1.89 \times 10^{-3}$$

$$a = \frac{h}{\sqrt{2}} \quad h^2 = 2a^2 \quad \sqrt{2} = 1.414$$

$$a = \frac{.0075}{1.414} = 5.30 \times 10^{-3}$$

$$a = 5.30 \times 10^{-3}$$

$$a^2 = 2.81 \times 10^{-5}$$

$$h^2 = 2a^2$$

$$h^2 = 2(2.81 \times 10^{-5})$$

$$h^2 = 5.63 \times 10^{-5}$$

$$\text{Pixel diam} = \text{diam } A_5/2 = \frac{1.89 \times 10^{-3}}{2} = 9.46 \times 10^{-4} \text{ inches}$$

Pixel Size = Pixel area

$$P_{area} = \frac{\pi (P_{diam})^2}{4} = \frac{3.14159\,(9.46 \times 10^{-4})^2}{4}$$

$$\text{Pixel size} = \text{Pixel}_{area} = 7.03 \times 10^{-7} \text{ sq. inches}$$

$$\#\ \text{Pixels/sq. in} = \frac{1}{7.03} \times 10^{7} = .1422 \times 10^{7}$$

133 line screen = 1,422,000 Pixels/sq. inch

System 1 - Encoding the Standard Page

150 line screen - Calculations

$h = \frac{1}{150} = .0006$

$A_{50} = \frac{4.44 \times 10^{-5}}{2} = 2.22 \times 10^{-5}$

$A_5 = \frac{A_{50}}{10} = \frac{2.22 \times 10^{-5}}{10} = 2.22 \times 10^{-6}$ sq. in.

$\text{diam} = \sqrt{4\, A_5/\pi} = \sqrt{4(7.07 \times 10^{-7})}$

$= \sqrt{2.83 \times 10^{-6}} = \underline{\underline{1.68 \times 10^{-3}}}$

$a = \frac{h}{\sqrt{2}} \qquad h^2 = 2a^2$

$\sqrt{2} = 1.414$

$a = \frac{.0006}{1.414} = 4.71 \times 10^{-3}$

$a = 4.71 \times 10^{-3}$

$a^2 = 2.22 \times 10^{-5}$

$h^2 = 2a^2$

$h^2 = 2(2.22 \times 10^{-5})$

$h^2 = \underline{\underline{4.44 \times 10^{-5}}}$

Pixel diam = diam $A_5/2 = \frac{1.68 \times 10^{-3}}{2} = \underline{\underline{8.41 \times 10^{-4} \text{ inches}}}$

Pixel Size = Pixel area

$P_{area} = \frac{\pi (P\,diam)^2}{4} = \frac{3.14159 (8.41 \times 10^{-4})^2}{4}$

Pixel Size $= P_{area} = 5.55 \times 10^{-7}$ sq. inches

$\#\ \text{Pixels}/\text{sq. in} = \frac{1}{5.55} \times 10^{7} = .1801 \times 10^{7}$

150 line screen = 1,801,000 Pixels/sq. inch