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Low-Speed Fingerprint Image Capture System User's Guide, June 1, 1993

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Instrumentation and Controls Division

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June 1993

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ACRONYMS

AFIS	Automatic Fingerprint Identification System
CPU	central processing unit
CTF	contrast transfer function
DOM	depth of modulation
DSP	digital signal processing
FBI	Federal Bureau of Investigation
FICS	Fingerprint Image Capture System
FIMF	Fingerprint Image Master File
FNU	FBI number
ICS	Image Capture System
ITN	Image Transmission Network
LAN	local area network
LED	light-emitting diode
lp	line pair
LS-FICS	Low-Speed Fingerprint Image Capture System
NIST	National Institute of Standards and Technology
ORNL	Oak Ridge National Laboratory
PCN	process control number
ppi	pixels per inch
SCSI	small-computer system interface
U	uncompressed
WASQ	wavelet adaptive scaler quantization

ABSTRACT

The Low-Speed Fingerprint Image Capture System (LS-FICS) uses a Sun workstation controlling a Lenzar ElectroOptics Opacity 1000 imaging system to digitize fingerprint card images to support the Federal Bureau of Investigation's (FBI's) Automated Fingerprint Identification System (AFIS) program. The system also supports the operations performed by the Oak Ridge National Laboratory- (ORNL-) developed Image Transmission Network (ITN) prototype card scanning system. The input to the system is a single FBI fingerprint card of the agreed-upon standard format and a user-specified identification number. The output is a file formatted to be compatible with the National Institute of Standards and Technology (NIST) draft standard for fingerprint data exchange dated June 10, 1992. These NIST compatible files contain the required print and text images. The LS-FICS is designed to provide the FBI with the capability of scanning fingerprint cards into a digital format. The FBI will replicate the system to generate a data base of test images.

The Host Workstation contains the image data paths and the compression algorithm. A local area network interface, disk storage, and tape drive are used for the image storage and retrieval, and the Lenzar Opacity 1000 scanner is used to acquire the image.

The scanner is capable of resolving 500 pixels/in. in both x and y directions. The print images are maintained in full 8-bit gray scale and compressed with an FBI-approved wavelet-based compression algorithm. The text fields are downsampled to 250 pixels/in. and 2-bit gray scale. The text images are then compressed using a lossless Huffman coding scheme. The text fields retrieved from the output files are easily interpreted when displayed on the screen.

The user interface provides control over the operation of the LS-FICS. Input is checked for validity before being acted upon. Menus are used to assist user interaction wherever possible. The only typing required is for the entry of the fingerprint card identification number.

Detailed procedures are provided in the *User's Guide* for system calibration and operation. Software tools are provided to verify proper system operation.

1. INTENDED AUDIENCE

This document is intended to support those who are

- using the Low-Speed Fingerprint Image Capture System (LS-FICS) to scan cards,
- managing the LS-FICS workstation,
- calibrating the LS-FICS,
- using the National Institute of Standards and Technology (NIST) files of the captured images, and
- duplicating the LS-FICS.

Not all sections apply to all members of this diversified audience. For example, it is not necessary for the operators who scan cards to read the sections that apply to the workstation system configuration. Operators need to read only "Operating Modes" (Sect. 4.1) and "Routine Production Operation" (Sect. 5.2), and all others should at least skim all sections to determine which ones apply to them.

Detailed information on the Sun workstation and Lenzar ElectroOptics Scanner hardware and software are available in the vendor documentation. A directory of available documentation is provided in Appendix B.

2. INTRODUCTION

The LS-FICS uses a Sun workstation controlling a Lenzar ElectroOptics Opacity 1000 imaging system to digitize fingerprint card images to support the Federal Bureau of Investigation's (FBI's) Automated Fingerprint Identification System (AFIS) program. The system also supports the operations performed by the Oak Ridge National Laboratory-(ORNL-) developed Image Transmission Network (ITN) prototype card scanning system. The input to the system is a single FBI fingerprint card of the agreed-upon standard format and a user-specified identification number, either FBI number (FNU) or process control number (PCN). The output is a file formatted to be compatible with the NIST draft standard for fingerprint data exchange dated June 10, 1992. These NIST-compatible files contain the required print and text images. The following two sections describe the motivation behind the project, the basic requirements of the system, and outside interfaces to the system. The ORNL-developed software is based on the software developed for the ITN prototype scanner project. The ITN software was modified to support the Lenzar scanner and the operating modes required to produce the AFIS test set.

3. PURPOSE

The LS-FICS is designed to provide the FBI with the capability of scanning fingerprint cards into a digital format compatible with that required for the final FICS. Easing the throughput requirements allows the development of a system capable of producing test image data bases well in advance of the full system.

4. DESCRIPTION

The following sections describe the LS-FICS hardware and software components. The focus is on the ORNL-developed components and how they are integrated with vendor hardware and software.

4.1 OPERATING MODES

The LS-FICS operates in seven modes to support the required functions. The modes are summarized in Table 1.

4.2 INTERFACES

The LS-FICS is designed with simple external interfaces. The mode of operation specifies most of the parameters required for operation. The user must enter only the FNU or PCN (depending on the mode) and activate the scanner for each card.

The details of the outside interfaces depend, in part, on the mode of operation described above. The ultimate output of the LS-FICS is always a NIST-compatible output file (detailed in Appendix D) containing compressed images of the prints and, when required, text from the front and back of the card. The destination of the card images is the disk. The name of the NIST file is based on the unique identifier entered by the user when the card was scanned. The name depends on the operating mode. The form of the NIST file name and contents for each for the modes are shown in Table 2. The directory where the NIST files are stored is defined by UNIX environment variables. The environment variables used for each mode are also given in Table 2. The files are archived to tape as needed by using the UNIX "TAR" or "BAR" utility.

4.3 COMPONENTS

The block diagram in Appendix A shows the main hardware components of the LS-FICS. The Lenzar Subsystem contains both the imaging and image acquisition functions. The Host Workstation contains the image data paths and the compression algorithm. The local area network (LAN) interface, disk storage, and tape drive are used for image storage and retrieval.

4.3.1 Imaging Subsystem

A Lenzar Opacity 1000 scanner is used to acquire the image. Two serial ports on the workstation provide the control information to the Lenzar's imaging stage. The VME rack contains the high-speed interface modules for the Lenzar system's camera.

4.3.2 Host Workstation

The 64.0-MB Sun Sparc IPX contains the VME to S-Bus converter that makes the image available to applications in the host. The image compression accelerator is added to speed up the image compression algorithm. The workstation uses Sun OS Version 4.1.3 with OpenWindows Version 3.

Table 1. Mode summary

Mode	Description	Use
Conversion	Scans the fingerprints from selected cards to generate the FBI number-keyed test data base to simulate the Fingerprint Image Master File. The resulting National Institute of Standards and Technology (NIST) format file contains 14 compressed prints.	ITN
Card scan	Scans and saves a series of two-sided card images (including text) indexed by process control number to be used to simulate a "new work" data stream when required. The resulting NIST format file contains 14 compressed prints and the compressed images of the card front and back text areas.	ITN
Emulator	Simulates the presence of the final Fingerprint Image Capture System (FICS) on the Image Transmission Network (ITN) local area network. The images scanned previously in the "Card Scan Mode" are made available to the network at a rate determined to be representative of the final FICS throughput.	ITN
End-to-end	Provides a full-function, real-time demonstration at the rate determined by the slowest component in the system. The full card compressed image NIST file is made available to the network as soon as the card image scanning and image compression are complete.	ITN
Conversion uncompressed	Scans the prints from selected cards to generate Federal Bureau of Investigation (FBI) number-keyed test data. The resulting NIST format file contains 14 uncompressed prints.	AFIS
AFIS	Scans the prints from selected cards to generate the FBI number-keyed Automatic Fingerprint Identification System (AFIS) test set. The resulting NIST format file contains 10 compressed prints.	AFIS
AFIS uncompressed	Scans the prints from selected cards to generate the FBI number-keyed AFIS test set. The resulting NIST format file contains 10 uncompressed prints.	AFIS

4.3.3 Disk Storage

The disk storage system contains a total of 2.0 GB of storage interfaced through the integral small-computer system interface (SCSI) adapter. One disk partition with a capacity of about 900 MB is dedicated to the FBI_NIST_DIR area.

Table 2. NIST filename forms

Mode	Filename form	NIST contents	Directory where files are stored
Conversion	fnu.NIST	14 compressed print images	FBI_NIST_DIR
Card scan	pcn.NIST	14 compressed print images and compressed images of the card front and back text areas	PCN_NIST_DIR
Emulator	pcn.NIST	14 compressed print images and compressed images of the card front and back text areas	NA
End-to-end	pcn.NIST	14 compressed print images and compressed images of the card front and back text areas	PCN_NIST_DIR
Conversion uncompressed	fnu.14P_U_NIST	14 uncompressed print images	FBI_NIST_DIR
AFIS	fnu.10P_C_NIST	10 compressed print images (rolled prints only)	FBI_NIST_DIR
AFIS uncompressed	fnu.10P_U_NIST	10 uncompressed print images (rolled prints only)	FBI_NIST_DIR

4.4 STANDARDS

To accommodate interfacing with other agencies and groups, the LS-FICS maintains compatibility with many governmental, national, and international standards. The Sun host runs the Sun OS implementation of the UNIX operating system, the Sun communicates via RS-232 to the transport controller, an integral Ethernet port is IEEE 802.3 compatible, and the output file contains print images in NIST-compatible format. The 2-bit gray-scale, 250-pixels/in. (ppi) text image portions are compressed and stored in record Type 7 as allowed under the June 10, 1992, NIST draft standard. The disk and tape interfaces are SCSI compatible to allow subsequent expansion as required.

4.5 PERFORMANCE CHARACTERISTICS

The scanner is capable of resolving 500 ppi in both x and y directions. The print images are maintained in full 8-bit gray scale and compressed with an FBI-approved wavelet-based compression algorithm. Decompression from the output file regenerates an image with perceptible but acceptable degradation. The text fields are downsampled to 250 ppi and 2-bit gray scale. The text images are then compressed by using a lossless Huffman coding scheme. The text fields retrieved from the output files are easily interpreted when displayed on the screen.

The user interface always displays the last image scanned. The image is downsampled to 1K × 1K for display in the host workstation window.

4.6 LIMITATIONS AND CONSTRAINTS

Image quality is determined by the Lenzar scanner. A new calibration run is necessary any time the scanner setup is modified or the light bulb is replaced. These procedures are in the "Calibration and Adjustment" section of this document (Sect. 5.3).

The disk space allotted for on-line storage is limited, so if the scanner runs continuously without having the output files removed by either the LAN interface or moved to tape and the files deleted, a "disk full" message may appear at the user interface.

4.7 USER INTERFACE

The user interface provides control over the operation of the LS-FICS. Input is checked for validity before being acted upon. The first implementation of the validity checks verifies that the entered parameters are within previously indicated limits. Menus are used to assist user interaction wherever possible. The only typing required is for the entry of the FNU or PCN.

Any faults detected during operation are displayed on the screens. The menu window displays a summary, and the shell-tool window provides more detail.

4.8 FILE AND DEVICE MANAGEMENT

The files are placed in areas dictated by UNIX environment variables set at user login. If any of these are modified, all software must be stopped and restarted. Several of the environment variables used are listed below. These and other environment variables are defined in "/lsfics/lsfics_home/lsfics.env."

- COMP_IMAGE_DIR—Path for compressed and uncompressed print image intermediate files. These are temporary files that are reused by the software during normal operation.
- PCN_NIST_DIR—Path to the NIST files generated in emulator and end-to-end modes. These are deleted during network access after being transferred to the image storage area on the network.
- FBI_NIST_DIR—Path to the NIST files generated in AFIS, AFIS-U (uncompressed) conversion, and conversion-U modes. These must be removed by archiving to tape and manually deleting them.
- PCN_ARC_DIR—Path to the location of NIST files generated in card scan mode. These files are transferred, during emulator mode, to the PCN_NIST_DIR area.

The user can view these paths by typing "env" in the shell-tool window.

4.9 IMAGING

The Lenzar imaging subsystem prepares the image for use by the Sun host. It illuminates the card, moves it under the camera, digitizes the image, and passes the image segments to the Sun host. Functionality was added to the Lenzar software to execute Lenzar "trace" files on request from the LS-FICS software.

The trace files used for this system scan either a full card side or the bottom 75% of a card and create a Sun raster file. The LS-FICS software reads this file for its input.

4.10 IMAGE DATA PATHS

The card is scanned by the Lenzar Opacity 1000 scanner and software. The ORNL-developed software initiates image acquisition by specifying the name of a trace file to the LS-FICS module that was added to the standard Lenzar software. The Lenzar Opacity 1000 acquires the required image segments and then assembles them into a Sun raster file. The complete raster image is segmented by field, compressed (dependent on mode), and written into the appropriate NIST-formatted output file. A block diagram of the basic image flow is shown in Fig. 1.

In each mode, the NIST file output routine gathers the appropriate compressed image files into a single structure in memory, which is then written to a disk file. The output NIST file is written under an intermediate name and then renamed (UNIX mv command). This technique of writing the files under a different name and then renaming them prevents other users from accessing the files before they are completely written.

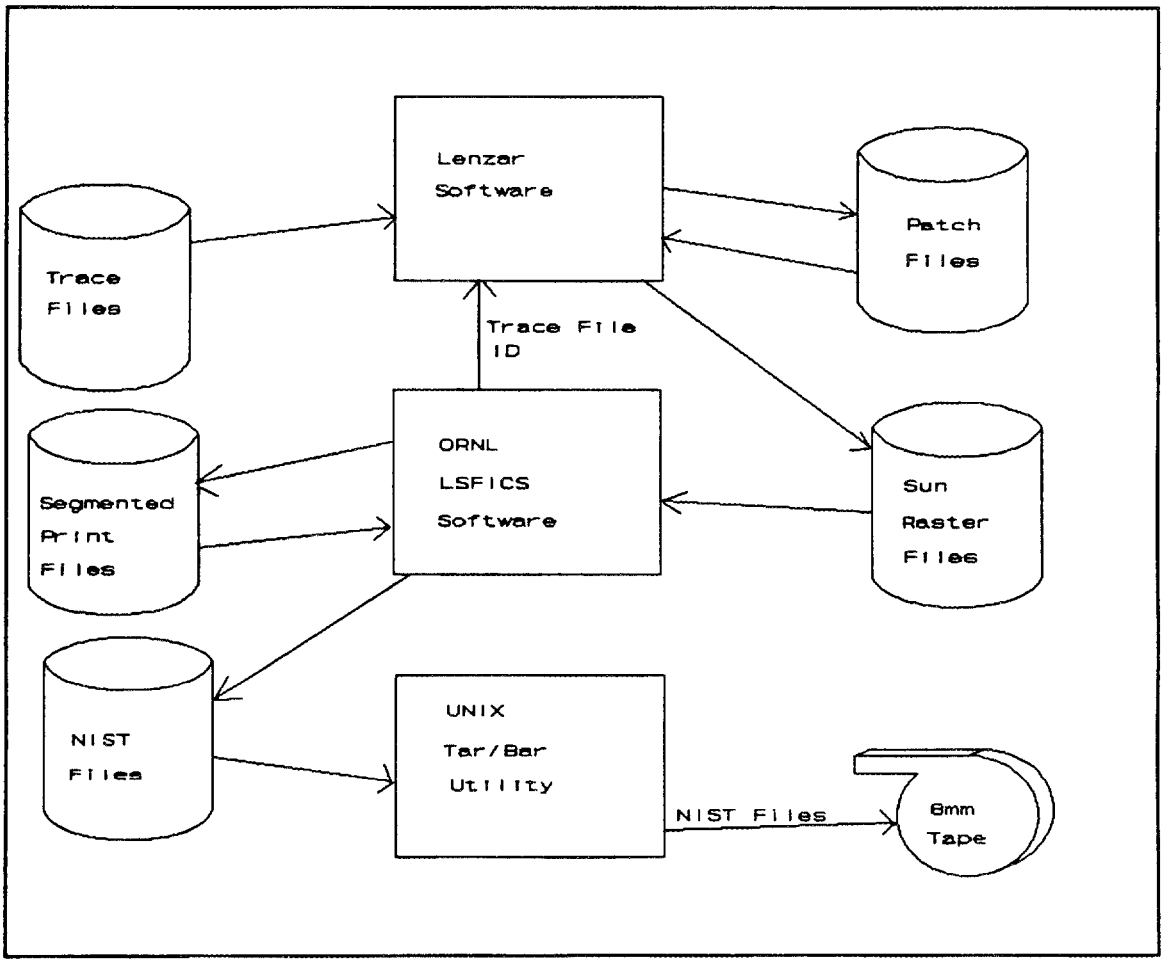


Fig. 1. Basic image flow.

The operating mode ultimately determines the details of the file contents and the final disposition of the file, that is, the directory on the disk and whether or not the file is written to tape or is accessed and deleted over the network. The sections below describe in detail how the image data are handled in each of the different modes.

4.10.1 AFIS Mode

AFIS mode NIST files are written to the directory pointed to by the environment variable FBI_NIST_DIR since the NIST file names are keyed to the FNU entered at the scanner user interface. As the front of each card is scanned, the 10 print areas are compressed, assembled into a structure, and written to disk. These files must be removed from the disk as more cards are scanned.

4.10.2 AFIS-U Mode

AFIS-U mode NIST files are written to the directory pointed to by the environment variable FBI_NIST_DIR since the NIST file names are keyed to the FNU entered at the scanner user interface. As the front of each card is scanned, the 10 print areas are segmented, assembled into a structure, and written to disk. These files must be removed from the disk as more cards are scanned.

4.10.3 Conversion Mode

Conversion mode NIST files are written to the directory pointed to by the environment variable FBI_NIST_DIR since the NIST file names are keyed to the FNU entered at the scanner user interface. As the front of each card is scanned, the 14 print areas are compressed, assembled into a structure, and written to disk. These files must be removed from the disk as more cards are scanned.

When used as an ITN scanner, a network access program periodically copies files from this directory to an area reserved for the accumulation of these files. If, for some reason, this process is not clearing these files from local storage, the user must clear them out or stop scanning cards. The user can use the available "tapetool," "BAR," or "TAR" utility to output these files to tape. Once the user is assured that the transfer to tape was successful, the files must be deleted so that sufficient disk space is available for new conversion mode files.

4.10.4 Conversion-U Mode

Conversion-U mode NIST files are written to the directory pointed to by the environment variable FBI_NIST_DIR since the NIST file names are keyed to the FNU entered at the scanner user interface. As the front of each card is scanned, the 14 print areas are segmented, assembled into a structure, and written to disk. These files must be removed from the disk as more cards are scanned.

4.10.5 Card Scan Mode

The card scan mode assembles the 14 compressed print images plus the front and back compressed text images found in the COMP_IMG_DIR area into a NIST file keyed by the PCN entered at the scanner user interface when the card was scanned. The NIST file is

written to an area pointed to by the environment variable PCN_ARC_DIR. These files are then available for access in emulator mode when they are periodically moved (UNIX mv command) into the directory pointed to by the environment variable PCN_NIST_DIR for network access. Once in this directory, the files are treated the same as files generated in conversion mode or end-to-end mode.

4.10.6 Emulator Mode

Once card scan mode has made NIST files available in the PCN_ARC_DIR area, the user may activate emulator mode to periodically copy each file into the PCN_NIST_DIR area for network access. The period of the transfer is user selectable and is designed to emulate the rate at which the final FICS scanner will be able to scan cards.

At the period specified by the user, each file in the PCN_ARC_DIR is transferred (via the mv command to avoid actually writing the large file) to the network access area pointed to by FBI_NIST_DIR. As the network access program transfers these files for final storage, they are deleted to make space available for more files.

Note that this is the only mode that does not actually scan a card. It can be activated without power on the transport and imaging subsystems. No new image segments are generated, and no new NIST files are produced.

4.10.7 End-to-End Test Mode

The end-to-end test mode generates NIST files directly into the PCN_NIST_DIR for immediate access by the network. This is the fastest way to get a card scanned and into the network and is expected to be used to demonstrate the full data path of the system, from card to network transmission.

The NIST file is generated from all 14 compressed print and both text (front and back) images found in the COMP_IMG_DIR area. Once the file is completely written under an intermediate name, it is renamed (mv command) to the pcn.NIST name format designated for network access.

4.11 IMAGE COMPRESSION

The images from a scanned fingerprint card are quite large. The nominal card scanning resolution is 500 ppi. For a standard fingerprint card, which is 8 by 8 in., the scanned images are over 16 MB each. To reduce the disk capacity needed to store scanned fingerprint images, each image is compressed to reduce its size.

The images scanned from the fingerprint cards are individually compressed by an FBI-approved compression algorithm. The details of the compression algorithm are available from the FBI. The adaptations for use in this system are detailed in the following subsections.

4.11.1 Fingerprint Compression

The FBI-provided wavelet adaptive scaler quantization (WASQ) algorithm for image compression consists of three major components: (1) wavelet filter, (2) quantization, and (3) lossless coding.

The wavelet filter transforms the image from pixels representing the intensity of incident light on the sensor to coefficients representing the range of spatial frequencies in the image. The purpose of this transformation is to separate features of interest in the image, such as fingerprint ridges and valleys from unimportant clutter such as the texture of the paper. Each iteration of the wavelet filter results in four subimages of the original image. Each subimage is one-fourth the size of the original image and contains a specific range of frequencies of that original image. One subimage represents the lower frequency contents of the original image. This is the essence of the image. The other three subimages represent the vertical edges, horizontal edges, and diagonal edges. This can be thought of as separating the image into its fundamental component and the fine details as represented by the low-frequency image and the edge content respectively.

By reapplying the wavelet filter over the subimages, the original image content is further divided into a hierarchy of smaller subimages containing a specific range of spectral information or subbands. Each level in the hierarchy describes the original image at a different scale and resolution. The wavelet filter operates on the fingerprint image to isolate the fingerprint information from unimportant detail.

The quantization process converts the coefficients to discrete values. The WASQ algorithm uses adaptive quantization. That is, the level of quantization is determined from the numbers available to quantatize. If there were few numbers between 9.5 and 10.5 in our example, we might choose to increase the level of quantization to assign all numbers between 5 and 15 with the value of 10. The WASQ quantization function measures the energy content of each subband. If the subband energy is low, then it is unlikely that significant information is contained in that subband. Therefore, the level of quantization can be set high. As a result, a small number of numbers is needed to represent the entire subband, thus creating a large amount of redundant information. Conversely, if the subband energy is high, the level of quantization is reduced, using more numbers to represent the subband.

The lossless coder removes the redundancies created by quantization. The WASQ algorithm implements a Huffman coder modified with run-length encoding to reduce the size of the image. Normally, each value in the image occupies the same amount of storage space. That is, the value of 1 is allocated the same space as the value of 100. The premise of Huffman coding is that the most frequently occurring values should occupy less space than infrequently occurring values. Thus the Huffman coder scans the image, assigning symbols to the quantized values based on how often the values are found throughout the image.

Each quantized value in the image is assigned a Huffman symbol. The symbol is merely another number used to represent a character or value in the input image. The collection of assignments is kept in a symbol table, which accompanies the output image file. In Huffman coding, the goal is to maximize the number of small symbols in the image.

Run-length encoding greatly increases the compression by reducing many pixels to a single symbol. For example, if a particular line has 27 continuous pixels of value 0, then all 27 pixels can be represented by a single symbol. When the compressed file is read for decompression, the accompanying symbol table indicates that the symbol should be replaced with a sequence of 27 zeroes in the output stream.

4.11.2 Text Area Compression

Compression of the text fields of fingerprint cards is done slightly differently from that of the prints. The upper portion, down to and including the first row of rolled prints, on the front side of the fingerprint card and the entire back side are currently defined as text

regions. The text compression consists of (1) decimation, (2) quantization, and (3) lossless coding.

Decimation is simply dividing the image resolution in half by excluding every other pixel and every other line. This results in an image that is one-fourth the size (in bits) of the original.

Quantization and lossless coding are identical to that used in print compression, except that the level of quantization is fixed at two digital bits. This limits the gray-scale reproduction available to four levels. Since the text areas contain none of the detail of the print areas, this reduction is acceptable.

4.12 IMAGE STORAGE AND RETRIEVAL

The images scanned from the cards are transmitted, in Sun raster format, by the intermediate files to the LS-FICS process. The name of the Sun raster file is defined by the INPUT_FILE environment variable. The Sun raster file is located in the directory specified by the FULL_INPUT_FILE or BOTTOM_INPUT_FILE environment variables. The print images, one for each image segment, are passed through intermediate files FP_1.cmp through FP_16.cmp in the directory pointed to by the environment variable COMP_IMG_DIR.

4.13 MODE SPECIFIC STORAGE AREAS

The final output NIST-formatted files are sent to the directories required for the mode specified.

The NIST file destinations are determined by the environment variables shown in Table 2.

4.14 STORAGE FORMATS

The input Sun raster file is stored as a raster array, one byte per pixel representing the 256 levels of gray scale, with the required header information.

The compressed image files are generated by compression algorithms designed specifically for prints or text. Both the compressed and uncompressed segmented files contain eight header bytes of file information about the conversion algorithm so that decompression can be done more easily. The first byte represents the version number of the compression algorithm used. The next six bytes indicate the resolution of the original image in x and y pixels.

The format of the final output files is as specified by the NIST draft standard dated June 10, 1992. Recent extensions allow the use of record Type 7 for user-specified images. This implementation places compressed text images in Type 7 records immediately following the 14 Type 4 records containing the compressed prints. The text image records contain the same type of header as specified for the Type 4 records. These image records do not end with the <FS> terminator, as specified by NIST.

Details of the ITN Image Capture System (ICS) implementation of the NIST file format are contained in Appendix D.

5. OPERATION

The operation of this system requires that both Lenzar and LS-FICS software be started. Configuring the system for normal scanning must be performed by qualified personnel. The procedures for preparing the system for operators to scan cards are in the "Calibration and Adjustment" section of this document (Sect. 5.3).

5.1 MODE SELECTION

For the AFIS scanning task, only the AFIS and AFIS-U modes are permitted. The modes for ITN compatibility may be enabled by an authorized person defining the ITN_MODES environment variable.

The menu allows the user to choose one of the modes specified. In conversion and AFIS modes, the operator is asked to enter the FNU, and all other modes request the PCN. Once the FNU/PCN is entered, the operator clicks on "accept" and is then instructed to place the card, fingerprint side up, on the stage. If the reverse (text) side is required, the user is prompted to turn the card over and "click start when ready." The entry of the identification number is checked only to verify that at least one character was entered. **Note that these numbers are used in creating the file names for the NIST-formatted output files, so care should be taken to make them unique. Identical numbers will cause the system to overwrite files previously stored.**

In emulator mode, the rate at which new images are made available to the network is programmable. The default rate is 2.4 s (±0.1 s), the fastest is 0.5 s, and the slowest is 120.0 s. The rate can be set by the user in increments of 0.1 s. The actual rate of the operation is a function of the operating system and could vary by a few tenths of a second if the central processing unit (CPU) load is heavy. The specific card images being processed are displayed at the user interface.

5.2 ROUTINE PRODUCTION OPERATION

Table 3 lists the steps required for normal card scan operation. Periodically, the card-image files must be archived to tape. Steps to perform the archive are listed in Table 4. The operator should remove jewelry from his/her hands to prevent damage to the stage glass during operation.

5.3 CALIBRATION AND ADJUSTMENT

This section includes the procedures to calibrate, perform the required adjustments, power up the system, and power down the system. Some of these procedures must be performed daily, and others are required only when service has been performed on the Lenzar scanner. Table 5 documents when each procedure should be used. This document does not include any Lenzar adjustments that are not considered by Lenzar as a normal user task. The procedures described here in are to be performed by a skilled technician or engineer. The system must be operated in an area with reduced lighting for optimal image quality, as specified by Lenzar.

Table 3. Basic scanning steps

Step	Description
1	The system must be set up and calibrated. If not set up properly, contact supervisor.
2	If the screen lock is active (moving geometric patterns on screen), unlock the screen by executing the following: Press the return key on the keyboard and Enter the correct password in the prompt window and press **return**.
3	Select the correct mode by clicking on the mode button with the right mouse button and then clicking the desired mode with the left mouse button.
4	Enter the process control number (PCN) or fingerprint number (FNU) as prompted. The mouse pointer must be in the Low-Speed Fingerprint Image Capture System window in order to enter the data. The PCN and FNU are case sensitive and are used to generate the National Institute of Standards and Technology file name. Previous entries may be overwritten by double clicking on the data entry field and then entering the new number. After double clicking on the field, previously entered data will be cleared when the next character is entered.
5	Select the **accept** button.
6	Place the fingerprint card on the stage as directed.
7	Select the **start** button. The system will scan the card and may compress the fingerprint images, depending on the mode. For modes that do not require that the other side of the card be scanned, return to step 4 to scan another card using the same mode.
8	If required for the selected mode, flip the card on the stage as directed and select **start** to scan the back of the fingerprint card. When completed, return to step 4 to scan another card using the same mode.
9	When scanning is complete, lock the screen by Placing the mouse on a blue section of the screen between application windows, Pressing the right mouse button to bring up the menu, Selecting the **utilities** submenu, and Selecting **screen-lock**.

Table 4. Tape archive procedure

Step	Description
1	If this is the first archive to a new tape cartridge, place a tape in the 8-mm drive. The write-protect tab must be in the right-hand position to allow writing to the cartridge. The system manager will specify how many archives are to be performed to each cartridge.
2	Type the command "NIST_archive" in the shell-tool window. Messages will be displayed in the shell-tool window as the files are copied to tape. The center and bottom light-emitting diodes (LEDs) on the tape drive will blink as the files are copied. Contact the system manager if the top LED on the tape drive lights.
3	If this is the last archive to be performed to a cartridge, eject the cartridge by pressing the button on the front of the tape drive.

Table 5. Calibration procedure summary

Procedure	When used
Complete Low-Speed Fingerprint Image Capture System (LS-FICS) start-up from login	Each time the system is started from the "login" prompt. Weekly when the system is in continuous production use.
Lenzar start-up and calibration	Each time the Lenzar software is started.
Lenzar image acquisition	To acquire raw images using the Lenzar interface.
Abbreviated Lenzar calibration	Daily when the system is in normal production.
Lenzar stage home calibration	After any work is performed on the Lenzar scanner that would result in the position of the card in the image field changing.
LS-FICS trace file creation	Only when the scanning process is changed or after the Lenzar stage home calibration.
LS-FICS segmentation	When the stage home calibration is performed or the segmentation reference card changes.
Power down	When the system will not be used for an extended period, a power outage is expected, or any other situation requiring a complete system shutdown.
Power up	Any time the system is started from an unpowered state.

5.3.1 Complete LS-FICS Start-up from Login

This procedure is used to bring up the system to a point where images may be acquired by an operator from the login point. Except for the login step, this procedure must be executed any time the lsfia (low-speed-FICS image acquisition) task is started. This is because the Lenzar software does not maintain calibration information across separate executions. Steps required to perform the complete start-up are given in Table 6.

Table 6. Complete LS-FICS start-up

Step	Description
1	Logon the Sun by entering "lsfics" at the user prompt and the password at the password prompt. The OpenWindows facility will be started automatically. At completion, three windows will be visible on the screen. The lower right portion of the screen will display the file manager, a command console window will be displayed on the lower left of the screen, and a shell-tool window will occupy the upper right of the screen.
2	Start the Lenzar software and calibrate the scanner as described in the "Lenzar Start-up and Calibration" section (Sect. 5.3.2).
3	Close all except the main Lenzar window. The windows are closed by selecting **done** in each one.
4	Select **LSFICS** from the lsfia task's main window. This will cause the LS-FICS window to appear.
5	Move the LS-FICS window to the lower left area of the screen. This is accomplished by placing the pointer on the top boarder of the window, holding the middle mouse button down, and moving the window with the mouse.
6	Minimize the lsfia task's main window by pressing the right mouse button with the pointer on the top border of the window and selecting the **close** option from the resulting menu.
7	Select **listen** in the LS-FICS window.
8	Start the lsfics application by entering "scan" in the shell-tool window. Temporary files will be copied to the /temp filesystem. This will require about 1 min. After the file copy is done, the lsfics window will appear and the system will be ready to scan fingerprint cards.

5.3.2 Lenzar Start-up and Calibration Procedure

The procedure detailed in Table 7 gives the overall steps required to perform the complete calibration using the LP2000 software. For detailed descriptions of the individual menus, options, and calibration process, refer to the LENZAR ElectroOptics *Trainer's Manual for the Lenzpro 2000 Image Acquisition Shell*, November 1992. This procedure must be executed whenever the Lenzar scanner is powered up. Portions of the procedure must be executed as directed in the "Abbreviated Lenzar Calibration" procedure (Sect. 5.3.4) to compensate for system drift when the system is in continuous production use.

Table 7. Lenzar calibration

Step	Description
1	Verify that the lamp voltage is set to 13 V and the lens f-stop is set to f/5.6. The system must be powered on for at least 30 min before performing this procedure.
2	If not previously done, logon to the system and start the operating program by entering "lsfia &" in the shell-tool window. One Lenzar error message will appear in the shell-tool window as the task starts.
3	Place the sheet containing the Air Force target (shown in Appendix G) in position under the glass cover.
4	From the stage window, select **Target**. The stage will move to the center position.
5	Select **Focus** from the calibration window. If focus adjustment is required, follow the detailed procedure given in Sect. 3.2 of the Lenzar trainer's manual.
6	Press the middle mouse button in the calibration menu window when the focus procedure is completed.
7	Select **Scaling** from the calibration window. The stage menu will appear, and a red box will be present on the monitor window. Using the buttons on the stage window, move the stage so that the red box contains one and only one corner of a box. See Sect. 3.3 of the Lenzar trainer's manual for more details.
8	Once the stage is in the correct position with the corner of the black square in the red box, select **Done** in the stage window. The system then performs the scaling operation. After completion, the calibration window reappears.
9	Remove the Air Force target sheet and place an unprinted fingerprint card under the glass. The blank card must be a blank piece of fingerprint card stock.
10	In the calibration window, select **Color** as the calibration mode.
11	Select **Center** from the stage window.
12	Select **Exposure** from the calibration window. The system will perform an exposure calibration for each color. The filter goes to clear upon completion.
13	Select **Gradient** from the calibration window. As with exposure, a gradient calibration is performed for each color. A clear filter indicates completion.
14	Select **Home** from the stage window. The stage will move to the upper left position, ready for image acquisition.

WARNING: Selecting **Quit** from the main lsfia or lia menus will cause all calibration data to be lost. This calibration procedure must be performed every time the operating software is started.

5.3.3 Lenzar Image Acquisition Procedure

Images may be acquired with the Lenzar scanner using the procedure in Table 8.

Table 8. Lenzar image acquisition procedure

Step	Description
1	Place sheet to be acquired under the glass cover. Select **Home** from the stage window.
2	From the filter wheel window, select **Blue**.
3	From the mosaic window, select **Capture**.
4	If patch files already exist, a message will appear indicating that existing files will be overwritten. Click **Continue** on this message if it appears.
5	The mosaic feature selection window will appear. Select **OK** to start the image acquisition. The monitor window will show each patch as it is being acquired.
6	To store the image as a Sun raster file: open the mosaic window; select **Sun Raster** in this window; enter the desired image file name; enter the path for the raster file to be generated; then select **Build Image**. A beep will sound when the build operation is complete.
7	To view the Sun raster image, open a UNIX shell outside the LP2000 software. (It is not necessary to quit the operating software.) Enter: cd image_file_directory xv image_file_name

5.3.4 Abbreviated Lenzar Calibration

Periodically, while the system is in continuous operation, a subset of the Lenzar calibration must be repeated. These calibration steps are required to compensate for drift in the scanner components. This subset of the "Lenzar start-up and calibration" procedure includes scaling, focus, and gradient calibration. Initially, it is recommended that this procedure be performed daily. The calibration steps are given in Table 9.

5.3.5 Lenzar Stage Home Calibration

This procedure is required after any adjustment or repair of the Lenzar scanner that results in movement of the stage home position in relation to the image field. The procedure is given in Table 10. After this procedure is completed, an image of a fingerprint card should be near the center of the total image area with near-equal overscan on all sides.

5.3.6 Creating Trace Files for LS-FICS

The lsfia task executes a "trace" file to capture and generate Sun raster files for the fingerprint card images. The LS-FICS task specifies one trace file for a full card scan and another trace file for a scan of the bottom 75% of a card. The trace files are created by recording image acquisitions using the lsfia Autopilot function and then editing the file to include additional steps. The steps to create new trace files are given in Table 11.

Table 9. Abbreviated Lenzar calibration

Step	Description
1	Press the middle mouse button to terminate the lsfia "listen" function if active. The grayed-out button in the lsfia's LSFIA window will become white.
2	Open the lsfia task's main window by clicking on its icon with the left mouse button.
3	Select **Calibration** from the main lsfia window.
4	Select **Stage** from the main lsfia window.
5	Place the sheet containing the Air Force target in position under the glass cover.
6	Select **Scaling** from the calibration window. The stage menu will appear, and a red box will be present on the monitor window. Using the buttons on the stage window, move the stage so that the red box contains one and only one corner of a box. See Sect. 3.3 of the Lenzar trainer's manual for more details.
7	Once the stage is in the correct position, select **Done** in the stage window. The system then performs the scaling operation. After completion, the calibration window reappears.
8	Remove the Air Force target sheet and place an unprinted fingerprint card under the glass. The blank card must be a blank piece of fingerprint card stock.
9	In the calibration window, select **Color** as the calibration mode.
10	Select **Center** from the stage window.
11	Select **Exposure** from the calibration window. The system will perform an exposure calibration for each color. The filter goes to clear upon completion.
12	Select **Gradient** from the calibration window. As with exposure, a gradient calibration is performed for each color. A clear filter indicates completion.
13	Select **Home** from the stage window. The stage will move to the upper left position, ready for image acquisition.
14	Select **Done** in the stage window.
15	Select **Done** in the calibration window.
16	Minimize the main lsfia window by pressing the right mouse button with the pointer on the window's top border and selecting the **Close** option.
17	Press the **Listen** button in the LSFICS lsfia window.

5.3.7 LS-FICS Segmentation Calibration

The image acquisition portion of the system must be given the location of the fingerprint card within its field of view so that accurate segmentation of the fingerprint areas can be done. This procedure, detailed in Table 12, is required during initial setup, following any adjustments that affect the location of the card image in the Sun raster file that is generated by the Lenzar subsystem.

Table 10. Stage home calibration

Step	Operation
1	Start the LS-FICS task by entering "scan" in the shell-tool window.
2	Start and calibrate the scanner.
3	Place a reference fingerprint card on the scanner's stage.
4	Select **home** in the stage window to place the stage in the home position.
5	Using the mosaic function, capture and view a full image of the fingerprint card. Use blue light.
6	The card image should be centered in the view with near-equal overscan on each edge.
7	If the card is centered correctly, no adjustment is necessary; if not, proceed with the next step.
8	Select **home** in the stage window to place the stage in the home position.
9	Edit the position coordinates and select **move direct** in the stage window to establish a new initial scan position. Record this position.
10	Using the mosaic function, capture and view a full image of the fingerprint card. Use blue light.
11	Repeat steps 7 through 9 until the fingerprint card image is near the center of the image area.
12	Record the initial stage position that should become the new home position.
13	Exit the lsfia task.
14	Edit the /lsfics/lp2000/stage.cfg file, changing the home coordinates to the values recorded in step 11.
15	Repeat steps 2 through 7 to verify that the home position is now correct.
16	Execute the "Creating Trace Files for LS-FICS" procedure.
17	Execute the "LS-FICS Segmentation Calibration" procedure.

The procedure provides a method to determine the x and y pixel coordinates of one reference point. That point is defined as the midpoint of the cross in the upper left-hand corner of the Left Index box in the fingerprint card. These coordinates are with respect to the upper left corner of the image, which has coordinates of (0,0). Appendix F illustrates the measurement point selection that is used for the segmentation calibration.

To determine the reference point, an image of the standard blank fingerprint card is acquired. The pixel coordinates of the reference point are then read and stored in a C include file. As a result, the new pixel coordinates found do not take effect until a recompilation of the LS-FICS system software is performed.

Table 11. Trace file creation

Step	Operation
1	Back up the old trace files by entering the following commands in the shell-tool window: % cd /lsfics/lsfics_home % mv full.tra full.tra_sav % mv bottom.tra bottom.tra_sav.
2	Start and calibrate the scanner.
3	Start the LS-FICS task by entering "scan" in the shell-tool window.
4	Place a reference fingerprint card on the scanner's stage.
5	Select **home** in the stage window to place the stage in the home position.
6	Select **autopilot** in the lsfia task's main window to bring up the Autopilot window.
7	Enter "/lsfics/lsfics_home/full.tra" in the Autopilot window for the trace file specification.
8	Select **Start Trace** in the Autopilot window.
9	Select **FilterWheel** in the lsfia task's main window.
10	Select **Blue** in the FilterWheel window.
11	Select **Done** in the FilterWheel window.
12	Select **Mosaic** in the lsfics task's main window.
13	Enter "/temp/full/patch" as the patch file specification in the Mosaic window.
14	Enter "/temp/full/card.scr" as the Image file specification in the Mosaic window.
15	Select **Capture** in the Mosaic window.
16	Select **OK** in the Mosaic Feature Selection window. The entire front of the card will be scanned and will appear in the Monitor window.
17	Select **Mosaic** in the main lsfics menu.
18	Select **Build Image** in the Mosaic window.
19	Select **Autopilot** in the main lsfia window to bring up the Autopilot window.
20	Select **Close Trace** in the AutoPilot window.
21	Enter "/lsfics/lsfics_home/bottom.tra" in the Autopilot window for the trace file specification.
22	Select **Start Trace** in the AutoPilot window.
23	Select **FilterWheel** in the main lsfics window.
24	Select **Blue** in the FilterWheel window.
25	Select **Done** in the FilterWheel window.
26	Select **Mosaic** in the main lsfics menu.

Table 11 (continued)

Step	Operation
27	Enter "/temp/bottom/patch" as the patch file specification in the Mosaic window.
28	Enter "/temp/bottom/card.scr" as the Image file specification in the Mosaic window.
29	Select **Capture** in the Mosaic window.
30	Click on the top row of squares in the Monitor window to deselect these image segments.
31	Press **OK** in the Mosaic Feature Selection window. The bottom 75% of the card will be scanned and will appear in the monitor window.
32	Select **Mosaic** in the main lsfics menu.
33	Select **Build Image** in the Mosaic window.
34	Select **Autopilot** to bring up the Autopilot window.
35	Select **Close Trace** in the Autopilot window.
36	Edit /lsfics/lsfics_home/full.tra and add the command "IMG; iaImageType; 5" as the first line in the file. Also add the command "STG; iaStageLoad;" as the next-to-last command in the file. An easy way to do this edit is to copy the added command lines from one of the "....tra_sav" files.
37	Edit /lsfics/lsfics_home/bottom.tra and add the command "IMG; iaImageType; 5" as the first line in the file. Also add the command "STG; iaStageLoad;" as the next-to-last command in the file. An easy way to do this edit is to copy the added command lines from one of the "....tra_sav" files.

5.3.8 Power Up/Down Procedures

It will be necessary at times to turn off the workstation and subsystems. Situations requiring turn off may include anticipation of a power failure and maintenance. This procedure is to be used when it is necessary to turn off the Sun workstation and/or the peripherals attached to it. The Lenzar scanner can be turned off separately from the workstation. Under normal conditions, the workstation should remain on. The Lenzar scanner should also remain on except when scanning will not be performed for several shifts. The steps to power down the system are given in Table 13, and the steps to power up the system are given in Table 14.

Table 12. Segmentation calibration

Step	Operation
1	Start and calibrate the scanner.
2	Start the LS-FICS task by entering "scan" in the shell-tool window.
3	Place a reference fingerprint card on the scanner's stage
4	Use the Lenzar software to capture an image of the complete fingerprint card using the "Lenzar Image Acquisition Procedure." Use "/temp/full/card.scr" as the output file path.
5	Close all lsfia (Lenzar program) subwindows and minimize the lsfia task's main window.
6	Use the "xv" program to view the captured image by entering the following command in the shell-tool window: % xv /temp/full/card.scr.
7	After the image appears, zoom in on the upper left corner of the L Index box. Zooming is performed by first drawing a window over the desired section of the image by holding down the middle mouse button. Then, press the right mouse button. A control window will appear. At this point, select the crop button in this panel. The image will be removed except for the selected portion within the window. Now, select the double-size button to enlarge the image section to a desired size. Place the cursor crosshair in the middle of the point where the lines cross on the card. Display the x, y pixel coordinates by pressing the left mouse button. Record these values and exit from xv.
8	Using a suitable text editor, add the recorded coordinates to the file "meas_cord.h" in the /lsfics/ui/inc directory. This should be done by commenting out the present values and appending the new values to the end of the file along with the name of the person making the change and the date and time. This file is a C language include file for the LS-FICS system software. As a result, the new coordinate values will not take effect until a new compilation and build of the software. The software is recompiled by copying the new file to the directory /lsfics/ui/etc, moving there, and executing the "make ui" command: % cd /lsfics/ui/etc % make ui.
9	Then exit and restart the LS-FICS task.

Table 13. Power down

Step	Description
1	Log on the workstation as root.
2	Enter the following commands to halt the system: sync;sync;sync;shutdown now "message" halt. The text string "message" will be written to the system log file for a record of why the system was shut down.
3	When the system has completed the shutdown, power down the equipment in the following sequence: a. Lenzar scanner (if on) using the switch on the back of the blue Lenzar rack. b. Disk enclosure using the rear panel switch. c. Tape enclosure using the rear panel switch. d. Performance Technologies VME chassis using the switch on the lower back panel. e. Monitor using the switch on the lower front. f. Sparc workstation using the rear panel switch.

Table 14. Power Up

Step	Description
1	Power up the equipment in the following sequence: a. Monitor using the switch on the lower front. b. Disk enclosure using rear panel switch. c. Tape enclosure using rear panel switch d. VME chassis using the switch on the lower back panel. e. Sparc workstation using the rear panel switch. f. Lenzar scanner (if needed) using the switch on the rear of the blue Lenzar rack.
2	After turning on the Sparc, the system will enter a memory self-test that will require about 15 min to complete; then loading the operating system will begin. To skip the memory test, perform the following steps: a. Hold the "Stop" and press the "a" key. This will cause the memory test to stop, and a ">" monitor prompt will be displayed. b. Type "b" followed by "return." This will initiate loading of the UNIX operating system. The system should load and be ready for login in about 2 min. If the system is starting after an abnormal shutdown such as a power failure, the operating system start-up may perform an extra operation to correct inconsistencies in the disk file system and repeat the start-up operations. Typically, this will double the operating system start-up time to about 4 min.

6. TESTING, MAINTAINING, AND TROUBLESHOOTING

The system is designed to operate easily and effectively for the several months required for the activities planned. This section details the testing procedure available for the user to verify operation; the tools available to assist in calibrating critical components, quality verification, and system maintenance; and techniques that can be used to minimize the potential for failures; and finally ways to mitigate the impact of any degradation in the operation of the system.

6.1 ACCEPTANCE TESTING

A test plan is available that describes the methodology that was used to verify that the components of the system performed their intended function. The acceptance test procedure is designed to provide a quick check of the end-to-end functionality to verify that no catastrophic failures have occurred since the original testing. Appendix E contains the acceptance test procedure.

6.2 NIST FILE VERIFICATION

A tool is available in the area /lsfics/read_nist to extract individual fingerprint or text records from the NIST files and output the compressed image for subsequent decompression as detailed below. The tool is activated as shown below:

```
% fgp 15.
```

This step would extract record 15 (front text) from the file pointed to by the environment variable FGP_FILE in the directory pointed to by the environment variable FGP_DIR and output the extracted record to the file fgp_15_NIST.CMP. The setting up of these environment variables is shown below:

```
% setenv FGP_DIR $COMP_IMG_DIR
% setenv FGP_FILE 1122334.NIST.
```

The program defaults to the user's current directory and a file named test_file.NIST if these variables are not initialized. The output file always goes to the user's current directory.

6.3 COMPRESSION VERIFICATION

The compressed images can be verified by decompressing the images stored in the COMP_IMG_DIR and displaying them on the host workstation. Tools supplied with the system are not part of the deliverable but can be used as a guide for preparing software to decompress these images. Consult the acceptance test procedure (Appendix E) for details on how to verify the entire image data path.

Fingerprint images can be decompressed with the decompress print (dcp) tool. Details of this tool are given in "Decompression Tool" (Sect. 6.4).

The file /lsfics/read_nist/aliases.env sets up some aliases and environment variables to ease the testing. A command, view n, allows image n to be extracted from the NIST file, decompressed, and viewed in a single command, as illustrated below:

```
% cd /itn/read_nist
% source /itn/read_nist/aliases.env
% view 1
% view 2
.
.
.
% view 16.
```

Recall that images 15 and 16 represent the front and back text respectively. Refer to the acceptance test procedure (Appendix E) for further details.

6.4 DECOMPRESSION TOOL

To test the compression software developed at ORNL, a decompression utility was written that decompresses and displays compressed fingerprint files. The decompression function automatically determines whether the compressed file is a fingerprint image or a text region and will select the appropriate decompression technique.

The function is named "dcp" and is activated as follows:

dcp file_in [-o]utput (file_out) [-s]ilent [-d](n) [-v]erbose

where the arguments to dcp are

file_in is the input filename to decompress.

The available options are

-o: Output filename, save the uncompressed image as <filename>on disk. Default off.
-s: Silent, omit the on-screen display. Default off.
-d: Decimate, reduce the display size by n = 1, 2, 4, or 8.
-v: Verbose, print information about file_in on the CRT screen. Default off.

Examples:

1. dcp foo.bar.cmp

will decompress the file foo.bar.cmp and display the resultant image in an OpenWindows format on the screen. The uncompressed image will not be saved, and the reconstructed image will be the original size (unity decimation).

2. dcp foo.bar.cmp -o foo.bar.uncmp

decompresses and displays as in Example 1 but also saves the uncompressed image as foo.bar.uncmp.

3. dcp foo.bar.cmp -o foo.bar.uncmp -d 2

decompresses, displays, and saves as in Example 2 but decimates by a factor of 2. This action will reduce the image to one-fourth its original size in both the on-screen image and the saved disk file.

4. dcp foo.bar.cmp -v

does not perform any decompression functions; just tells pertinent information about foo.bar.cmp such as image dimensions and compression type.

6.5 MAINTENANCE

The only normal maintenance required for the workstation and peripherals is the cleaning of the 8-mm tape drive head. The head should be cleaned as directed in the vendor's manual.

Since the optics are sensitive to contamination, no smoking should be permitted around the system. Deposits on the optics can significantly degrade the image quality.

6.6 PREVENTION

Unless the disk directories are kept cleaned, failures resulting from the full disk could become troublesome. Establishing a regimen for cleaning the camera lens, transport, and tape drives could help prevent failures. The procedures used must be carefully followed since improper cleaning can cause more damage than not cleaning at all.

A periodic check, using the tools like those detailed above, can give an early warning indicating an incipient failure. Distributing faulty images would be a serious problem, so it is important to verify that the system is performing as required at periodic intervals.

During the normal operation of the equipment, parameters falling outside the normal range can indicate a problem. Executing the % view n instruction detailed above (Sect. 6.3) and observing the location of the form frame with respect to the print gives an indication of the need for recalibrating the segmentation. The compression ratios listed in the shell-tool window during the scanning process give an indication of the health of the imaging subsystem.

Normally, these compression ratios are in the 9.0 to 15.0 range. Any fingerprints that show a compression ratio greater than this range should be suspect. Consistent ratios over 15.0 usually mean that the fine detail of the image is being lost; usually indicating a need to check the focus on the camera. Procedures for these activities are detailed in "Calibration and Adjustment" (Sect. 5.3).

6.7 MITIGATION

Establishing a backup procedure reduces recovery problems should a disk failure occur. System and application software disk partitions should be backed up after any changes such as installation of new products. A system log should also be maintained for the system and should contain dated and signed entries for all maintenance performed and problems encountered.

6.8 POTENTIAL IMPROVEMENTS

This section details areas where additional development would produce improvements in efficiency, accuracy, robustness, or ease of use.

6.8.1 Image Compression

This system uses the same processor and digital signal processing board as the ITN scanner. Since the time the ITN system was developed, advanced SPARC workstations and SBus processors have become available. The potential exists for an estimated 50% reduction in compression time by taking advantage of the new technology.

6.8.2 Image Storage

Since the system is SCSI based, new tape or disk drives can be added to improve on-line capacity. Any additional drives should have at least the same throughput (MB/s) as those included with the system.

6.8.3 Overall Performance

Image data are transferred to and from disk about six times from image capture to NIST file creation in the current system. Performance could be improved by modifying the Lenzar and ORNL software to minimize the use of intermediate disk storage. It is estimated that this modification could improve the uncompressed mode performance by about 25–50%. For the compressed modes, the performance increase would be less because compression is the largest scan-time component.

Appendix A. LOW-SPEED FINGERPRINT IMAGE CAPTURE SYSTEM BLOCK DIAGRAM

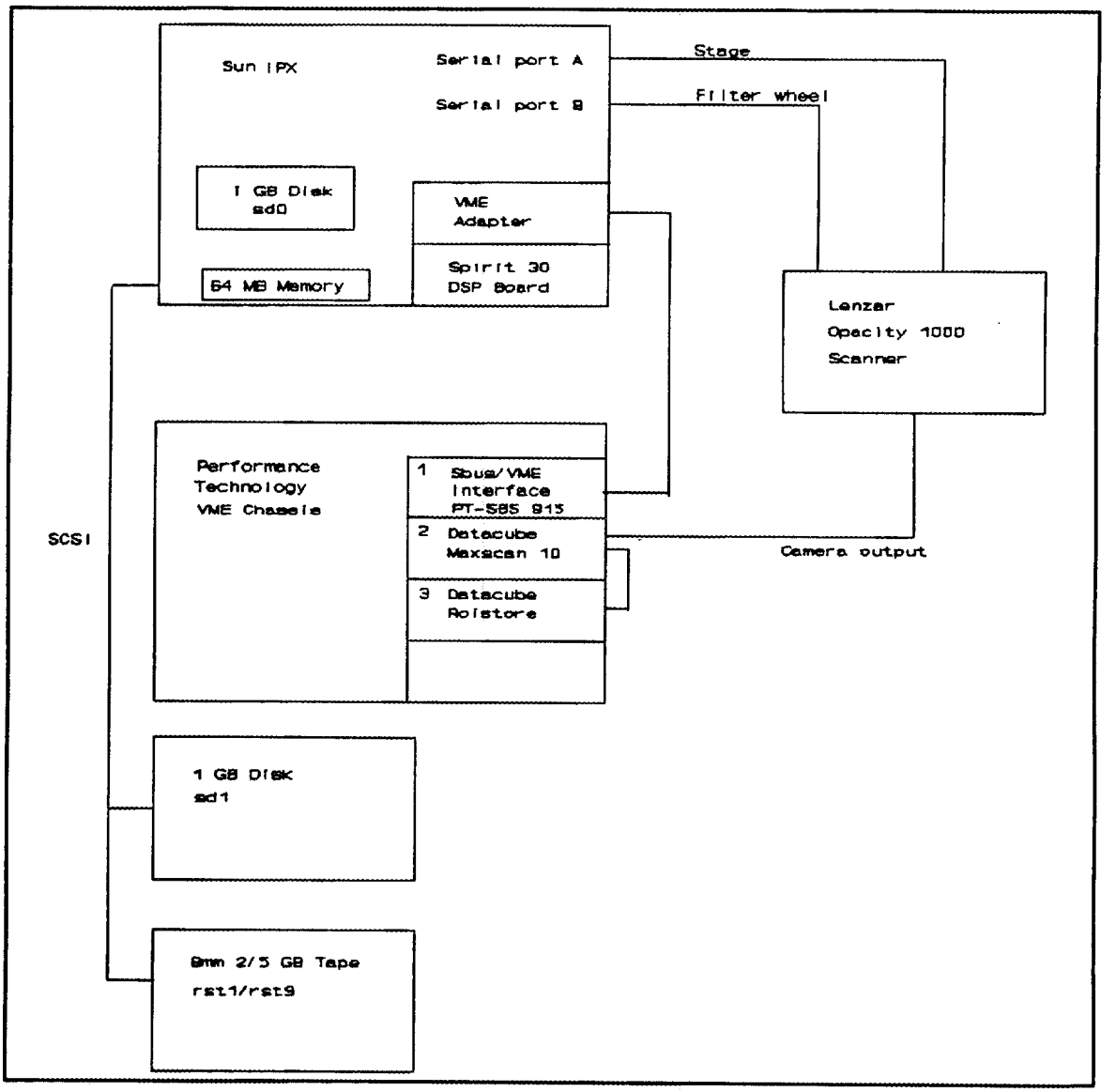


Fig. A.1. Block diagram showing the main hardware components of the Low-Speed Fingerprint Image Capture System.

Appendix B. LOW-SPEED FINGERPRINT IMAGE CAPTURE SYSTEM DOCUMENTATION LIST

SUN DOCUMENTATION

System and Network Administration

SunOS 4.1.2 Release and Install

Fortran User's Guide/Reference Guide/Numerical Computations Guide

Writing Device Drivers STREAMS Programming

SunView Systems Programmer's Guide Pixrect Reference

Programmer's Language Guides

SunView Programmer's Guide

Global Index

SunOS Documentation Tools

SunOS Reference Manual, Volumes I, II, and III

Debugging Tools/Sun Source Browser Reference (SunView)

Debugging Tools/Sun Source Browser Reference (Open Windows)

Sun C Programmer's Guide/ANSI C Programmer's Guide/Numerical Computations Guide

Network Programming Guide

SunOS User's Guide, Getting Started

Sunview User's Guide

OpenWindows Version 2, Installation and Start-Up Guide

OpenWindows Version 2, User's Guide

OpenWindows Version 2, Release Notes

SunOS User's Guide, Basic Troubleshooting

SunOS User's Guide, Customizing Your Environment

DeskSet Environment Reference Guide

OpenWindows Version 3 for SunOS 4.1x, DeskSet Reference Guide

Desktop SPARC Software Package, DeskSet Reference Guide

SPARCWORKS C Compiler

SPARCWORKS Fortran Compiler

Miscellaneous paperwork related to guides, computers, and software.

OTHER VENDOR DOCUMENTATION

Lenzar Programmer's Manual

Lenzar Trainer's Manual

Lenzpro 1000 Fingerprint Digitizer Documentation Manual

Anorad Positioning Table Installation and Maintenance Manual

I-Series I-Step/I-Serv Controllers Programming and Hardware Manual

Cybernetic Micro Systems - CY545 Stepper Motor Controller Manual

TCR 10 Power Supply Instruction Manual

NPI Disk Subsystem User's Guide

ORNL-SUPPLIED HARDWARE AND SOFTWARE DOCUMENTATION

Low-Speed Fingerprint Image Capture System User's Guide (ORNL/TM-12414)

Appendix C. LOW-SPEED FINGERPRINT IMAGE CAPTURE SYSTEM HOST DIRECTORY STRUCTURE DIAGRAM

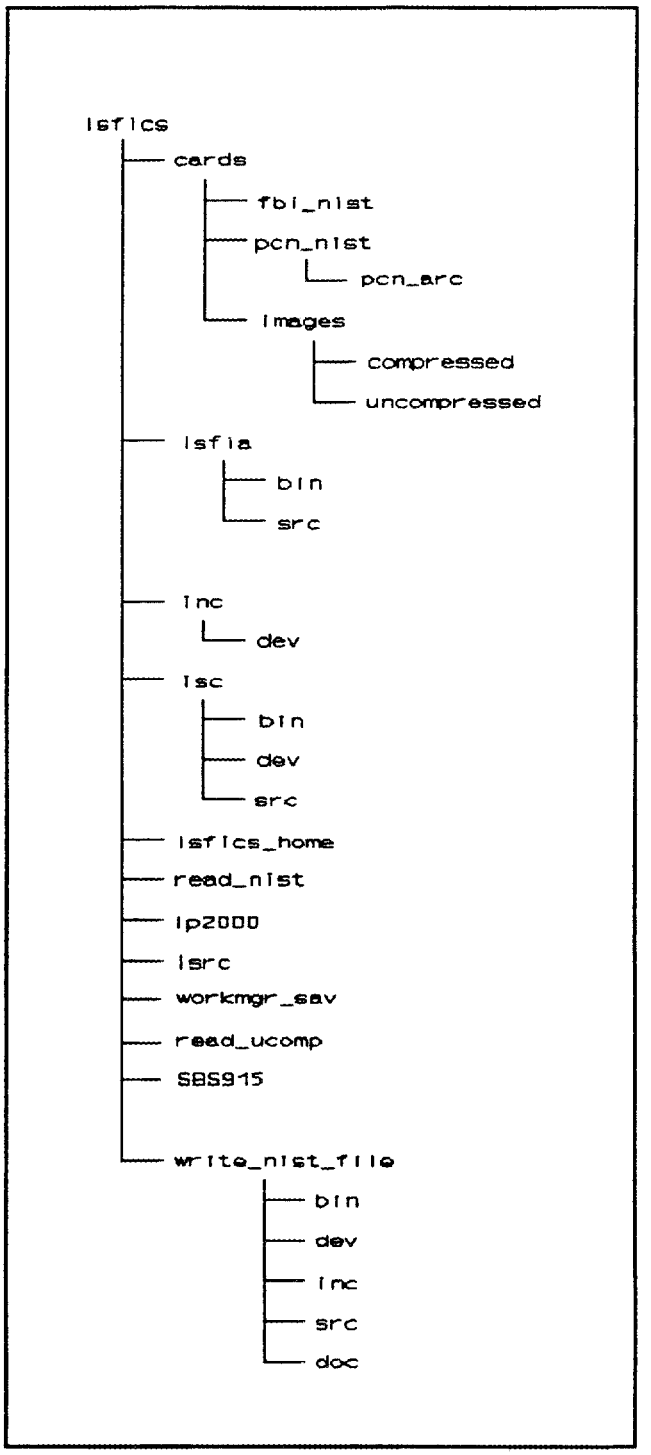


Fig. C.1. Low-Speed Fingerprint Image Capture System host directory structure diagram.

Appendix D. IMAGE TRANSMISSION NETWORK IMAGE CAPTURE SYSTEM PROTOTYPE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY FILE DESCRIPTION

D.1. INTRODUCTION

This document describes and gives examples of the fields in the National Institute of Standards and Technology (NIST) fingerprint files generated by the Image Transmission Network (ITN) Image Capture System prototype. The format is based on the NIST draft standard dated June 10, 1992. Files generated in card-scan mode will contain one Type 1 record followed by 14 Type 4 compressed image records and two Type 7 records containing the front and back text images. The file generated in conversion mode contains one Type 1 record followed by 14 Type 4 compressed image records. The Type 7 (user-defined) records are described in Sect. D.2.

D.2. FIELDS FOR THE ITN PROTOTYPE TYPE 7 RECORDS

The first two data fields of the Type 7 record are defined by the NIST standard. The remaining fields are defined here for use in this application.

The Type 7 header shall be 12 B (bytes), including the mandatory 5 B specified in the NIST standards draft NIST-CSL 1-199x, dated June 10, 1992.

1. Logical record length (LEN)

   This mandatory 4-B field shall occupy bytes 1 through 4. It shall contain the length of the logical record specifying the total number of bytes, including every byte of all the fields in the record. The NIST standard requires this field for all Type 7 records.

2. Image designation character (IDC)

   This mandatory 1-B field shall occupy byte 5 of the Type 7 record. It shall be used to identify the image data contained in this record. The IDC contained in this field shall be a binary representation of the IDC found in the file content of the Type 1 record. The NIST standard requires this field for all Type 7 records.

3. Card side

   This 1-B field shall occupy byte 6 of the Type 7 record. It shall contain a binary value of zero if this record contains the image data from the card front and a binary value if the record contains image data from the card back.

4. Image scanning rate

   This 1-B field shall occupy byte 7 of the Type 7 record. This field shall contain a binary zero.

5. Horizonal line length

   This 2-B field shall occupy bytes 8 and 9 of the Type 7 record. It shall be used to specify the number of pixels contained on a single scan line of the image.

6. Vertical line length

   This 2-B field shall occupy bytes 10 and 11 of the Type 7 record. It shall be used to specify the number of scan lines contained in the image.

7. Gray-scale compression algorithm

   This 1-B field shall occupy byte 12 of the Type 7 record. It shall be used to specify the type of gray-scale compression used (if any). A binary zero denotes no compression. Otherwise, the contents of this byte shall be a binary representation for the number allocated to the particular compression technique used by the interchange parties.

8. Image data

   This binary field shall contain all of the gray-scale image data.

D.3. EXAMPLE OF RECORDS FOR A CARD SCAN NIST FILE

TYPE 1 RECORD (ONE)	
Length (LEN)	1.01:213<GS>
Version (VER)	1.02:0200<GS>
Content (CNT)	1.03:1<US>16<RS>4<US>0<RS>4<US>1<RS> 4<US>2<RS>4<US>3<RS>4<US>4<RS> 4<US>5<RS>4<US>6<RS>4<US>7<RS> 4<US>8<RS>4<US>9<RS>4<US>10<RS> 4<US>11<RS>4<US>12<RS>4<US>13<RS> 7<US>14<RS>4<US>15<GS>
Type of transaction (TOT)	1.04:Itn card scan<GS>
Date (DAT)	1.05:19920825<GS>
Priority (PRY)	1.06:4<GS>
Destination agency identifier (DAI)	1.07:123456789<GS>
Originating agency identifier (ORI)	1.08:ornl12345<GS>

Transaction control number (TCN)	1.09:123<GS>
Transaction control reference (TCR)	1.10:abc<GS>
Native scanning rate (NSR)	1.11:19.6850<GS>
Transmitting resolution	1.12:19.6850<FS>

FIRST TYPE 4 RECORD

Length (LEN)	00 00 45 4E (HEX)
Image designation character (IDC)	00 (HEX)
Impression type (IMP)	03 (HEX)
Finger position (FGP)	01 FF FF FF FF FF (HEX)
Image sampling rate (ISR)	00 (HEX)
Horizontal line length (HLL)	03 20 (HEX)
Vertical line length (VLL)	03 00 (HEX)
Gray-scale compression algorithm (GCA)	01 (HEX)
Image data	Gray-scale image data for rolled right thumb

SECOND TYPE 4 RECORD

Length (LEN)	00 00 39 3C (HEX)
Image designation character (IDC)	01 (HEX)
Impression type (IMP)	03 (HEX)
Finger position (FGP)	02 FF FF FF FF FF (HEX)
Image sampling rate (ISR)	00 (HEX)
Horizontal line length (HLL)	03 20 (HEX)
Vertical line length (VLL)	03 00 (HEX)
Gray-scale compression algorithm (GCA)	01 (HEX)
Image data	Gray-scale image data for rolled right index finger

LAST (14TH) TYPE 4 RECORD

Length (LEN)	00 00 89 AC (HEX)

Image designation character (IDC)	0D (HEX)
Impression type (IMP)	03 (HEX)
Finger position (FGP)	0E FF FF FF FF FF (HEX)
Image sampling rate (ISR)	00 (HEX)
Horizontal line length (HLL)	06 40 (HEX)
Vertical line length (VLL)	03 C0 (HEX)
Gray-scale compression algorithm (GCA)	01 (HEX)
Image data	Gray-scale image data for plain left four finger

FIRST TYPE 7 RECORD

Length (LEN)	00 04 FC 58 (HEX)
Image designation character (IDC)	0E (HEX)
Card side	00 (HEX)
Image sampling rate (ISR)	00 (HEX)
Horizonal line length (HLL)	10 00 (HEX)
Vertical line length (VLL)	08 E0 (HEX)
Gray-scale compression algorithm (GCA)	02 (HEX)
Image data	Gray-scale image data for front text area

SECOND TYPE 7 RECORD

Length (LEN)	00 03 C8 99 (HEX)
Image designation character (IDC)	0F (HEX)
Card side	00 (HEX)
Image sampling rate (ISR)	00 (HEX)
Horizonal line length (HLL)	10 00 (HEX)
Vertical line length (VLL)	10 00 (HEX)
Gray-scale compression algorithm (GCA)	02 (HEX)
Image data	Gray-scale image data for back card

Appendix E. LOW-SPEED FINGERPRINT IMAGE CAPTURE SYSTEM ACCEPTANCE TEST PROCEDURE, JUNE 11, 1993

E.1 INTENDED AUDIENCE

This document is intended to help those who are testing the Low-Speed Fingerprint Image Capture System (LS-FICS). The tests focus on those that exercise the critical components, provide the most efficient testing, and establish a minimum test that can be performed at any time to verify base functionality. Detailed hardware and software documentation is available elsewhere. A directory of available documentation is available in Appendix B of the user's guide.

E.2 INTRODUCTION

The acceptance test procedure is intended to exercise critical components to uncover the most likely faults without relying on exhaustive testing to uncover all possible faults. A key measure of the success of this procedure is its ability to verify end-to-end system functionality and quality with minimum operator intervention.

The most important attribute to verify in the LS-FICS system is the quality of the final product. The first section of the procedure verifies the image quality of the scanner. The second group of procedures describes the most effective way to assure the user that the output, in fact, is as expected. Next, we verify the various options available, exercising the ones that require the most complex functions. The final test is to verify that the fault conditions are handled properly. The order of the testing reflects the priority of these activities in the design. The quality of the image is always most important, then the required functionality, and finally response to various fault conditions. During the testing, the user may enter any anomalous input in response to a prompt to verify that the system responds appropriately. We have attempted to optimize for the normal case but accommodate the off-normal conditions as exceptions. This technique allows us to optimize performance for the normal modes of operation and minimize the impact of testing for off-normal conditions.

Response to off-normal conditions is usually a message and a return to the prompt for input. Occasionally, the system will accept what may be considered erroneous input and produce output based on the input. We determined that only those input conditions that actually jeopardize the integrity of the system should be flagged. The "are you sure" questions are minimized.

Completion of the Lenzar Opacity 1000 acceptance test procedure is required as a prerequisite to this test plan. That procedure is titled "Acceptance Procedure for the Lenzpro Opacity 1000 Digitizer Model MO-SS-12-12-C050."

E.3 IMAGE QUALITY VERIFICATION

The image quality verification section of the test procedure describes the image quality test procedures and results required for the acceptance of the LS-FICS.

E.3.1 IMAGE QUALITY TEST PROCEDURE

All of the image quality tests described below shall be performed by using an (MT-1) Image Evaluation Test Target microcopy chart, which can be obtained from Applied Image, Inc., Rochester, New York. The digitizer must first be calibrated by using the "Lenzar Start-up and Calibration Procedure" (Sect. 5.3.2) in the user's guide.

E.3.2 SPATIAL SAMPLING FREQUENCY TEST

The spatial sampling frequency shall be verified by performing the following steps for both the horizontal and vertical axes:

1. Using the "Lenzar Image Acquisition Procedure" (Sect. 5.3.3) in the user's guide, acquire an image of the specified microcopy bar chart with the card oriented such that the 6-in. reference line is parallel to the axis being verified. Build an image in Sun raster file format with a file name in the form, "/temp/filename."
2. Display the image by using "xv" as given in the procedure. After the image appears, zoom in on each of the 6-in. end markers. Zooming is performed by first drawing a window over the desired section of the image holding the middle mouse button. Then, press the right mouse button. A control window will appear. At this point, select the crop button in this panel. The image will be removed except for the selected portion within the window. Select the double-size button repeatedly to enlarge the image section to a desired size.
3. Record the x- and y-pixel locations at the midpoint of the reference mark. This point is the middle pixel between the edges of the reference mark line. The x, y coordinates are displayed by moving the crosshair to the desired spot on the image and pressing the left mouse button. The spacing is determined by subtracting the coordinates of the axis being measured.
4. Verify that the spacing between the reference marks is 3000 ± 3 pixels.

E.3.3 SIGNAL-TO-NOISE RATIO TEST

The following two quantities are to be measured over a 0.25- by 0.25-in. area in the microcopy chart test image by using the white and black reference areas:

1. signal/dark noise = (white mean - dark mean)/standard deviation dark and
2. signal/white noise = (white mean - dark mean)/standard deviation white.

The minimum of the two values above shall be >125 for the 0.25- by 0.25-in. test area located at the center of the image and >100 at other locations within the image.

The following procedure shall be used to measure each mean and standard deviation.

1. Place the microcopy chart on the stage under the glass cover.
2. From the stage window, move the stage so that the white circular portion of the target is centered within the image shown on the monitor window.
3. Perform Exposure and then Gradient from the calibration window.
4. Select "Blue" from the filter wheel window.

5. From the mosaic window select "Capture." Choose "Clear All" from the submenu. Then click once on the upper left square in the monitor window. Next, choose "OK" from the submenu. A single image will be taken.
6. Store the image as a Sun raster file. Open the mosaic window. Select "Sun Raster" in this window. Enter the desired white image file name. Then select "Build Image." A beep will sound when the build operation is complete.
7. Install the lens cap over the lens. Repeat steps 5 and 6 to acquire the dark image. Remove the lens cap.
8. Using analysis software, determine the mean and standard deviation of a 0.25- by 0.25-in. area within both the white and black reference images. These values are used as above to calculate the signal/noise ratios.

E.3.4 CONTRAST TRANSFER FUNCTION TEST

The contrast transfer function (CTF) shall be verified from the test image of the microcopy chart as follows:

1. For spatial frequencies of 1, 2, 4, and 6.3 line pair(s)/mm (lp/mm), calculate the depth of modulation (DOM) as

$$\text{DOM} = \frac{\text{maximum gray value} - \text{minimum gray value}}{\text{maximum gray value} + \text{minimum gray value}} .$$

2. For each of the above spatial frequencies, calculate the CTF as:

$$\text{CTF} = \frac{\text{DOM at specified frequency}}{\text{DOM at 1.0 lp/mm}} .$$

3. Verify that the values obtained for the CTF are greater than or equal to the following:

Spatial frequency (lp/mm)	CTF value
2	0.9
4	0.7
6.3	0.5

E.3.5 GRAY-LEVEL MEASUREMENT

The following procedure shall be used to perform the gray-level measurements:

1. Calibrate the digitizer as directed in the "Lenzar Start-up and Calibration Procedure" (Sect. 5.3.2 of the user's guide).
2. Place the microcopy chart on the stage under the glass cover.
3. Select "Blue" from the filter wheel window.
4. From the stage window, move the stage so that the microcopy chart within the target sheet is centered within the image shown on the monitor window.
5. From the mosaic window select "Capture." Choose "Clear All" from the submenu. Then click once on the upper left square in the monitor window. Next, choose "OK" from the submenu. A single image will be taken.

6. Store the image as a Sun raster file. Open the mosaic window. Select "Sun Raster" in this window. Enter the desired microcopy image file name. Then select "Build Image." A beep will sound when the build operation is complete.
7. Using suitable image analysis software, measure the maximum and minimum gray-level values at 1, 2, 4, and 6.3 lp/mm frequencies on the microcopy chart image.

E.4 AUTOMATIC FINGERPRINT IDENTIFICATION SYSTEM (AFIS) MODE VERIFICATION

The AFIS mode verification test defines a minimum procedure to verify that the base functionality of the AFIS is operational for compressed scans. It verifies image acquisition, host interface, and data path integrity. The image quality is verified by viewing the raw image and the National Institute of Standards and Technology (NIST) file extracted and decompressed segments on the same workstation. The following steps will perform the verification:

1. Logon, calibrate the Lenzar scanner, and start the user interface as described in the user's guide (Sects. 5.3.1 and 5.3.2).
2. In the shell-tool window, move to the read_nist directory and execute the script file containing required aliases by entering

```
% cd /lsfics/read_nist
% source aliases.env.
```

3. Select "AFIS" mode on the LS-FICS menu. Hold the right mouse button down while sliding it to the desired mode. Only the AFIS and AFIS-U (uncompressed) modes should be available.
4. Enter the FBI number (FNU) for the card to be scanned, click accept, and place the card fingerprint side up on the stage. Click "Start" when the card is ready.
5. Verify that the image on the screen is the card scanned. Note the compression ratios listing in the shell-tool window. Compression ratios should be between 9.0 and 15.0. Any ratio >18 probably indicates a focus problem.
6. When the processing is complete (menu prompts for the next card), click to the shell-tool window for verification of the output file.
7. Set up the environment variables for examining the NIST file of compressed images by entering

```
% setenv FGP_DIR $FBI_NIST_DIR
% setenv FGP_FILE fbn.10P_C_NIST ,
```

   where "fbn" is the actual FNU entered when the card was scanned.
8. Verify that the NIST file is accessible by entering

```
% ls -l $FGP_DIR/$FGP_FILE .
```

   Check the date and time to verify that this is the image scanned above.

9. Verify that the print images can be extracted, decompressed, and displayed by entering

```
% view 1
% view 2
.
.
.
% view 10 .
```

Each image should be checked against the card to verify that the images are representations of the scanned fingerprints. The compression algorithm is not lossless, so some degradation in the image is unavoidable. The registration of the form outline with the print is an indication of the need for segmentation calibration. The fingerprint should be centered within the square of the form. Any significant deviation indicates a need for recalibration of the segmentation.

E.5 AFIS UNCOMPRESSED MODE VERIFICATION

The AFIS uncompressed mode verification test defines a minimum procedure to verify that the base functionality of the system is operational for uncompressed scans. It verifies image acquisition, segmentation, and NIST file creation. The image quality is verified by viewing the raw image and the NIST file extracted and decompressed segments on the same workstation. The following steps will perform the verification:

1. Select "AFIS-U" mode on the LS-FICS menu. Hold the right mouse button down while sliding it to the desired mode. Only the AFIS and AFIS-U modes should be available.
2. Enter the FNU for the card to be scanned, click "accept," and place the card print side up on the stage. Click "start" when the card is ready.
3. Verify that the image on the screen is the bottom 75% of the card scanned.
4. When the processing is complete (menu prompts for the next card), click to the shell-tool window for verification of the output file.
5. Set up the environment variables for the NIST file of compressed images by entering

```
% setenv FGP_DIR $FBI_NIST_DIR
% setenv FGP_FILE fbn.10P_U_NIST ,
```

   where "fbn" is the actual FNU entered when the card was scanned.
6. Verify that the NIST file is accessible:

```
% ls -l $FGP_DIR/$FGP_FILE .
```

   Check the date and time to verify that this is the image scanned above.
7. Verify that the print images can be extracted and displayed. The following commands will extract the images from the NIST file, place the individual prints in a Sun raster file and display them:

```
% uview 1
```

```
% uview 2
.
.
.
% uview 10 .
```

Each image should be checked against the card to verify that the images are representations of the scanned fingerprints. Exit the view for each image by selecting "quit" from the OpenWindows frame menu. This menu is displayed by pressing the right mouse button with the pointer on the frame title bar or by pressing the right mouse button anywhere on the image while holding down the "Alt" key.

E.6 CONVERSION UNCOMPRESSED MODE VERIFICATION

The conversion uncompressed mode verification test verifies correct operation for the uncompressed conversion mode. It verifies image acquisition, segmentation, and NIST file creation. The image quality is verified by viewing the raw image and the NIST file extracted segments on the same workstation. The following steps will perform the verification.

1. Exit the LS-FICS application while leaving the LSFIA (low-speed-FICS image acquisition) task running by selecting the "exit" button in the LS-FICS window.
2. Create the environment variable to enable the Image Transmission Network (ITN) modes by entering

   ```
   % setenv ITN_MODES .
   ```

3. Restart the LS-FICS software by entering "scan" in the shell-tool window.
4. Select "CONVERSION-U" mode on the LS-FICS menu. Hold the right mouse button down while sliding it to the desired mode.
5. Enter the FNU for the card to be scanned, click accept, and place the card print side up on the stage. Click "start" when the card is ready.
6. Verify that the image on the screen is the bottom 75% section of the card scanned.
7. When the processing is complete (menu prompts for the next card), click to the shell-tool window for verification of the output file.
8. Set up the environment variables for the NIST file of compressed images by entering

   ```
   % setenv FGP_DIR $FBI_NIST_DIR
   % setenv FGP_FILE fbn.14P_U_NIST ,
   ```

   where "fbn" is the actual FNU entered when the card was scanned.
9. Verify that the NIST file is accessible by entering

   ```
   % ls -l $FGP_DIR/$FGP_FILE .
   ```

   Check the date and time to verify that this is the image scanned above.

10. Verify that the print images can be extracted and displayed. The following commands will extract the images from the NIST file, place the individual prints in a Sun raster file, and display them:

```
% uview 10
% uview 11
.
.
% uview 14 .
```

Each image should be checked against the card to verify that the images are representations of the scanned fingerprints. Exit the view for each image by selecting "quit" from the OpenWindows frame menu. This menu is displayed by pressing the right mouse button with the pointer on the frame title bar or by pressing the right mouse button anywhere on the image while holding down the "Alt" key.

E.7 END-TO-END MODE VERIFICATION

The end-to-end mode verification test defines a minimum procedure to verify base functionality of the system in modes requiring scanning of both card sides. It verifies image acquisition, and NIST file creation. The image quality is verified by viewing the raw image, and the NIST file extracted and decompressed segments on the same workstation. The following steps will perform the verification:

1. Select "end-to-end" mode on the LS-FICS menu. Hold the right mouse button down while sliding it to the desired mode.
2. Enter the process control number (PCN) for the card to be scanned, click "accept," and place the card print side up on the transport. Click "start" when the card is ready.
3. Verify that the image on the screen is the card scanned by checking the PCN in the upper right corner for the appropriate identification number.
4. Turn the card over and click "accept" on the menu when instructed to do so.
5. Verify that the back-side image displayed is from the card scanned.
6. When the processing is complete (menu prompts for the next card), click to the shell-tool window for verification of the output file.
7. Set up the environment variable for NIST file of compressed images by entering

```
% setenv FGP_DIR $PCN_NIST_DIR
% setenv FGP_FILE pcn.NIST ,
```

where "pcn" is the actual PCN entered when the card was scanned.

8. Verify that the NIST file is accessible by entering

```
% ls -l $FGP_DIR/$FGP_FILE .
```

Check the date and time to verify that this is the image scanned above.

9. Verify that the print images can be extracted, decompressed, and displayed by entering

```
% view 9
% view 10
.
.
.
% view 16 .
```

Recall that positions 15 and 16 represent the card front and card back text respectively. Each image should be checked against the card to verify that the images are representations of the scanned prints. The compression algorithm is not lossless, so some degradation in the image is unavoidable. The registration of the form outline with the print is an indication of need for segmentation calibration.

E.8 CARD-SCAN MODE VERIFICATION

The card-scan mode scans cards into a different storage area on the disk so that they can be moved later (in emulator mode) into the actual image directory. For the card-scan mode verification test, execute the same procedure as above except the FGP_DIR environment variable set in step 7 is set to the temporary directory used for scanned cards:

```
% setenv FGP_DIR $PCN_ARC_DIR
% setenv FGP_FILE pcn.NIST .
```

The PCN entered at the scan is used as the file name in the environment variable set here.

E.9 EMULATOR MODE VERIFICATION

The emulator mode does not use the transport; it moves files from the temporary storage area, $PCN_ARC_DIR, to the card image area, $PCN_NIST_DIR, for further processing. To test this mode, select the mode, select the time period for the transfer operation, and wait for completion. Note that all the files scanned in card-scan mode will be transferred. To verify the transfer, execute the following commands in the shell-tool window:

```
% ls -l $PCN_ARC_DIR
% ls -l $PCN_NIST_DIR
```

before and after execution of the emulator mode. Verify that the card images scanned in the card-scan mode above moved from the first area to the second.

E.10 CONVERSION MODE VERIFICATION

The conversion mode involves the transfer of the image file, containing only card-front fingerprint images, to tape and back again. The records contain no text images, so no access above position 14 will be available. The conversion mode verification test varies from the end-to-end verification in the setting of the environment variables:

```
% setenv FGP_DIR $FBI_NIST_DIR
% setenv FGP_FILE fbi.NIST .
```

The FNU entered at the scan is the file name used in the environment variable above. After the cards are scanned, they are moved to tape as described below.

The following procedure is used to archive all *NIST files in the directory specified by the FBI_NIST_DIR environment variable to the 8-mm tape in TAR format. The files are deleted after they are archived.

1. Place a tape in the 8-mm drive. The write-protect tab must be in the right-hand position to allow writing to the cartridge. The button on the lower left front of the drive is used to open the drive.
2. Type the command "NIST_archive" in the command window. This command will cause the file to be archived to tape. Messages will be displayed in the command window as the files are archived to tape.
3. Use the "tapetool" utility to verify that the files are on the tape. See the Sun-supplied documentation for details on using "tapetool."
4. When the operation has completed, remove the tape from the drive.
5. Once all files have transferred successfully, the disk files can be deleted with the following command:

   ```
   % r -f *NIST .
   ```

   To retrieve the test files from the tape, move to the proper directory by entering

   ```
   % cd $FBI_NIST_DIR ,
   ```

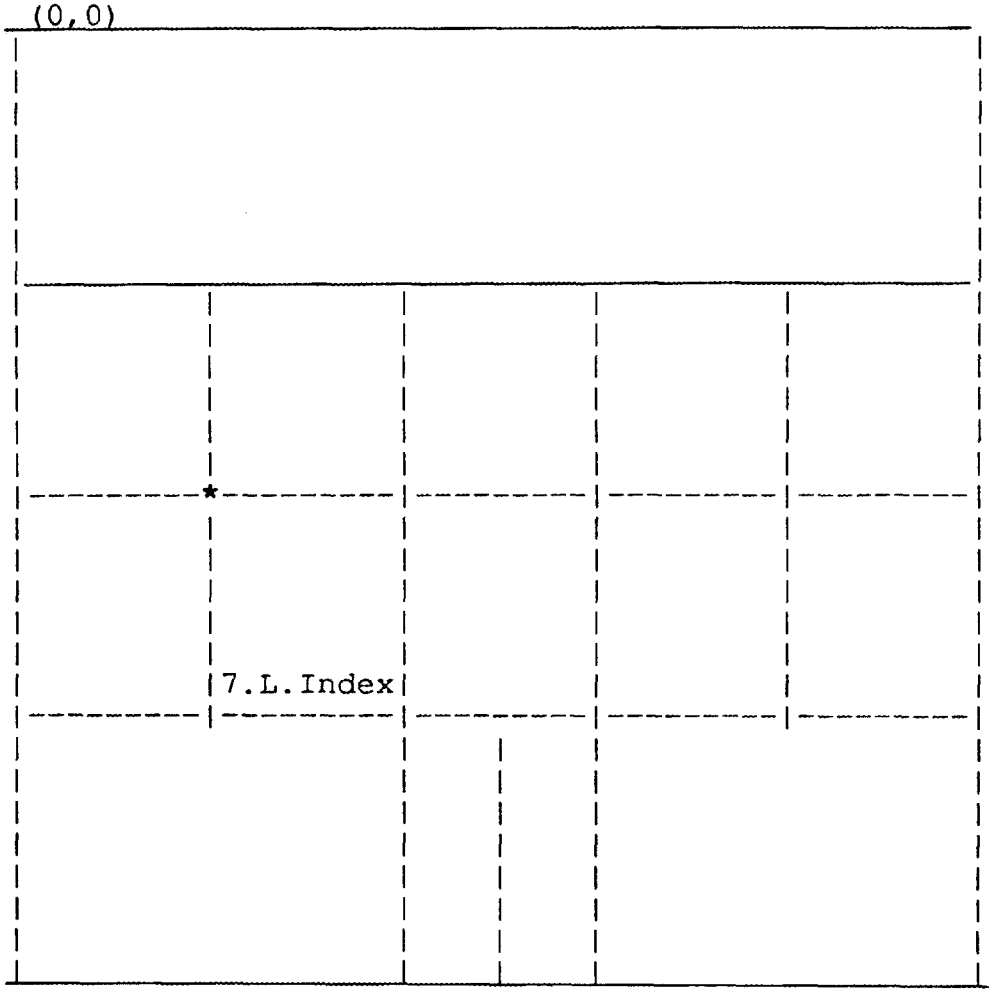
   so that the retrieved files will be in the proper directory. Activate the "tapetool" utility by typing "tapetool." Select the "props..." option to change the default device to the required "/dev/rst1" and select apply. The "list" option lists the available files on the tape. Selecting the file desired causes it to be copied back into the FBI_NIST_DIR area for subsequent viewing. An option under "read" allows all files to be selected. Use the "view" or "uview" command to verify the integrity of the images retrieved from the tape. The images should match the fingerprint images from the card with the FNU that matches the file name retrieved.

E.11 FAULT HANDLING VERIFICATION

The fault handling verification test forces certain faults to verify that the system responds predictably under these fault conditions. This test consists of executing the tests above but entering erroneous input at the menu selections. The tester should hit return at various times and verify that nothing happens that would seriously alter the output files.

The power fail test involves the unexpected interruption of power from the system. The system should recover from the power outage within 15 minutes (including the memory test) after the power has been restored.

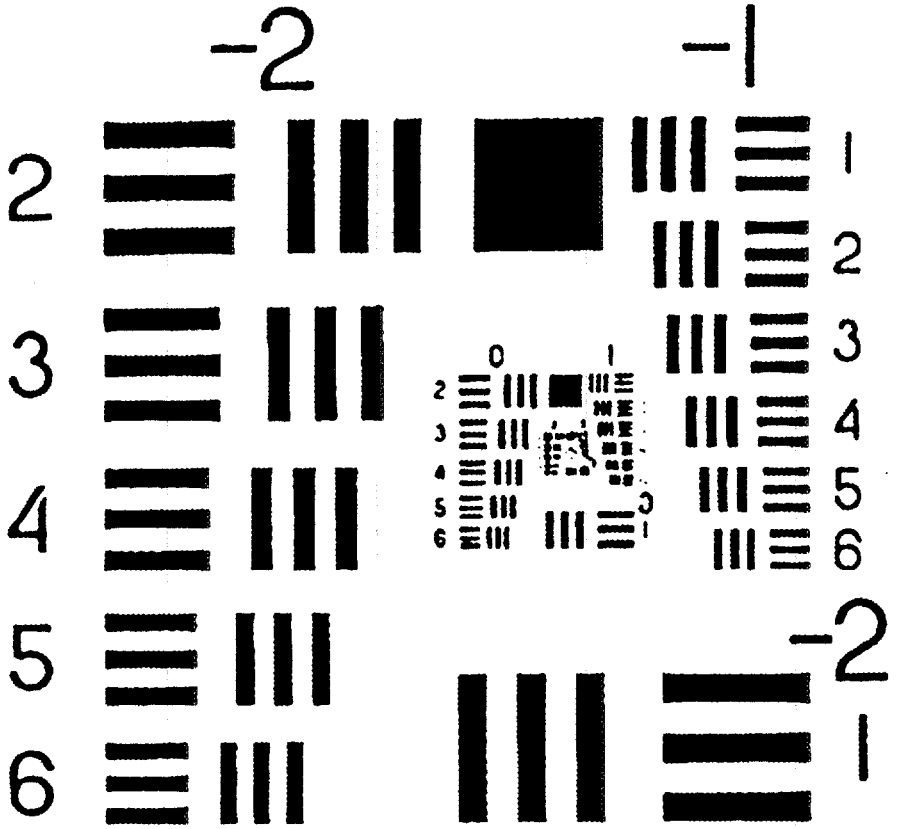
Appendix F. LOW-SPEED FINGERPRINT IMAGE CAPTURE SYSTEM SEGMENTATION CALIBRATION REFERENCE SELECTION



* Measurement point

Fig. F.1. Low-Speed Fingerprint Image Capture System segmentation calibration reference selection.

Appendix G. AIR FORCE TEST TARGET



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Appendix H. LOW-SPEED FINGERPRINT IMAGE CAPTURE SYSTEM SOFTWARE INSTALLATION AND SETUP

This appendix describes how to install and configure the necessary software on the Low-Speed Fingerprint Image Capture System (LS-FICS) Sun workstation. The information is intended for use when it is necessary to reinstall all system software or to duplicate the system. This appendix was created without access to the LS-FICS system, so the information should be used as guidelines only and is intended for use by experienced Sun system managers.

Several software components are needed in addition to SunOS for the LS-FICS application. These components include

- Sonitech Spirit30 DSP board support software,
- Lenzar LP2000 software, and
- Oak Ridge National Laboratory- (ORNL-) developed LS-FICS software.

The Lenzar, Sonitech, and ORNL-developed software was delivered with the system on 8-mm tape. The Lenzar 0.25-in. tape software distributions were also delivered with the system. The Lenzar software is installed in the LS-FICS directory and is included on the LS-FICS tape.

Disk partition information was included in the system log of the delivered system. If the disks are repartitioned, the new partition information should be documented in the system log.

A brief description of the steps necessary to install and configure the workstation software for the LS-FICS are given in Table H.1.

Table H.1. Low-Speed Fingerprint Image Capture System (LS-FICS) software installation

Step	Description
1	Install the SunOS as described in the Sun documentation. The system must be configured to support asyncronous input/output and include the components to support SunView and OpenWindows development. Because the LS-FICS application uses about 64 MB of swap space for a temporary file system, about 192 MB of total swap space is needed.
2	Install the digital signal processing (DSP) board support software by restoring the /usr/local/c30 and /usr/local/spirit30 directories from 8-mm tape.
3	Execute the DSP board installation procedure as directed by the vendor's documentation.
4	Restore the /lsfics directory tree from 8-mm tape by using the UNIX "TAR" utility.
5	Perform the LP2000 software installation procedure given in the "Lenzpro 1000 Fingerprint Digitizer" documentation, except it is not necessary to restore the software from tape, because this was done in step 4.
6	Perform the steps necessary to support the Exabyte 8505 tape drive as described in the National Peripherals, Inc., document "Sun Computer Helical Scan Tape Subsystem Installation Guide."

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