American National Standard

for information systems –

fingerprint identification – data format for information interchange

ANSI/NBS-ICST 1-1986

american national standards institute, inc.
1430 broadway, new york, new york 10018

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American National Standard for Information Systems –

Fingerprint Identification – Data Format for Information Interchange

Sponsor

Institute for Computer Sciences and Technology of the National Bureau of Standards

Approved August 25, 1986

American National Standards Institute, Inc

American National Standard

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FOREWORD (This Foreword is not a part of the American National Standard ANSI/NBS-ICST 1-1986.)

Law enforcement and criminal justice agencies are increasing the use of automated fingerprint identification systems to determine the personal identity of subjects under their jurisdiction. These systems typically scan and digitize fingers or fingerprint images. The digitized representations of the fingerprints are processed and information about selected features is extracted. These data are then automatically compared with corresponding data elements from subjects contained in a file maintained by the agency to determine whether or not a candidate match occurs. Any candidate match is then subjected to verification by visual examination of the fingerprint images by a qualified fingerprint examiner.

This standard provides methods for agencies that use automatic fingerprint identification systems obtained from different suppliers to exchange fingerprint information. The standard provides for the exchange of any combination of descriptive textual information, extracted feature (minutiae-based) information, or fingerprint image information for direct input to a remote automated fingerprint identification system processor.

The Institute for Computer Sciences and Technology of the National Bureau of Standards sponsored the development of this standard using the canvass method to demonstrate evidence of consensus. The principal authors of the standard were R. M. McCabe and R. T. Moore.

This standard was approved as an American National Standard by ANSI on August 25, 1986.

Suggestions for improvement of this standard will be welcome. They should be sent to National Bureau of Standards, ICST, Bldg. 225/ Rm. A216, Attn. Fingerprint Standards, Gaithersburg. MD 20899.

The following organizations recognized as having an interest in the standardization of the data format for the interchange of fingerprint information were contacted prior to the approval of this standard. Inclusion in this list does not necessarily imply that the organization concurred with the submittal of the proposed standard to ANSI.

Alaska Department of Public Safety
Anchorage Police Department
Arvin Calspan
Baltimore Police Department
California Department of Justice,
    CAL-ID
    Criminal Identification and Information Branch
    Latent Print
Chicago Police Department
Colorado Bureau of Investigation
De La Rue Printrak, Inc
Delaware State Police
Ektron Corporation
Fairfax County, Virginia Police
Federal Bureau of Investigation,
    National Academy
    Identification Division
Fingermatrix, Inc
Florida Department of Law Enforcement
Florida Metro-Dade Police Department Records and Identification Bureau
Georgia Crime Information Center
Home Office, London, England
Houston, Texas Police Department,
    Data Processing
    Latent and Ten Print
Identification and Security Systems, Inc
Identix, Inc
Information Systems Engineering
International Association of Chiefs of Police, Inc
International Association for Identification
Logica Space and Defense Systems Limited
Los Angeles Police Department
Maryland Department of Public Safety and Correctional Services
Minnesota Bureau of Criminal Apprehension
Morpho Systems
NEC Information Systems, Inc
New York City Police Department
New York State Criminal Justice Services
Prince George's County, Maryland Police Department
Puerto Rico Police
Royal Canadian Mounted Police
San Jose, California Police Department
San Francisco, California Police Department,
    Criminal Information Division
    Crime Laboratory
Sao Paulo, Brazil Police Department
Search Group, Inc
Thomas De La Rue Industries Graficas, Sao Paulo, Brazil
U.S. Postal Service
U.S. Secret Service
Virginia State Police,
    Department of Information Technology
    Records and Statistics
Wayne County, MI, Office of Prosecuting Attorney

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Fingerprint Identification – Data Format for Information Interchange

1. Scope and Purpose

This standard defines the content, format, and units of measure for reporting a subject's descriptive data and fingerprint information that is intended for interchange between administrations or organizations using different types of automated or semiautomated fingerprint identification systems. Such systems may record and utilize data having content, format and units of measure as defined in this standard. Alternatively, they may record and use the fingerprint information in any format if facilities and software are provided to convert the information to and from the format they use and the format defined in this standard. The information interchanged in accordance with this standard shall be limited to descriptive text information, digitized fingerprint image data, and geometric fingerprint minutiae information that is entered by an operator or observed and detected by the source fingerprint reading equipment. This information is intended to serve as input for automated or semiautomated fingerprint identification systems at locations other than the one having possession of the fingerprint card, which is the source of the information.

2. Referenced Standards and Publications

2.1 American National Standards. This standard is intended to be used in conjunction with the following American National Standards. When these standards are superseded by revisions approved by the American National Standards Institute, Inc, the revisions shall apply.

ANSI X3.4-1986, Information Systems — Coded Character Sets — 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII)

ANSI X3.27-1978, Magnetic Tape Labels and File Structure for Information Interchange

ANSI X3.39-1986, Information Systems — Recorded Magnetic Tape for Information Interchange (1600 CPI, Phase Encoded)

ANSI X3.54-1986, Information Systems — Recorded Magnetic Tape for Information Interchange (6250 CPI, Group-Coded Recording)

2.2 Other Standards. This standard is also intended to be used with International Standards for Information Processing — ISO 7-Bit Coded Character Set for Information Interchange, ISO 646-1983.[1]

2.3 Other Publications. National Crime Information Center (NCIC) Code Manual. Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 1984.[2]

3. File Description

This standard defines a logical file that may contain from one to four different types of logical records pertaining to a single subject. Each type of logical record is given a type

[1] Available from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

[2] Available from the U.S. Department of Justice, Federal Bureau of Investigation, 10th and Pa. NW, Washington, DC 20535.

number. The Type-1 record contains information about the transaction that the file is to be used for and a listing of the type of logical records contained in the file. It also contains the identification of the agency that prepared the file and textual descriptive information about the subject. A Type-1 record, which is required for each subject, contains certain fields of information in which entries are mandatory. Type-2 records contain minutiae data and related information about a single finger. There may be up to 10 of these Type-2 records in a file, each of which is for a different finger. Type-3 records contain low resolution image data. There may be up to 10 of these Type-3 records in a file, each of which is for a different finger. Type-4 records contain high resolution image data, each from a single finger. There may be up to 10 of these Type-4 records in a file, each of which is for a different finger. The use of Type-2, Type-3, and Type-4 records is optional. Type-3 and Type-4 records may be from the same or different fingers as the Type-2 records in the file.

3.1 File Contents. A single Type-1 logical record shall be present for each subject, while 0 to 10 Type-2, Type-3, or Type-4 logical records may be formed for each subject, depending on both the number of fingerprints available for processing, and the options that are selected. For each Type-1 and Type-2 record that is formulated, the fields contained within that record shall be numerically ordered.

A logical file shall contain information relating only to a single individual. For additional individuals, new logical files shall be generated.

3.2 File Format. The descriptive data on a subject, the minutiae data from that subject's fingerprint(s) and the image data from that subject's fingerprint(s) may be contained within a single logical file. All descriptive and minutiae-related information and certain descriptors of image data records shall be recorded in variable length fields using the 7-bit American National Standard Code for Information Interchange (ASCII) as described in ANSI X3.4-1986 and Appendix B. The data in Type-3 and Type-4 records are recorded in binary. Details concerning the physical format of this file appear in section 13.

3.2.1 Logical Record Types. Each logical file shall be viewed as consisting of at least one but not more than 31 logical records, with each record pertaining to the same subject. These logical records may be one of four types. A Type-1 record, the first logical record, shall provide information about the type of transaction involved, the contents of the file, and the originator or source of the physical record. Identification and descriptive information about the subject of the fingerprint information is also contained in this record. All Type-2 logical records shall contain geometric and topological minutiae-based fingerprint information. Type-2 records represent processed image data from which the location and orientation descriptors of extracted minutiae characteristics are listed. Each of these Type-2 logical records shall contain the minutiae data read from a single

fingerprint.

Type-3 and Type-4 records represent the image data that have received a lesser amount of processing. These records differ from each other only in the resolution at which the image was read. Type-3 logical records shall contain image data at a nominal resolution of 10 pixels per millimeter and Type-4 records shall contain image data at a nominal resolution of 20 pixels per millimeter. Each of the Type-3 and Type-4 records shall contain data from a single fingerprint.

From the data in either of these Type-3 or Type-4 records, it would be possible to reconstruct the fingerprint image, whereas it would not be possible to do this with a Type-2 record. These two record types may be viewed as being closer to the raw fingerprint data than a Type-2 record.

3.2.2 Impression Association Number. From the above, it can be seen that up to three logical records may be generated in a logical file for the same single fingerprint impression or direct reading of a fingerprint. In order to relate these logical records to each other, an Impression Association Number (IAN) shall be included in each logical record. As a logical file can contain no more than 10 unique impressions (one from each finger) for the same individual, the IAN within a logical file shall range from 0 to 9. The IAN assigned to each impression shall be the finger position number from Table 11 if the finger position is known. If the finger position is not known, the IAN should be the most likely finger position or it may be assigned a number arbitrarily. Each Type-2, Type-3, or Type-4 logical record generated from the same impression shall carry with it the same IAN, thereby providing a cross reference between these records of the same impression.

3.3 Record Format.

For each type of logical record, several information fields shall be present. Data entries within information fields may be further subdivided into information items that are used to convey different aspects of the data contained in that field.

3.3.1 Information Separators. In the Type-1 and Type-2 records, mechanisms for delimiting information items within a field, fields within a logical record, and multiple occurrences of certain of these data and logical records are implemented by use of the four ASCII (ISO) information separators. These characters are used to separate and qualify information in a logical sense. Viewed in a hierarchical relationship, the File Separator (FS) is the most inclusive and it is used to separate logical records. This is followed by the Group Separator (GS), the Record Separator (RS), and finally the Unit Separator (US). Table 1 lists these ASCII separators, the ISO mnemonics, the column/row position in the ASCII table, and a description of their use within this standard.

The four characters shall be used only as separators of data items, and only one of them may be used between any two data items. A US character can never immediately precede an RS character. An RS cannot immediately precede a GS, nor a GS immediately precede an FS character. Appendixes C and D illustrate the use of these information separator

Table 1: Information Separators

ASCII	ISO	Pos.	Description
FS	IS4	1/12	Separates logical records of a physical record.
GS	IS3	1/13	Separates fields of a logical record.
RS	IS2	1/14	Separates multiple data entries (subfields) of an information field.
US	IS1	1/15	Separates individual information items of the field or subfield.

characters.

These separators shall be in addition to any other symbols, punctuation, or delimiters as specified in this standard.

3.3.2 Record Layout. For Type-1 and Type-2 records, which shall be recorded in ASCII, each information field that is used shall be numbered in accordance with this standard. The format of each field shall consist of a field number followed by a colon (:), followed by the information item(s) appropriate to that field. Subfields within a field shall be separated by the RS character. Individual information items within a field or subfield shall be separated by the US character except in fields where Federal Bureau of Investigation, National Crime Information Center (NCIC) protocols are applicable.

In addition to the identifying number, information fields shall be separated from other information fields by the ASCII control character, Group Separator, GS.

Where the information for any field is not available, or not applicable, that field shall be omitted.

Type-3 and Type-4 records shall be recorded as four ordered binary fields. The first three fields containing identification data shall be of fixed length, while the fourth field containing scan data shall be of the length as specified in the Type-1 record. In contrast to the Type-1 and Type-2 records, neither the field identifier number, nor its following colon shall be used in Type-3 or Type-4 records. Furthermore, as all the field lengths of these two records are either fixed or specified, none of the four separator characters (US, RS, GS, or FS) shall be interpreted in any Type-3 or Type-4 record.

Table 2: Minutia Types

Type	Description
A	Ridge Ending
B	Bifurcation
C	Compound (Trifurcation or Crossover)
D	Type Undetermined

4. Fingerprint Information Descriptors

4.1 Minutia Type Identification. This standard defines four identifier characters that are used to describe the type of any minutia. These are shown in Table 2. A ridge ending is designated Type A. It occurs when a friction ridge comes to an end, or terminates, within the fingerprint and without splitting into two or more continuing ridges. A bifurcation, designated Type B, occurs when a ridge divides, or splits and forms two ridges that continue on past the point of division for a distance that is at least equal to the spacing between adjacent ridges at the point of bifurcation. A minutia is designated Type C, a compound type, when it is either a trifurcation (a single ridge that splits into three ridges) or a crossover (two ridges that intersect). When a minutia is not, or cannot, be clearly categorized as one of the above three types, it shall be classed as undetermined, Type D.

4.2 Minutia Numbering. Each minutia in the fingerprint shall be identified by assigning it an arbitrary index number. The numbering shall begin at one and be incremented by one for as many times as there are minutiae. This allows each minutia to be uniquely identified.

4.3 Ridge Counts. Ridge counts may be made from each minutia in a fingerprint to certain other minutiae. When this occurs, ridge counts between designated minutiae are associated with the applicable index numbers so as to ensure maintenance of the proper relationships.

4.4 Minutia Coordinate System. The relative position of minutiae entered in Type-2 records shall be expressed as positive integers in units of 0.01 mm in a Cartesian

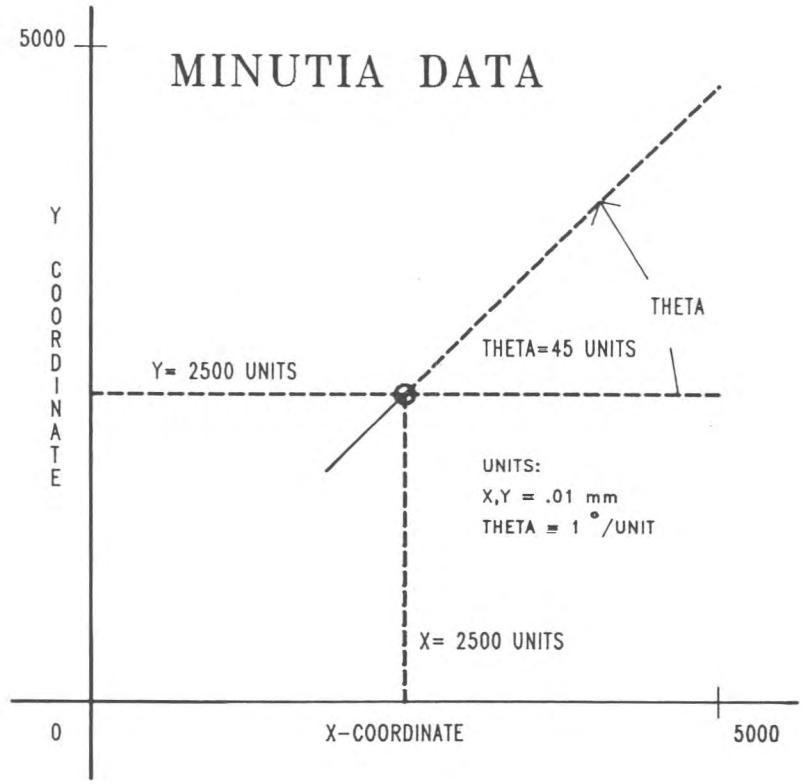

Figure 1
Minutia Coordinate System

coordinate system located in Quadrant 1. In this coordinate system, values of X increase from left to right and values of Y increase from bottom to top. Values of both X and Y are equal to or greater than "0000" and are typically less than "5000". If the conversion to this coordinate system is from a system that normally centers the fingerprint image during the registration process, that center position shall be assigned the value, X = 2500, Y = 2500. Figure 1 illustrates the defined coordinate system.

The exact features or characteristics of a minutia that are used to establish its position

are system dependent and outside the scope of this standard.

The relative orientation, Theta, of a ridge ending, a bifurcation, or a minutia of undetermined type shall be expressed as positive integers in units of degrees. Theta is the angle between the horizontal axis of the coordinate system and the direction that a ridge ending points, assuming that a ridge ending is analogous to a pointing finger. A ridge ending that is formed by a ridge lying parallel to the X axis, and ending in the direction of increasing values of X, has an orientation of zero degrees. Counterclockwise rotation of this ridge about the ridge ending causes the value of Theta to increase.

A bifurcation may be converted to a ridge ending by logical inversion, i.e., transposing the identity of ridges and valleys. The orientation of a bifurcation is expressed as if this inversion had occurred. This convention causes no significant change in the orientation of a minutia if it appears as a ridge ending in one impression of a fingerprint and as a bifurcation in another impression of the same fingerprint.

No orientation shall be assigned to compound minutiae; however, a value of "000" shall be entered for Theta in the Type-2 logical record entry.

The exact features or characteristics of a minutia that are used to establish its orientation are system dependent and outside the scope of this standard.

5. Fields for Type-1 Logical Records

In the following description of fields for the Type-1 logical records, the use of any field is optional except those that have been specifically designated as mandatory. Where any field covers a descriptive item that is identical to a National Crime Information Center (NCIC) descriptive item, the entries for that field shall comply with the abbreviations and formats shown in the NCIC code manual.[2] However, the RS separators may be used in place of periods to separate entries in subfields.

5.1 Field 1. Transaction Type. This field is mandatory and shall always be used. Numeral "1" is followed by a colon and a single character selected from Table 3 designating the type of transaction and processing that this logical file should be given. If more than one transaction identifier is appropriate, then each identifier should be separated from the next by the RS separator character. For example, the identifiers B, C, or N would normally be used in conjunction with the L or T search identifiers to indicate the disposition of the transaction records. The last character of this field shall be a GS separator character used to separate Field 1 from the next field.

Table 3: Transaction Types

Identifier	Transaction Description
A	File addition - no search required
B	Add to file if no hit made
C	Add to File
E	Expungement - delete existing record
L	Latent search - report results
N	Do not add to file
T	Ten print search - report results
U	Update existing record with this new or improved data
X	Transaction type defined by user agreement

5.2 Field 2. File Content. As the second mandatory field of the Type-1 record, Field 2 lists each of the logical records in the logical file by record type, record length, and its IAN. Equal IANs signify different logical records from the same fingerprint impression. The field begins with the numeral "2" followed by a colon to indicate Field 2. The remainder of the field shall consist of one or more subfields. Each subfield shall contain information items describing a single logical record found in the current logical file. The subfields shall be entered in the same order in which the logical records will be ordered. The RS separator character shall be entered between subfields.

The first subfield of Field 2 shall describe the current Type-1 record. It shall be comprised of three information items. The first information item shall be a "1" to indicate that this subfield describes a Type-1 record. The second information item shall be the length of this Type-1 logical record expressed as the total number of bytes, including every character in the record. The third and final information item shall be the total count of the Type-2 plus Type-3 plus Type-4 records contained in this logical file. This number is also equal to the count of the remaining subfields of Field 2. The US separator character shall be entered between the first and second information items, and between the second and third information items.

The remaining subfields of Field 2 shall each be comprised of three information items. The first information item shall be a single character chosen from Table 4, which states the record type. The second information item shall be the length of the logical record expressed as the number of bytes contained in the record. The third and final information

Table 4: Logical Record Types

Identifier	Logical Record Description
1	Descriptive text
2	Minutiae data
3	Low resolution image data
4	High resolution image data

item shall contain the appropriate IAN of that logical record. The US character shall be used to separate the information items.

As stated previously, a logical file shall contain one Type-1 record of general information about the subject of the data and the fingerprint impression(s). For each fingerprint impression (either inked or direct), a single Type-2, or Type-3, or Type-4 logical record, or any combination of these logical records may also be present. Therefore, as many as three logical records may be recorded for each fingerprint. When this is the case, the IAN of each of these logical records shall be the same.

The GS character shall separate the last subfield of Field 2 from the next field.

NOTE: Although it may not always be explicitly repeated in the remainder of this standard, *certain rules for the use of separators within Type-1 and Type-2 records shall always be observed.* Multiple information items within a field or subfield shall be separated by the US separator, multiple subfields shall be separated by the RS separator, and information fields shall be separated by the GS separator.

5.3 Field 3. Parameters of the Type-3 Record. This field is mandatory when one or more Type-3 records (image data scanned at approximately 10 pixels/mm) are included in the current file. Five information items are required to be present in this field. These are data quantization (5.3.1), scan pixels per 100 mm (5.3.2), scan sequence (5.3.3), image size (5.3.4), and the data compaction algorithm (5.3.5). The US separator character shall be used between each of these information items within the field.

The parameters of this field are used to describe the record created from a normal inked rolled fingerprint impression on a fingerprint card. Such an impression has black ridges on a white background with the tip of the finger pointing upward. Horizontal scan lines will be approximately parallel to the flexion crease and vertical scan lines will run approximately perpendicular to the crease in such a fingerprint impression. All of the Type-3 records in a file shall use the same parameters as stated in this field. Those records

Table 5: Storage Requirements

Gray Bits/Pixel	Pixels/Byte	Bytes/Pixel
2	4	1/4
3-4	2	1/2
5-8	1	1
9-16	1/2	2

with differing scanning parameters shall be in different logical files.

5.3.1 Data Quantization. The data quantization item is the first information item of Field 3. The entry is a value from 0 to 16 and this value identifies the image as being either thinned binary "skeletal", unthinned binary, or gray scale. An entry of "0" represents a binary image in which ridges have been thinned to a single pixel in width. An entry of "1" represents a binary image where the ridges have not been thinned. For either type, the image data are represented as 8 pixels per byte. The pixels appear in the byte from left (most significant bit) to right (least significant bit) in the same sequence that they were scanned. A pixel having a value of "0" indicates a ridge or black area, while a "1" represents a valley, groove, or white area.

An entry value from 2 to 16 indicates that the image contains gray scale data in which each pixel of the data is quantized to the number of bits of the entry value. The packing and encoding of this data shall be in accordance with Table 5.

The pixels appear in the byte in the same sequence that they were scanned. The entry "2" specifies that four pixels shall be packed in a single byte. However, an entry of "3" in this field specifies that only two pixels shall be packed in a single byte. Each three-bit pixel shall be stored as if it were a four-bit pixel with the left bit zero filled and the 3 data bits right justified. When 5 to 7 bits of quantization are used for each pixel, those data bits shall be right justified in the bytes with the 1 to 3 leftmost (most significant) bits of the bytes zero filled. Similarly, when 9 to 15 bits of quantization are used, each pixel shall require 2 bytes of storage, with those 9 to 15 data bits being right justified in 2 bytes with the leftmost 1 to 7 bits zero filled. When 2 bytes are used to represent a pixel, the first byte in the sequence is the most significant one.

For gray scale images, the higher the gray scale number, the whiter the image. Pixels at the center of a valley shall have higher gray scale values than pixels in the center of a ridge.

5.3.2 Scan Pixels per 100 Millimeters. The second information item in Field 3 shall state the exact number of pixels per 100 mm and shall use four digits to represent

this value to the nearest integer. This permits reconstruction of a Type-3 image to scale.

5.3.3 Scan Sequence. The third information item in Field 3 is the scanning sequence. This requires a four-digit entry. The first digit is "0" if the initial scan is vertical (up or down a column) and it is "1" if it is horizontal (across a row). The second digit is "0" if the row scan is left to right and "1" if it is right to left. The third digit is "0" if the column scan is top to bottom and "1" if it is bottom to top. The fourth digit is "0" if the pixel arrangement is "square" (pixels on two adjacent rows are directly below each other) and "1" if the pixel arrangement is "hexagonal" (pixels on adjacent rows staggered by one half of a sample step).

5.3.4 Image Size. The fourth information item in Field 3 is the image size in units of pixels. Three digits shall be used to indicate the number of pixels in a row. These shall be followed by the character "X" and 3 more digits indicating the number of rows in a column.

Although, the entries made to indicate the number of pixels in each row and column shall be the exact number of pixels scanned, the amount of storage required to contain the data from the initial scan line (and each subsequent scan line) shall be an integral number of bytes. If the combination of the quantization used and the number of pixels in the initial scan do not result in an integral number of bytes, then the data in the last byte of each scan line shall be left justified and zero filled.

5.3.5 Data Compaction Algorithm. The fifth and final information item in Field 3 is a single character code that identifies any data compaction algorithm used on the Type-3 record data. A "0" shall be entered if no data compaction is used. Any compaction algorithm that is used prior to the adoption of data compaction standards for fingerprint image data[3] shall be mutually agreed upon between the sender and the recipient of the data.

5.4 Field 4. Parameters of the Type-4 Record.

This field is mandatory when one or more Type-4 records (image data scanned at approximately 20 pixels/mm) are included in the current file. Five information items are required to be present in this field. These are data quantization (5.4.1), scan pixels per 100 mm (5.4.2), scan sequence (5.4.3), image size (5.4.4), and data compaction algorithm (5.4.5). The US separator character shall be used between each of these information items within the field.

The parameters of this field are used to describe the record created from a normal inked rolled fingerprint impression on a fingerprint card. Such an impression has black ridges on a white background with the tips of the finger pointing upward. Horizontal scan lines will be approximately parallel to the flexion crease and vertical scan lines will run approximately perpendicular to the crease in such a fingerprint impression. All of the

[3]These standards are currently under development. Contact the sponsor for current information about availability.

Type-4 records in a file shall use the same parameters as stated in this field. Those records with differing scanning parameters must be in different logical files.

5.4.1 Data Quantization. The data quantization item is the first information item of Field 4. The entry is a value from 0 to 16 and this value identifies the image as being either thinned binary "skeletal", unthinned binary, or gray scale. An entry of "0" represents a binary image in which ridges have been thinned to a single pixel in width. An entry of "1" represents a binary image in which the ridges have not been thinned. For either type, the image data are represented as 8 pixels per byte. The pixels appear in the byte from left (most significant bit) to right (least significant bit) in the same sequence that they were scanned. A pixel having a value of "0" indicates a ridge or black area, while "1" represents a valley, groove, or white area.

An entry value from 2 to 16 indicates that the image contains gray scale data in which each pixel of the data is quantized to the number of bits of the entry value. The packing and encoding of this data shall be in accordance with Table 5. The pixels appear in the byte in the same sequence that they were scanned. The entry "2" specifies that four pixels shall be packed in a single byte. However, an entry of "3" in this field specifies that only 2 pixels shall be packed in a single byte. Each three-bit pixel shall be stored as if it were a four-bit pixel with the left bit zero filled and the 3 data bits right justified. When 5 to 7 bits of quantization are used for each pixel, those data bits shall be right justified in the bytes with the 1 to 3 leftmost (most significant) bits of the bytes zero filled. Similarly, when 9 to 15 bits of quantization are used, each pixel shall require 2 bytes of storage, with those 9 to 15 data bits being right justified in 2 bytes with the leftmost 1 to 7 bits zero filled. When 2 bytes are used to represent a pixel, the first byte in the sequence is the most significant one.

For gray scale images, the higher the gray scale number, the whiter the image. Pixels at the center of a valley shall have higher gray scale values than pixels in the center of a ridge.

5.4.2 Scan Pixels per 100 Millimeters. The second information item in Field 4 shall state the exact number of pixels per 100 mm and shall use four digits to represent this value to the nearest integer. This permits reconstruction of a Type-4 image to scale.

5.4.3 Scan Sequence. The third information item in Field 4 is the scanning sequence. This requires a four-digit entry. The first digit is "0" if the initial scan is vertical (up or down a column) and it is "1" if it is horizontal (across a row). The second digit is "0" if the row scan is left to right and "1" if it is right to left. The third digit is "0" if the column scan is top to bottom and "1" if it is bottom to top. The fourth digit is "0" if the pixel arrangement is "square" (pixels on two adjacent rows are directly below each other) and "1" if the pixel arrangement is "hexagonal" (pixels on adjacent rows staggered by one half of a sample step).

5.4.4 Image Size. The fourth information item in Field 4 is the image size in units of pixels. Three digits shall be used to indicate the number of pixels in a row. These

shall be followed by the character "X" and three more digits indicating the number of rows in a column.

Although, the entries made to indicate the number of pixels in each row and column shall be the exact number of pixels scanned, the amount of storage required to contain the data from the initial scan line (and each subsequent scan line) shall be an integral number of bytes. If the combination of the quantization used and the number of pixels in the initial scan do not result in an integral number of bytes, then the data in the last byte of each scan line shall be left justified and zero filled.

5.4.5 Data Compaction Algorithm. The fifth and final information item in Field 4 is a single character code identifying any data compaction algorithm used on the Type-4 record data. A "0" shall be entered if no data compaction is used. Any compaction algorithm that is used prior to the adoption of data compaction standards for fingerprint image data shall be mutually agreed upon between the sender and the recipient of the data.

5.5 Field 5. Formatting Agency Identifier.

This field is mandatory and shall always be included. This field shall contain the identification of the administration or organization that read the fingerprint(s) and converted the fingerprint information to the standardized format in this record and who has in its possession the fingerprint images that were used to produce the Type-2, Type-3, or Type-4 records or that could be used to verify any candidate identification. Note that this agency is not necessarily the arresting agency in the case of criminally related transactions. However, if this agency has a nine-character, originating agency identifier (ORI) number assigned by the Federal Bureau of Investigation's National Crime Information Center (NCIC), it shall be included as the first information item of this field. Otherwise, a code of NA shall be entered for this information item.

The remaining three information items within this field are optional if a valid ORI number is present in the first information item of this field, and mandatory if an "NA" code is entered in the first information item. These last three information items shall be the name of the formatting agency, its complete mailing address, and its complete telephone number including area code, and shall be separated from the first information item by the RS separator character. The name, address, and telephone number shall be in free-text format, entered in sequence, and with each of the information items separated by the US-ASCII character. The ASCII group separator character, GS, shall be used to separate this field from the following field.

5.6 Field 6. Transaction Control Number.

This field is mandatory and contains the transaction control number as assigned by the formatting agency. This control number shall be assigned to a transaction in which the fingerprint information from

a single individual has been converted to this standardized format. For any transaction that requires a response, the respondent shall refer to this number in communicating with the formatting agency.

5.7 Field 7. Date. This is a mandatory field and contains the date that the fingerprint information was converted to the format specified in this standard. The date shall appear as six digits. The first two digits are the tens and units value of the month; the next two digits represent the day, and the final two digits represent the year. For example, 072185 represents July 21, 1985.

The use of all remaining fields in the Type-1 record is optional.

5.8 Field 8. Originating Agency and Case Number (ORI-OCA). This optional field contains the nine-character originating agency identifier (ORI) that has been assigned by the NCIC to the originating agency. This is followed by a US character and the originating agency case identifier (OCA) that has been assigned by this agency. Multiple ORI-OCA entries may be listed and separated by the RS character.

5.9 Field 9. FBI Number (FBI). This field contains the subject's FBI number, if known. A valid FBI number shall be no more than nine alphanumeric characters. Multiple FBI numbers are not permitted.

5.10 Field 10. State Identification Number (SID). This field contains any known state identification numbers. The format is the standard two-character abbreviation of the state name, followed by the number. The maximum length of the SID shall be limited to ten alphanumeric characters. If there is an SID from more than one state, each additional state identification number subfield shall be separated from the previous subfield by the RS character.

5.11 Field 11. Social Security Number (SOC). This field contains the subject's social security number, if known. This number shall be entered as nine consecutive digits with no imbedded punctuation characters. Up to ten social security numbers may be entered. Each shall be separated from the next by the RS separator character.

5.12 Field 12. Miscellaneous Identification Number (MNU). If there are any miscellaneous identification numbers, the source of such numbers shall be entered in this field. Its format shall be a two-letter identifying code, followed by a hyphen (-), followed by the number itself. Table 6 lists the acceptable two-letter identifying codes. If a specific miscellaneous number does not appear in this table, then the "OA" (originating

agency police or identification number) code shall be used, and its identity should be explained in Field 29 - Identification Comments. As many as ten miscellaneous numbers may be included in this field. Each MNU shall be separated from the next by the RS separator character.

5.13 Field 13. Name (NAM). This field contains the name(s) of the subject. The format shall be the surname followed by a comma (,) followed by the given name(s), which are separated by a space. Part 4 of the NCIC Code Manual describes in greater detail the manner in which each name is to be entered. Additional names (aliases and alternative spellings) follow, separated by RS characters and are recorded in the same format. As many as 100 different names and aliases may be entered in this field.

5.14 Field 14. Place of Birth (POB). The subject's place of birth may be entered in this field. If used, indicate in this POB field the state (Mexican, U.S.), territorial possession, province (Canadian), or country of birth. The appropriate two-letter abbreviation shall be used as listed in the NCIC Code Manual.

5.15 Field 15. Date of Birth (DOB). This field contains the date of birth, which may be entered in this field as a six-digit number in the same format as specified in Field 7. Multiple occurrences of this field may be listed to indicate different dates of birth with each entry being separated by the RS separator character.

5.16 Field 16. Date of Birth Range. For purposes of indicating an age range, a pair of two-digit numbers may be entered separated by a hyphen (-) to specify the probable earliest and latest estimated year of birth.

5.17 Field 17. Sex (SEX). This field is used to contain the sex of the subject. For males an "M" shall be recorded, for females an "F", and a "U" for unknown.

5.18 Field 18. Race (RAC). If the race of the subject is to be entered in this field, select the predominent race code from Table 7.

5.19 Field 19. Skin Tone/Complexion (SKN). This field shall contain the subject's skin tone or complexion. General descriptors shall be listed by one of the codes chosen from Table 8.

5.20 Field 20. Scars, Marks, or Tattoos (SMT). For each scar, mark, or tattoo present on the subject, the appropriate NCIC code may be used in this information item. Up to ten such codes may be entered and shall be separated by the RS

Table 6: Miscellaneous Numbers

Code	Identifying Agency
AF	Air Force Serial Number
AS	Air National Guard Serial Number[4]
AR	Alien Registration Number
AS	Army Serial Number[4]
CI	Canadian Social Insurance Number
MC	Marine Corps Serial Number
MD	Mariner's Document or Identification Number
AS	National Guard Serial Number[4]
NS	Navy Serial Number
OA	Originating Agency Police or Identification Number
PP	Passport Number
PI	Personal Identification Number (State issued numbers)
PS	Port Security Card Number
MP	Royal Canadian Mounted Police Identification or Fingerprint Section Number
SS	Selective Service Number
CG	U.S. Coast Guard Serial Number
VA	Veterans Administration Claim Number.

4 These branches all use the same two-character code.

Table 7: Race Code

Code	Race
A	Asian or Pacific Islander
B	Black
I	American Indian or Alaskan Native
U	Unknown Origin
W	White

Table 8: Skin Tone

Code	Skin Tone
ALB	Albino
BLK	Black
DRK	Dark
DBR	Dark Brown
FAR	Fair
LGT	Light
LBR	Light Brown
MED	Medium
MBR	Medium Brown
OLV	Olive
RUD	Ruddy
SAL	Sallow
YEL	Yellow

separator character.

5.21 Field 21. Citizenship. The appropriate two-letter NCIC country code may be entered in the field for the subject's citizenship(s). If more than one country, the subject's original citizenship shall be listed first, followed by other citizenships, separated by RS separators.

Table 9: Eye Color

Code	Eye Color
BLK	Black
BLU	Blue
BRO	Brown
GRY	Grey
GRN	Green
HAZ	Hazel
MAR	Maroon
MUL	Multicolored
PNK	Pink
XXX	Unknown

5.22 Field 22. Height (HGT). This field contains the subject's height in feet and inches. This information item shall be a three-digit code. The first (leftmost) digit is used to show feet while the two rightmost digits are used to show the inches between 00 and 11.

5.23 Field 23. Height Range. If an optional range of height is given, it shall be expressed as two three-digit numbers formatted as described in Field 22 and separated by a hyphen (-) indicating the shortest and tallest heights of the subject.

5.24 Field 24. Weight (WGT). The subject's weight in pounds may be entered in this field.

5.25 Field 25. Weight Range. If an optional range of weight is given, it shall be expressed as two numbers separated by a hyphen (-), indicating the minimum and maximum weights of the subject.

5.26 Field 26. Color Eyes (EYE). The three-letter code from Table 9 may be used to indicate the subject's color of eyes. If the eyes are of different color, the color of the left eye shall be entered first, followed by the US separator, followed by the color of the right eye.

Table 10: Hair Color

Code	Hair Color
BLK	Black
BLN	Blond or Strawberry
BRO	Brown
GRY	Gray or Partially Gray
RED	Red or Auburn
SDY	Sandy
WHI	White
XXX	Unknown

5.27 Field 27. Hair Color (HAI). The three-letter code from Table 10 may be used to indicate the subject's color of hair.

5.28 Field 28. NCIC Fingerprint Classification (FPC). If available, the subject's complete 20-character NCIC "preferred" or "head" classification shall be entered. This entry is composed of the concatenation of 2-character classification codes for each of the 10 fingers as shown in Part 4 of the NCIC Code Manual (e.g., an "XX" for an amputated finger and a "SR" for a scarred or mutilated finger). The method by which the the classification was generated shall be entered as the second information item of this field as follows: (1) "A", automatically generated classifications; (2) "M", for manually generated classifications; or (3) "U", for unknown. These two information items shall be separated with the US separator.

If finger references are to be used in connection with the 20-character classification code, the finger and its associated reference(s) shall be entered as the third information item of this field and shall be separated from the second information item of this field by the US separator character. The format for finger references shall be the finger position code as selected from Table 11, followed by the US separator and the reference class or classes for that finger. Multiple references for the same finger shall be separated from each other by the US separator. If more than one finger of the classification is to be referenced, then each finger and its associated references shall be separated from the next finger and its references by the RS separator character.

When the 20-character NCIC classification is available, it shall be entered in Field 28. However, if only the pattern types are known, then they shall be entered in Field 29 as described in 5.29. However, both fields shall not be used together in the same Type-1

Table 11: Finger Position Code

Code	Finger Position
U	Unknown Finger
1	Right Thumb
2	Right Index Finger
3	Right Middle Finger
4	Right Ring Finger
5	Right Little Finger
6	Left Thumb
7	Left Index Finger
8	Left Middle Finger
9	Left Ring Finger
0	Left Little Finger

record. If neither the NCIC classification nor the pattern types are available, both Field 28 and Field 29 shall be omitted.

5.29 Field 29. Pattern Types. This field contains information about the finger(s) pattern types. The format is the most likely finger position code as selected from Table 11 followed by the US separator and the pattern type code as chosen from Table 12. If multiple pattern types are used for reference, they shall be separated from each other by the US separator. Multiple fingers shall be separated by the RS separator.

5.30 Field 30. Blood Type (BLT). If known, the subject's blood type code taken from Table 13 shall be entered in this field.

5.31 Field 31. Operator's License Data. This field may be used to enter operator's license data for a motor vehicle, or a license issued by the FAA, or both. It consists of three information items, each separated by the US separator character. The first item is the operator's license number. The complete license number shall be entered, omitting spaces, hyphens, and symbols. The second item is the appropriate two-character alphabetic code for the jurisdiction that issued the license. Codes used are the same as those used for the POB field. The license state of a pilot's license issued by the FAA shall be entered as "US". The final information item shall contain the last two digits of the

Table 12: Pattern Type Code

Code	Pattern
PA	Plain Arch
TA	Tented Arch
RL	Radial Loop
UL	Ulnar Loop
PW	Plain Whorl
CP	Central Pocket Loop
DL	Double Loop
AW	Accidental Whorl
WN	Whorl, Type Not Designated
RS	Right Slant Loop
LS	Left Slant Loop
SR	Scar
XX	Amputation

Table 13: Blood Type

Code	Blood Type
APOS	A Positive
ANEG	A Negative
AUNK	A Unknown
BPOS	B Positive
BNEG	B Negative
BUNK	B Unknown
ABPOS	AB Positive
ABNEG	AB Negative
ABUNK	AB Unknown
OPOS	O Positive
ONEG	O Negative
OUNK	O Unknown

highest year in which the operator's license is valid.

5.32 Field 32. Identification Comments. Additional miscellaneous identification remarks may be entered in this field. Multiple comments shall be separated with the RS separator.

5.33 Field 33. User Assignable Field. This field may be used to enter any information or data into the file for which provision has not been established within this standard. When used to convey additional information from the sender to the recipient, the content and format of the data shall be mutually agreed upon.

5.34 Field 34. Duplicate Response. When a transaction requires a response, that response shall always be made to the agency identified in Field 5, citing the transaction control number in Field 6. Field 34 may be used by the formatting agency to request that a duplicate response be made to another agency on transactions that are identified as T or L in Field 1. This requirement might occur, for example, when a local agency submits a fingerprint card to a state bureau which then converts the fingerprint data to the standard format and submits it to another state, or to the national level.

The first entry in Field 34 is the nine-character originating agency identifier (ORI) that has been assigned by the NCIC to the agency that is to receive the duplicate response, followed by the US separator character.

If no ORI number has been assigned to this agency, a code of NA shall be entered for this information item. This is followed by a US character and the name of the agency, its complete mailing address, and its complete telephone number including area code and followed by a US separator character. The name, address, and telephone number shall be in free-text format, entered in sequence, with each of the items separated by the US separator character.

This is followed by the character # and the originating agency case identifier (OCA) that has been assigned by that agency. Multiple OCA numbers may be listed and separated by the US separator character.

If duplicate responses are to be sent to more than one agency, the RS character shall be entered, and the format defined in this standard shall be followed for each additional agency.

The format and content of transaction responses is outside the scope of this standard.

Field numbers 35 to 49 are reserved for future use.

5.35 End of Logical Record Type-1. Immediately following the last information field in the Type-1 logical record, an FS separator character is required to separate it from the next logical record. This FS character shall replace the GS character that is

normally used between information fields. Appendix D contains an example of the record layout for a Type-1 logical record.

6. Fields for Type-2 Logical Records

When a Type-2 record is included in a file, each of the fields that are designated as mandatory shall be included.

6.1 Field 50. Impression Association Number (IAN). This field is mandatory for a Type-2 record and shall be used to relate this logical record for the same impression to a Type-3 logical record, a Type-4 logical record, or both. The appropriate IAN between "0" and "9" shall be entered in this field even if no Type-3 or Type-4 records for the same impression are present in this file.

6.2 Field 51. Impression Type. The code describing the manner by which the fingerprint impression was obtained shall be placed in this mandatory field. A code from Table 14 shall be entered in this field to signify that the image was obtained directly from the finger, or that the impression was that of a latent, plain, or rolled print.

Table 14: Impression Type

Code	Impression Type
0	Directly from Finger
1	Latent Impression
2	Plain Impression
3	Rolled Impression

6.3 Field 52. Originating Fingerprint Reading System. The originator's designation or name for the particular fingerprint reading system that generated this record shall be placed in the first information item of this mandatory field. All the remaining information items of this field are optional. The second information item of this field shall indicate the method by which the minutiae data was read and recorded. The following coding shall be used: (1) "A", if the data was automatically read and recorded

without any possibility of human editing; (2) "U", if human editing was possible but unneeded; (3) "E", if the data was automatically read but manually edited before recording; (4) "M", if the data was manually read. The third information item is an optional, two-character, user-generated subsystem designator that uniquely identifies the originator's equipment. Each information item shall be separated from the next item by the US separator character.

6.4 Field 53. Finger Position. This mandatory field contains a character designating the finger position that produced information in this Type-2 record. If the exact finger position cannot be determined, multiple finger positions may be entered, separated by the RS character. Table 11 lists the codes to be used for each finger.

6.5 Field 54. NCIC Fingerprint Class or Pattern Type. This mandatory field shall contain the NCIC class from Part 4 of the NCIC Code Manual or the pattern classification from Table 12. If the finger cannot be classified or the pattern type is unknown, then "UN" shall be entered in this field. Reference finger classes may be entered and separated by the RS character. In any case, the entry or entries made in this field shall conform to the entry or entries made in Field 28 or Field 29, as regards NCIC format or pattern type format.

6.6 Field 55. Core Position. If the pattern type of the finger is a loop or a plain whorl, and if this optional field is used, it shall contain the X and Y coordinate position of the core. If the pattern is any other type, this field is skipped. The X and Y values are coded as a single 8-digit integer number comprised of the 4-digit X-coordinate concatenated with, and followed by the 4-digit Y-coordinate.

6.7 Field 56. Delta(s) Position. If this optional field is used, it shall contain the X and Y positional coordinates of each delta that is present on the fingerprint. The X and Y values shall be recorded in the same manner as was done for the core position coordinates. Multiple occurrences of delta positions shall be separated by the RS separator.

6.8 Field 57. Number of Minutiae. The count of the number of minutiae recorded for this fingerprint shall be shown in this mandatory field.

6.9 Field 58. Ridge Count Indicator. This mandatory field shall be used to indicate the presence of ridge count information. A "0" in this field indicates that no ridge count information is available. A "1" indicates that ridge count information is available.

6.10 Field 59. Minutiae and Ridge Count Data. This mandatory field contains all of the individual minutiae and ridge count data associated with the current fingerprint impression. It shall be comprised of as many subfields as there are minutiae (stated in the minutiae count in Field 57). Each subfield shall be devoted to a single minutia and shall consist of multiple information items. The first two coded information items shall always appear; the appearance of others is system dependent. The information items are identified in the order that they shall appear. All information items are separated from the subsequent items by the US separator character.

6.10.1 Index Number. The first required information item is the index number, which is initialized to "1" and incremented by one for each additional minutia in the fingerprint. This index number serves to identify each individual minutia.

6.10.2 X, Y, and Theta Values. The X and Y coordinates (two 4-digit values ranging from 0 upward), and the Theta value (a 3-digit value between 000 and 359) comprise the second required information item. These three values shall be coded and recorded as a single 11-digit integer number corresponding to the concatenated X, Y, and Theta values, in that order.

6.10.3 Quality Measure. The third information item is a quality measure ranging from "0" to "63" for this minutia. The value "0" indicates a manually encoded minutia. The value "1" indicates that no method of indicating a confidence level is available, and values between "2" and "63" would indicate decreasing levels of confidence with "2" meaning the greatest confidence.

6.10.4 Minutia Type Designation. The fourth information item is the minutia type designation. This is a single alphabetic character as chosen from Table 2. If the minutia is of type "C", the Theta value as found above shall be recorded as "000".

6.10.5 Ridge Count Data. The final and optional information item consists of the ridge count data; if present it shall be formatted as a series of subitems, each consisting of a minutia number and a ridge count. This information is conveyed by listing the identity (index number) of the distant minutia followed by a comma, and the ridge count to that distant minutia. This in turn is followed by a US character. This information item may be repeated as many times as required for each minutia (subfield).

6.10.6 Record Separator. A Record Separator character, RS, is used at the end of the information items to introduce the first information item concerning data for the next minutia. The process is continued until all of the minutia and ridge data have been entered into the field.

6.11 Field 60. Relationship to Type-3 Record. If there is a Type-3 record for this impression, the relationship of the coordinate system of the image data in the Type-3 record to the coordinate system of this Type-2 record is shown in this optional field. The X position and Y position on the Type-2 coordinate system that would be occupied by the leftmost bottom pixel of the Type-3 record (image data), if it were

overlaid for best fit on the Type-2 data, are reported as 4-digit values. The orientation is reported as a 3-digit value in degrees of rotation that would be required to align the pixel rows of the Type-3 record with the X-axis of the Type-2 record. This is also measured from best fit superpositioning of data points. The rotation of the Type-3 record to achieve alignment is always measured in a clockwise direction and results in values of 000 to 359. The values of X and Y and rotation are concatenated and recorded as a string of 11 digits.

6.12 Field 61. Relationship to Type-4 Record. If there is a Type-4 record for this impression, the relationship of the coordinate system of the image data in the Type-4 record to the coordinate system of this Type-2 record is shown in this optional field. The X position and Y position on the Type-2 coordinate system that would be occupied by the leftmost bottom pixel of the Type-4 record (image data), if it were overlaid for best fit on the Type-2 data, are reported as 4-digit values. The orientation is reported as a 3-digit value in degrees of rotation that would be required to align the pixel rows of the Type-4 record with the X-axis of the Type-2 record. This is also measured from best fit superpositioning of data points. The rotation of the Type-4 record to achieve alignment is always measured in a clockwise direction and results in values of 000 to 359. The values of X and Y and rotation are concatenated and recorded as a string of 11 digits.

6.13 End of Logical Record Type-2. Immediately following the last information field in a Type-2 logical record, an FS separator character is required to separate it from the next logical record. This FS character shall replace the GS character that is normally used to end an information field. An example of the record layout for a Type-2 logical record is contained in Appendix D.

7. Additional Fingers

This completes the minutiae and ridge count descriptions for a single finger. Up to nine more fingers may be described within the logical file. For each additional finger, a Type-2 logical record, comprised of the mandatory fields from 50 to 61, shall be required, including the FS separator at the end of the last field.

8. Type-3 Logical Records

Type-3 logical records contain fingerprint image data that has been sampled at approximately 10 pixels per millimeter with gray scale representations of from 1 bit (binary or thinned binary "skeletal" image) to 16 bits. There are no limits on image size.

8.1 Fields for Type-3 Logical Records. When there are one or more Type-3 logical records, entries shall be provided in three, fixed-length, unnumbered fields that precede the image data in each Type-3 record. These 3 fields total 8 bytes and the field boundaries for each field are determined by byte counts. These three fields are of fixed length, while the size of the fourth field containing the image data is determined from the proper logical record size information item in Field 2 of the associated Type-1 record. The image data field is 8 bytes less than this value.

8.2 Impression Association Number (IAN). The IAN field is a single byte and the first byte of the Type-3 record. The binary value in this byte shall be in the range of 0 to 9 and shall be the same as the IAN for data from any other Type-2 or Type-4 record in the current file that were developed from the same finger or fingerprint.

8.3 Impresssion Type (1 byte required). The impression type field is a single byte occupying the second byte of a Type-3 record. The code describing the manner by which the fingerprint image information was obtained is placed in this field. The binary value of the proper code as chosen from Table 14 shall be entered in this field to signify that the image was obtained directly from the finger, or that the impression was from a latent, plain, or rolled print, respectively.

8.4 Finger Position (6 bytes required). This fixed-length field of 6 bytes shall occupy the third through eighth byte positions of a Type-3 record. It shall contain possible finger positions beginning in the leftmost byte (byte 3 of the record). The known or most probable finger position shall be entered as a binary number right justified and left zero filled within the 8-bit byte. Up to 5 additional finger positions may be referenced by entering the alternate finger positions in the remaining 5 bytes using the same format. The decimal code numbers for each finger can be found in Table 11. If the finger position is unknown, the binary equivalent of "55" (00110111), shall be entered in the leftmost byte and each of the remaining 5 bytes shall be filled with the binary equivalent of "255" (11111111). If less than 5 finger position references are to be used, the unused bytes shall be filled with the binary equivalent of "255".

8.5 Image Data. This field contains all of the binary or gray scale image data according to the quantization, scanning sequence, and size parameters as designated in Field 3 of the Type-1 record for this file. This completes the low-resolution image description for a single finger.

9. Additional Fingers

Up to nine more fingers may be described within the logical file. For each additional finger, a Type-3 logical record, comprised of the appropriate IAN, impression type, finger position, and image data shall be required.

10. Type-4 Logical Record

Type-4 logical records contain fingerprint image data that has been sampled at approximately 20 pixels per millimeter with gray scale representations of from 1 bit (binary or thinned binary "skeletal" images) to 16 bits. The minimum scanned area shall be 512 by 512 pixels and the scanned image shall be centered within the scan area.

10.1 Fields for Type-4 Logical Records. When there are one or more Type-4 logical records, entries shall be provided in three, fixed length, unnumbered fields that precede the image data in each Type-4 record. These three fields total 8 bytes and the field boundaries for each field are determined by byte counts. These three fields are of fixed length, while the size of the fourth field containing the image data is determined from the proper logical record size information item in Field 2 of the associated Type-1 record. The image data field is 8 bytes less than this value.

10.2 Impression Association Number (IAN). The IAN field is a single byte that is the first byte of the Type-4 record. The binary value in this byte shall be in the range of 0 to 9 and shall be the same as the IAN for data from any other Type-2 or Type-3 record in the current file that were developed from the same finger or fingerprint.

10.3 Impresssion Type (1 byte required). The Impression Type field is a single byte occupying the second byte of a Type-4 record. The code describing the

manner by which the fingerprint image information was obtained is placed in this field. The binary value of the proper code as chosen from Table 14 shall be entered in this field to signify that the image was obtained directly from the finger, or that the impression was from a latent, plain, or rolled print, respectively.

10.4 Finger Position (6 bytes required). This fixed-length field of 6 bytes shall occupy the third through eighth byte positions of a Type-4 record. It shall contain possible finger positions beginning in the leftmost byte (byte 3 of the record). The known or most probable finger position shall be entered as a binary number right justified and left zero filled within the 8-bit byte. Up to 5 additional finger positions may be referenced by entering the alternate finger positions in the remaining 5 bytes using the same format. The decimal code numbers for each finger can be found in Table 11. If the finger position is unknown, the binary equivalent of "55" (00110111), shall be entered in the leftmost byte and each of the remaining 5 bytes shall be filled with the binary equivalent of "255" (11111111). If less than 5 finger position references are to be used, the unused bytes shall be filled with the binary equivalent of "255".

10.5 Image Data. This field contains all of the binary or gray scale image data according to the quantization, scanning sequence, and size parameters as designated in Field 4 of the Type-1 record for this file. This completes the high-resolution image description for a single finger.

11. Additional Fingers

Up to nine more fingers may be described within the logical file. For each additional finger, a Type-4 logical record, comprised of the appropriate IAN, impression type, finger position, and image data, is required.

12. Another Individual

If fingerprint data for another individual is to be recorded or transmitted, a new logical file shall be generated for that individual using the same format as described previously.

13. Physical Format of Information Interchange

This standard has been designed to use either magnetic tapes or communication lines as a means of information interchange. Similar approaches and concepts will be utilized to define the required parameters for either medium. As stated in 4.1 and 4.2.3, all recorded or transmitted data for Type-1 or Type-2 logical records shall use the 7-bit ASCII character set to represent the coded information. For Type-3 and Type-4 logical records, a binary record format shall be employed and the ASCII character set shall not be used.

All data pertaining to a single subject shall be contained within a single physical file. Each file of information that is physically recorded on tape or transmitted via communication lines shall be delimited by the appropriate file delimiting characters or blocks and shall contain data only on a single subject. For purposes of this standard, a file shall be viewed as consisting of one or more segmented records, each recorded as fixed-length physical blocks. The length of each block shall be a maximum number of characters or bytes that are mutually agreeable to both the sender and recipient. This implies that one logical record or logical file as described in Section 4 may span one or more physical blocks. Furthermore, one physical block may contain one or more logical records. However, a physical block may only contain ASCII logical records or binary logical records. ASCII and binary logical records may not be intermixed within the same physical block.

When ASCII data is recorded, each physical block shall be of specified fixed length including information separator characters. The size of the last physical block of this ASCII data shall be of the appropriate size needed to complete the recording or transmission of the segmented record.

When binary data is recorded, each physical block shall be of specified fixed length. Again, the last physical block recording this binary data shall be of appropriate size to complete the recording or transmission of the segmented binary record. Each time a transition is made from recording or transmitting ASCII to binary data or binary to ASCII data, a new physical block is required.

13.1 Magnetic Tape Format. When this medium of exchange is used, either a 9-track, 1600 CPI (PE), or a 9-track 6250 CPI (GCR) tape shall be used for processing. The magnetic tape should conform to ANSI X3.27-1978, X3.39-1986, and X3.54-1986. However, owing to the variety of systems that may be processing this information, both the volume and file accessibility fields in the label sets should be liberally specified.

A file shall be recorded (including the information separator characters) in its entirety. One or more physical blocks shall be required for each file. Each physical block shall consist of the specified number of characters. The last physical block recording ASCII logical records need only be of appropriate length to complete the recording of information.

Binary records shall be recorded in a like manner. No padding of any physical block shall occur.

A new logical file shall be recorded on tape for each new subject. However, in order to eliminate excessive filemarks, a double "FS" character recorded as a single logical record shall be substituted for a filemark. This added logical record will not be accounted for in Field 2 of the Type-1 record. Each file shall be delimited on the tape by this double "FS" logical record. After the last file has been recorded, a double End-of-File mark shall be written.

13.2 Telecommunication Format Communication lines may also be used to transmit and exchange these fingerprint information files. When the data is exchanged via telecommunication methods, all the data transmitted shall conform to the format as specified in this standard. No extra control characters may be imbedded within the data, nor may any characters be omitted from the data.

APPENDIXES (The APPENDIXES are not a part of American National Standard ANSI/NBS-ICST 1-1986 but are included for information only.)

Appendix A
Expository Remarks

These expository remarks are intended to provide an explanation of the intended purpose of this standard and the rationale that shaped the formulation of some of its provisions.

Computer-based, automated fingerprint identification systems are available from a number of different suppliers. These systems are all similar in that they scan fingerprints or fingerprint images and extract features and assign metrics to them for comparison with similar data derived from file fingerprints. They differ in some cases with respect to the feature information that is extracted and the units of measure that are used to describe these features. In those instances where different systems do use the same feature information, a conversion of the units of measure permits data developed by one system to be searched against data in the files of another system. Although it is possible for each system to have a software routine to convert to and from the data format of each other system that uses the same feature information, the number of such conversion routines increases with the number of different systems. With more than three different systems it is more efficient to adopt a single "intermediate" data format so that each different system requires only a single conversion routine to go between that "intermediate" and its own native format.

Therefore, the main objective of the standard is to define an "intermediate" or "common" data format that may be used to express the various metrics required to describe or identify minutiae from any system. Data encoded from one system to the "common" format, may be processed by a second system by simply decoding the "common" format to the required format of the second system. This "intermediate" or "common" format is defined as the Type-2 record in the standard.

Some of the current minutiae-based fingerprint identification systems record only the position and orientation of fingerprint minutiae. Others also record ridge counts between selected neighboring minutiae. Data from the latter systems can be used (after conversion) by the former without penalty, since the unneeded ridge count information is simply discarded.

The converse is not true. Systems that do not detect and record ridge counts between minutiae fail to supply information that is needed and used by the other type of systems. Although estimates of the values of the missing data elements can be calculated from the geometric relationship of neighboring minutiae and knowledge of mean ridge wavelengths as a function of sex, these estimates are less accurate than measured values. The use of

calculated rather than measured values would be expected to degrade the performance of systems that require ridge count information.

To cope with this situation, the standard defines two additional types of records that permit the direct transfer of digital image information. Each of these types of records permits the transfer of either binary or gray scale fingerprint image information. The main difference between the two record types is in image resolution. Data from Type-4 records are of higher resolution than the Type-3. Data from these Type-3 and Type-4 records are intended to be used as input to the feature detection processors of systems that require information that is not produced by the system that scans the fingerprint and generates the record.

One other type of record is defined by the standard. This is the Type-1 record containing information necessary to identify the source and contents of the file. This record may also contain certain textual and descriptive information about the subject.

In defining the fields and types of records in the standard, a number of factors were taken into account. There was no intent to change either the features that any system detected or the units of measure it used to report them. In support of this, every effort was made to make the standard independent of any current system. The standard data format was not modeled after any of the existing system's data formats, but it included provisions to accept information about any of the features detected by each of the current minutiae-based systems. It also allowed for the addition of information that was deemed potentially useful to future systems even though this information is not presently used by any current system. It defined units of measure having higher precision than those currently in use by any system so as to minimize the quantization errors associated with data conversion. No restrictions were imposed on scanning sequence or quantization levels for the fingerprint image records. Instead, fields are provided for describing these and other relevant image scan characteristics.

The file of information exchanged about any subject must include data entries in a few of the fields of the Type-1 record. All other record types as well as many of the fields within record types are optional. Data entries in optional fields may be omitted if the data are unavailable or not applicable. The optional use of only certain record types, or fields within a record, provides an opportunity for one user to select the most appropriate information to exchange with another in a system specific manner. Since each field in a Type-1 or Type-2 record is individually numbered, there is never any question as to which fields are present.

Image data, as provided in Type-3 and Type-4 records, is represented in binary form as contrasted to the ASCII representation used for the Type-1 and Type-2 record data. Since it is somewhat awkward to switch most computer systems back and forth between ASCII and binary within a single record, it was decided that it would be best if the Type-3 and Type-4 records were completely binary. Since a binary data stream can produce any bit pattern, information separators are not unique and cannot be used to separate fields. An

alternative is to use fixed field lengths and to use byte counts to identify field boundaries. This alternative was selected, and along with it, the number of fields included in the binary data was reduced to four. These are: (1) a single byte impression association number, (2) a single byte indicating the type of impression, (3) six bytes to indicate the finger position and references, and, (4) the image data that forms the balance of the record. For each record, the image data is exactly eight bytes less than the total record length. The other relevant information about the image records has been moved to appropriate fields in the Type-1 record.

In the Type-1 record, a mandatory Field 2 summarizes each of the image records that might be in a file by its type and record length in bytes. It also provides a pointer to any records in that file that pertain to the same finger in order to provide, for example, a direct linkage between the minutiae data and the image data for a finger. This pointer is in the form of an impression association number. In a given file, this number has the same value in each type of record that contains data from the same finger or finger impression. The record length expressed as a byte count for each image data record in a file provides the information necessary to tell when the data associated with one fingerprint image ends and the next begins.

In Field 3 of the Type-1 record, which is mandatory when there is a Type-3 image record, and in Field 4 of the Type-1 record, which shall be used when there is a Type-4 record, scan parameters are provided. These include information about the exact scan resolution, the type of image (skeletal, binary, or gray scale) and its quantization, the scanning sequence and the image size. There is also provision for designation of a data compaction algorithm since this is an area of potential future standardization activity. Since it is considered unlikely that different scanners would be used for the different fingers of a given subject, these scan parameters have been placed in the Type-1 record rather than repeated with the image data record for each finger. In the unlikely event that a different set of scan parameters is used for different fingers in a series of Type-3 or Type-4 records for a subject, it is accomodated by initiating a new file for each different set of parameters.

The standard was intended to define how data were to be converted and formatted for interchange. It was not an objective of the standard to specify how data are to be read, or how features are to be extracted, or how descriptive measures are associated with these features, or even what accuracy that these descriptive measures will have. Instead, it has been assumed that the system user will employ whatever quality assurance measures are appropriate to make certain that the performance of the scanner, or the minutiae detection processor, or any other relevant elements of the system, stay at the highest levels of integrity, fidelity and accuracy that the particular system offers.

Appendix B
American National Standard Code for Information Interchange (ASCII)

b7 b6 b5 → / Bits b4 b3 b2 b1 ↓ / COLUMN → ROW ↓	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
	0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	DLE	SP	0	@	P	\	p
0 0 0 1	1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	2	STX	DC2	"	2	B	R	b	r
0 0 1 1	3	ETX	DC3	#	3	C	S	c	s
0 1 0 0	4	EOT	DC4	$	4	D	T	d	t
0 1 0 1	5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	6	ACK	SYN	&	6	F	V	f	v
0 1 1 1	7	BEL	ETB	'	7	G	W	g	w
1 0 0 0	8	BS	CAN	(	8	H	X	h	x
1 0 0 1	9	HT	EM	)	9	I	Y	i	y
1 0 1 0	10	LF	SUB	*	:	J	Z	j	z
1 0 1 1	11	VT	ESC	+	;	K	[	k	{
1 1 0 0	12	FF	FS	,	<	L	\	l	|
1 1 0 1	13	CR	GS	-	=	M	]	m	}
1 1 1 0	14	SO	RS	.	>	N	^	n	~
1 1 1 1	15	SI	US	/	?	O	_	o	DEL

Appendix C
Use of Information Separator Characters

FN is the Field Number of a field within a Type-1 or Type-2 record.
IF is the Information Field associated with an FN.
II is the Information Item belonging to an IF.
SF is the Subfield used for multiple entries of an II or an IF.

$\underset{S}{F}$ File separator — separates logical records.

$\underset{S}{G}$ Group separator — separates fields.

$\underset{S}{R}$ Record separator — separates subfields.

$\underset{S}{U}$ Unit separator character — separates information items.

The $\underset{S}{G}$ used between fields — the $\underset{S}{F}$ between logical records:

$$FN_j : IF \underset{S}{G} FN_k : .... \underset{S}{F} FN_l : IF \underset{S}{G}$$

For fields with more than 1 information item the $\underset{S}{U}$ is used:

$$FN_j : II_a \underset{S}{U} II_b \underset{S}{G} FN_k ... \underset{S}{F}$$

For fields with multiple subfields the $\underset{S}{R}$ is used:

$$FN_j : II_a \underset{S}{U} II_b \underset{S}{R} II_a \underset{S}{U} II_b \underset{S}{G} FN_k : SF \underset{S}{R} SF \underset{S}{G} FN ... \underset{S}{F}$$

Appendix D
An Example of the Use of the Standard

D1. General

In this Appendix, the use of the standard will be illustrated by example. An artificial fingerprint card has been created for this purpose. This card is shown in Figure D1. All of the names, descriptive data, and other entries on this card are fictitious, and the card shows only a single fingerprint impression in the box for the right forefinger. This card, and the single fingerprint impression on it, will be employed to provide a demonstration of the use of the standard.

A Type-1, Type-2, Type-3, and Type-4 record immediately follow Figure D1 in a representation of the form that these records would have as recorded on magnetic tape or transmitted over a communications channel. The Type-1 and Type-2 records consist of strings of characters. All of the ASCII characters except the separators are shown as ordinary characters. Actually, the separators are nonprinting characters, but here they are shown as the 2-character representations (US, RS, GS, and FS) that have been used throughout the standard, except that for this illustration the two characters are aligned one above the other rather than side by side. This has been done to facilitate recognition of the separators and to make the data entries in each field stand out more clearly.

A Type-3 and a Type-4 record immediately follow the ASCII data. Since the Type-3 and Type-4 records contain binary data, a different way of showing them is employed. The first 8 bytes of each of these records are numbers whose value can range between 0 and 255. Rather than show the binary bit pattern of these 8 bytes, their equivalent value in decimal is shown. The use of the "space" characters between each of these values is an artifact that has been introduced to aid human recognition. They do not exist in the actual record. Following these 8 values, the rest of the record is shown in true binary format. Here, a binary zero is represented by a dot on the page and a binary one is represented by the absence of a dot at the expected position on the page. There are as many dots and missing dot positions in each row as there are pixels in a row of the scanned image, and there are as many rows in each column as there were scan lines. By presenting the data in this manner, it is immediately apparent that it is indeed an unthinned binary replica of the fingerprint image in Figure D1.

Following the Type-4 record, there is a detailed explanation of the example. It begins with a discussion on a field-by-field basis of the contents of the ASCII representation of the Type-1 record. This is continued for the fields in the Type-2 record and illustrated with a plot of the minutia data from the fingerprint(Figure D2), and a figure showing how the ridge count data were obtained(Figure D3). There is also a figure illustrating the relationship between the coordinate systems of the image data in the Type-3 and Type-4 records with the minutiae data in the Type-2 record(Figure D4).

Figure D1.
Fictitious Fingerprint Card

1:T $\frac{G}{S}$ **2:**1 $\frac{U}{S}$ 232 $\frac{U}{S}$ 3 $\frac{R}{S}$ 2 $\frac{U}{S}$ 2130 $\frac{U}{S}$ 2 $\frac{R}{S}$ 3 $\frac{U}{S}$ 8200 $\frac{U}{S}$ 2 $\frac{R}{S}$ 4 $\frac{U}{S}$ 32776 $\frac{U}{S}$ 2 $\frac{G}{S}$ **3:**1 $\frac{U}{S}$ 0984 $\frac{U}{S}$ 1000 $\frac{U}{S}$ 256X256 $\frac{U}{S}$ 0 $\frac{G}{S}$ **4:**1 $\frac{U}{S}$ 1969 $\frac{U}{S}$ 1000 $\frac{U}{S}$ 512X512 $\frac{U}{S}$ 0 $\frac{G}{S}$ **5:**USDIR000Z $\frac{G}{S}$ **6:**8512120018 $\frac{G}{S}$ **7:**121285 $\frac{G}{S}$ **11:**228060456 $\frac{G}{S}$ **12:**AS-228060456 $\frac{G}{S}$ **13:**DOE,JOHN JAY $\frac{R}{S}$ DOE,JACK $\frac{G}{S}$ **14:**MD $\frac{G}{S}$ **15:**102050 $\frac{G}{S}$ **17:**M $\frac{G}{S}$ **18:**W $\frac{G}{S}$ **22:**510 $\frac{G}{S}$

APPENDIX

24:160 **26**:BRO **27**:BRO **50**:2 **51**:3 **52**:GP M **53**:2 **54**:AA TT **57**:57 **58**:1 **59**:1

27703300355 0 B 2,0 9,6 2 24703290186 0 B 1,0 3,5 3 24403010194 0 A 2,5 4,0 6,3 4 25103000009 0 B 2,5 3,0 5,0 7,1 5 27102970146 0 A 1,5 4,0 8,1 9,0 6 20502930043 0 A 3,3 11,0 12,0 7 24902910180 0 B 3,2 4,1 10,0 13,3 8 30202850138 0 A 1,4 9,2 14,0 15,1 9 28502820127 0 A 1,6 8,2 10,2 18,3 10 27102780333 0 B 5,1 7,0 9,1 18,1 11 17602680040 0 A 6,0 12,1 27,5 12 18402670221 0 A 6,0 11,1 20,6 27,4 13 24502670190 0 B 10,2 12,7 16,0 21,1 14 31802620117 0 A 8,0 15,2 22,1 15 33502590299 0 A 14,2 24,2 16 24902570049 0 B 13,0 17,0 20,2 21,0 17 25702520348 0 B 16,0 18,2 23,0 26,0 18 28502510321 0 A 10,1 17,2 19,1 26,2 19 30202480316 0 B 8,3 18,1 22,1 28,1 20 21502470036 0 B 6,7 12,6 21,2 29,0 21 24502470208 0 B 17,0 20,2 23,0 33,0 22 31702470307 0 A 14,1 19,1 24,1 28,3 23 25602450019 0 A 17,0 21,0 25,0 26,0 24 33102420307 0 A 15,2 22,1 32,5 25 25402410194 0 A 21,1 23,0 26,0 39,3 26 27602380338 0 B 17,0 25,0 28,0 30,0 27 18202330223 0 B 12,4 29,2 35,1 28 30102330334 0 B 19,1 22,3 30,1 32,0 29 20202300210 0 A 20,0 21,1 27,2 33,2 30 28002290347 0 B 26,0 28,1 31,0 34,1 31 26002250024 0 A 21,3 25,2 30,0 43,4 32 31002200333 0 A 24,5 28,0 34,2 37,2 33 20002150203 0 A 27,4 29,2 38,0 39,3 34 29302140352 0 A 30,1 32,2 37,0 44,4 35 16502130206 0 A 27,1 38,1 40,2 36 32702110334 0 B 32,0 37,1 41,2 37 30402070347 0 A 32,2 34,0 41,1 44,3 38 17602030200 0 B 33,0 35,1 40,0 42,2 39 21502010201 0 A 20,7 33,3 42,1 43,3 40 16201950189 0 A 38,0 42,1 52,7 41 32501910347 0 B 36,2 46,1 51,4 42 20001890018 0 B 38,2 39,1 48,2 52,4 43 23001880196 0 A 31,4 39,3 47,2 48,1 44 27701860012 0 A 37,3 43,1 45,1

47,0 $\frac{R}{S}$ 45 $\frac{U}{S}$ 28001770016 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 37,4 $\frac{U}{S}$ 44,1 $\frac{U}{S}$ 49,1 $\frac{U}{S}$ 50,1 $\frac{R}{S}$ 46 $\frac{U}{S}$ 32901770000 $\frac{U}{S}$ 0 $\frac{U}{S}$ B $\frac{U}{S}$ 41,1 $\frac{U}{S}$ 53,2 $\frac{R}{S}$ 47 $\frac{U}{S}$ 24401750190 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 43,2 $\frac{U}{S}$ 44,0 $\frac{U}{S}$ 50,2 $\frac{U}{S}$ 54,2 $\frac{R}{S}$ 48 $\frac{U}{S}$ 20701710186 $\frac{U}{S}$ 0 $\frac{U}{S}$ B $\frac{U}{S}$ 42,2 $\frac{U}{S}$ 43,1 $\frac{U}{S}$ 52,1 $\frac{U}{S}$ 54,2 $\frac{R}{S}$ 49 $\frac{U}{S}$ 28701710192 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 37,5 $\frac{U}{S}$ 45,1 $\frac{U}{S}$ 50,0 $\frac{U}{S}$ 55,2 $\frac{R}{S}$ 50 $\frac{U}{S}$ 25901630183 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 45,1 $\frac{U}{S}$ 47,2 $\frac{U}{S}$ 54,1 $\frac{U}{S}$ 57,2 $\frac{R}{S}$ 51 $\frac{U}{S}$ 30201620193 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 46,1 $\frac{U}{S}$ 49,1 $\frac{U}{S}$ 53,0 $\frac{U}{S}$ 55,1 $\frac{R}{S}$ 52 $\frac{U}{S}$ 16501580173 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 40,7 $\frac{U}{S}$ 48,1 $\frac{U}{S}$ 56,1 $\frac{R}{S}$ 53 $\frac{U}{S}$ 32801570005 $\frac{U}{S}$ 0 $\frac{U}{S}$ B $\frac{U}{S}$ 46,2 $\frac{U}{S}$ 51,0 $\frac{U}{S}$ 55,0 $\frac{R}{S}$ 54 $\frac{U}{S}$ 23701540007 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 48,2 $\frac{U}{S}$ 50,1 $\frac{U}{S}$ 57,1 $\frac{R}{S}$ 55 $\frac{U}{S}$ 29501530000 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 49,2 $\frac{U}{S}$ 51,1 $\frac{U}{S}$ 57,0 $\frac{R}{S}$ 56 $\frac{U}{S}$ 16801490355 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 48,3 $\frac{U}{S}$ 52,1 $\frac{R}{S}$ 57 $\frac{U}{S}$ 26901450000 $\frac{U}{S}$ 0 $\frac{U}{S}$ A $\frac{U}{S}$ 50,2 $\frac{U}{S}$ 55,0 $\frac{G}{S}$ **60:**12501110004 $\frac{G}{S}$ **61:**12501110004 $\frac{F}{S}$

2 3 2 255 255 255 255 255

Type-3 Record

2 3 2 255 255 255 255 255

Type-4 Record

D2. Explanation of Example

D2.1 Type-1 Record. In this subsection, entries for each individual field of the Type-1 record are repeated. Immediately after each entry there are explanatory comments about the entry.

$1{:}T^{G}_{S}$

The entry "1:" identifies this as Field 1, which designates the type of transaction for this file. The "T" indicates it is intended to be a ten-print search with results to be reported. In a real file for this type of transaction the data would not be limited to a single finger as it has been in this example for brevity. The GS character separates this field from the next.

$2{:}1\,\underset{S}{U}232\,\underset{S}{U}3\,\underset{S}{R}2\,\underset{S}{U}2130\,\underset{S}{U}2\,\underset{S}{R}3\;\underset{S}{U}8200\,\underset{S}{U}2\,\underset{S}{R}4\,\underset{S}{U}32776\,\underset{S}{U}2\,\underset{S}{G}$

The entry "2:" identifies this as Field 2, which describes the contents of the file. This is separated by a US from a "1" which indicates that the next two information items in this subfield pertain to the Type-1 record. A US separates this from "232" which is the total number of bytes in this Type-1 record. After another US separator, a "3" is entered to indicate that there are three more records in this file. In this case there are one each of Type-2, Type-3, and Type-4 record. An RS separates this subfield from the next. The following "2" indicates that the data in the subfield pertains to a Type-2 record; this is separated by a US from "2130", which is the length in bytes of that Type-2 record. Following another US is a "2", which is the impression association number (IAN) for this record. An RS separator appears next to separate this subfield from the next subfield, which pertains to a Type-3 record as shown by the entry "3". A US separator delimits the "3" from 8200, which is the total number of bytes in the Type-3 record. This number results from 256 pixels per row times 256 rows per column divided by 8 pixels per byte for a binary image, plus 8 bytes of fixed field information preceding the image data. The number of bytes is separated by a US from a "2" entry, which again represents the IAN. A final RS separates this from the final subfield, which begins with a "4" indicating that the data pertains to a Type-4 record. Again this is separated by a US from the "32776" entry, which is the number of bytes in this record. This number is developed from 512 pixels per row times 512 rows divided by 8 pixels per byte plus 8 bytes of header information. A GS separates this from the next field.

$3{:}1\,\underset{S}{U}0984\,\underset{S}{U}1000\,\underset{S}{U}256X256\,\underset{S}{U}0\,\underset{S}{G}$

The entry "3:" identifies this as Field 3. The field contains five information items that are separated from each other with US separators. The first entry of "1" shows that the Type-3 record of this file represents an unthinned binary image. The entry of "0984" means that the image scan resolution is 984 pixels per 100 mm. This is equivalent to 250 pixels per inch. The entry of "1000" indicates that the scan sequence is horizontal first, left-to-right, top-to-bottom, with a square pixel arrangement. The scan is analogous to a conventional television scan sequence. The "256X256" entry defines the image size as square with 256 pixels in each direction. The final entry of "0" means that no data compaction is used and the GS separates this field from the next field.

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4:1$^{U}_{S}$1969$^{U}_{S}$1000$^{U}_{S}$512X512$^{U}_{S}$0$^{G}_{S}$

The entry "4:" identifies this as Field 4. The field contains five information items that are separated from each other by US separators. The first entry of "1" shows that the Type-4 record of this file represents an unthinned binary image. The entry of "1969" means that the image scan resolution is 1969 pixels per 100 mm. This is equivalent to 500 pixels per inch. The entry of "1000" indicates that the scan sequence is horizontal first, left-to-right, top-to-bottom, with a square pixel arrangement. The scan is analogous to a conventional television scan sequence. The "512X512" entry defines the image as being square with 512 pixels in each direction. The "0" entry means that no data compaction has been used. The final GS separates this field from the next field.

5:USDIR000Z$^{G}_{S}$

The entry "5:" identifies this as Field 5. The field contains a single entry, "USDIR000Z", which is the ORI of the formatting agency. The other information items that might be contained in this field are optional when a valid ORI is present so they have been omitted in this example. The GS separates this field from the next field.

6:8512120018$^{G}_{S}$

The entry "6:" identifies this as Field 6. Following this is the entry "8512120018", which is the originating agency case number and is the "identifier" that has been selected by this agency for use as a transaction control number. The GS separates this field from the next field.

7:121285$^{G}_{S}$

The entry "7:" identifies this as Field 7. The entry "121285" represents the date December 12, 1985. The GS separates this field from the next field.

11:228060456$^{G}_{S}$

The entry "11:" identifies this as Field 11. Note that Fields 8, 9, and 10 are absent from this series. When optional fields are not needed or the information is not available, the field may be omitted. The entry "228060456" is a social security number for the subject. The GS separates this field from the next field.

12:AS-228060456$^{G}_{S}$

The entry "12:" identifies this as Field 12. The entry "AS-228060456" is an Army or National Guard serial number for the subject. The GS separates this field from the next field.

13:DOE,JOHN JAY$^{R}_{S}$DOE,JACK$^{G}_{S}$

The entry "13:" identifies this as Field 13. The entry "DOE,JOHN JAY" is the subject's surname "DOE" followed by his given names, "JOHN,JAY". This is separated from the "also known as" or alias name "DOE,JACK" by the RS separator. It should be noted that all of the ASCII separator characters are single, nonprinting characters that will not be confused with other textual entries. The GS separates this field from the next field.

14:MD$^{G}_{S}$

The entry "14:" identifies this as Field 14. This field identifies the subject's place of birth. The entry "MD" is the two letter abbreviation for the state of Maryland from Part 6 of the NCIC Code Manual. The GS separates this field from the next field.

15:102050$^{G}_{S}$

The entry "15:" identifies this as Field 15. This field identifies the subjects date of birth. The entry "102050" represents October 20, 1950. The GS separates this field from the next field.

17:M$^{G}_{S}$

The entry "17:" identifies this as Field 17, which contains information about the sex of the subject. The entry "M" designates male. The GS separates this field from the next field.

18:W$^{G}_{S}$

The entry "18:" identifies this as Field 18, which contains information about the race of the subject. The entry "W" designates white. The GS separates this field from the next field.

22:510$^{G}_{S}$

The entry "22:" identifies this as Field 22, which contains information about the height of the subject. The entry "510" represents a height of 5 feet and 10 inches. The GS separates this field from the next field.

24:160$^{G}_{S}$

The entry "24:" identifies this as Field 24, which lists the subject's weight. The entry "160" represents 160 pounds. The GS separates this field from the next field.

26:BRO$^{G}_{S}$

The entry "26:" identifies this as Field 26, which indicates the subject's color of eyes. The entry "BRO" represents brown from Table 9 and Part 4 of the NCIC Code Manual. The GS separates this field from the next field.

27:BRO$^{F}_{S}$

The entry "27:" identifies this as Field 27, which indicates the subject's color of hair. The entry "BRO" represents brown from Table 10 and Part 4 of the NCIC Code Manual. The FS separates this field and the entire Type-1 logical record from the next logical record.

D2.2 Type-2 Record. In this example the next logical record is a Type-2 record as was specified in Field 2. Notice that a number of optional fields have not been included in the Type-1 record.

50:2$^{G}_{S}$

The entry "50:" identifies this as Field 50, which defines the IAN. The value of the IAN is shown by the entry "2". The GS separates this field from the next field.

51:3$^{G}_{S}$

The entry "51:" identifies this as Field 51, which states the impression type. The entry "3" shows that it was a rolled impression. The GS separates this field from the next field.

52:GP$^{U}_{S}$M$^{G}_{S}$

The entry "52:" identifies this as Field 52, which names the originating fingerprint reading system that produced this Type-2 record. The entry "GP" means that the NBS Graphic Pen was used. This is separated by a US from the entry "M", which signifies that the reading was done manually. The GS separates this field from the next field.

53:2$^{G}_{S}$

The entry "53:" identifies this as Field 53, which specifies the finger position for this record. The entry "2" designates the right forefinger. The GS separates this field from the next field.

54:AA$^{R}_{S}$TT$^{G}_{S}$

The entry "54:" identifies this as Field 54, which contains information on NCIC pattern class(es). The entry "AA" signifies a plain arch. This is separated by an RS from the entry "TT", which references a tented arch. The GS separates this field from the next field.

57:57$^{G}_{S}$

The entry "57:" identifies this as Field 57, which specifies the number of minutiae in this record. The second "57" entry implies that the record contains descriptions of 57 minutiae. The GS separates this field from the next field.

58:1$^{G}_{S}$

The entry "58:" identifies this as Field 58, which indicates the availability of ridge count information. The entry "1" shows that ridge count information is available. The GS separates this field from the next field.

APPENDIX

59:1 U S 27703300355 U S 0 U S B U S 2,0 U S 9,6 R S

.....

10 U S 27102780333 U S 0 U S B U S 5,1 U S 7,0 U S 9,1 U S 18,1 R S

.....

57 U S 26901450000 U S 0 U S A U S 50,2 U S 55,0 G S

The entry "59:" identifies this as Field 59, which contains detailed information about each minutia. This is contained in a series of subfields, three of which are extracted from the complete record and listed above. (As an aid to understanding these examples, Figure D2 shows a plot of all of the minutiae in this fingerprint and Figure D3 shows an expanded view of the portion of the fingerprint in the neighborhood of minutia number 10, which also includes some of the ridge structure.) The entry of "1" indicates that the immediately following data pertains to minutia number 1. The entry "27703300355" indicates that the position of this minutia is at X=2770, Y=3300, and that its orientation is 355 degrees. The entry of "0" indicates that this minutia was manually encoded. The entry of "B" indicates that the minutia is a bifurcation. The entry "2,0" means that there is a ridge count of 0 between this minutia and minutia number 2. The entry of "9,6" indicates that there is a ridge count of six between this minutia and minutia number nine. The RS separates the data for this minutia from the data for minutia number 2.

The minutiae from number 2 through number 9 are omitted, and the next series of entries are for number 10. These indicate that its position is X=2710, Y=2780 and that its orientation is 333 degrees. The data was recorded manually; the minutia is a bifurcation; and the ridge count to number 5 is 1, number 7 is 0, number 9 is 1, and number 18 is 1. The RS separates this data from the data for minutia number 11.

The minutiae from number 11 to number 56 are omitted from this example. The final entry is for minutia number 57. Is is shown to have a position of X=2690, Y=1450, with orientation of 000 degrees. The data was recorded manually and the minutia is a ridge ending. The ridge count between it and number 50 is 2, and between it and number 55 it is 0. The GS separates this field from the next field.

60:12501110004 G S

The entry "60:" identifies this as Field 60, which shows the relationship of the image

data in the Type-3 record to the coordinate system of the Type-2 record. The next eight digits, "12501110", indicate that the lower left pixel of the image data occupies the position X=1250, Y=1110, on the minutiae data record. The final three digits, "004", indicate that the pixel rows of the image data would have to be rotated four degrees clockwise from the best fit position with the minutiae data to align them with the X-axis of the coordinate system. This relationship is illustrated in Figure D4. The GS separates this field from the next field.

$61{:}12501110004^{F}_{S}$

The entry "61:" identifies this as Field 61 which shows the relationship of the image data in a Type-4 record to the coordinate system of the Type-2 record. The next eight digits, "12501110", indicate that the lower left pixel of the image data occupies the position X=1250, Y=1110, on the minutiae data record. The final three digits, "004", indicate that the pixel rows of the image data would have to be rotated four degrees clockwise from the best fit position with the minutiae data to align them with the X-axis of the coordinate system. This relationship is illustrated in Figure D4. The FS separates this record from the next record.

APPENDIX

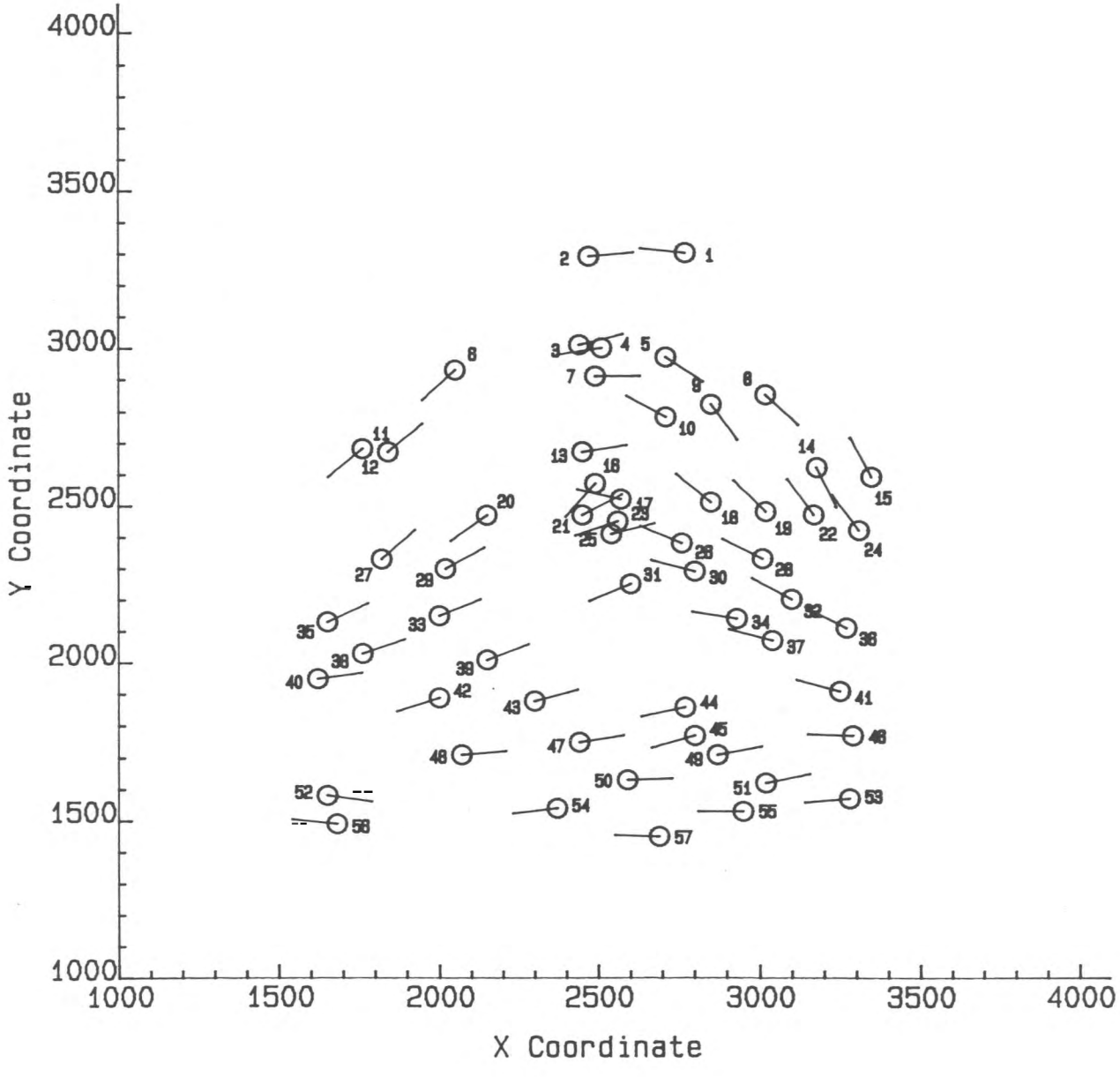

Figure D2
Plot of Minutiae

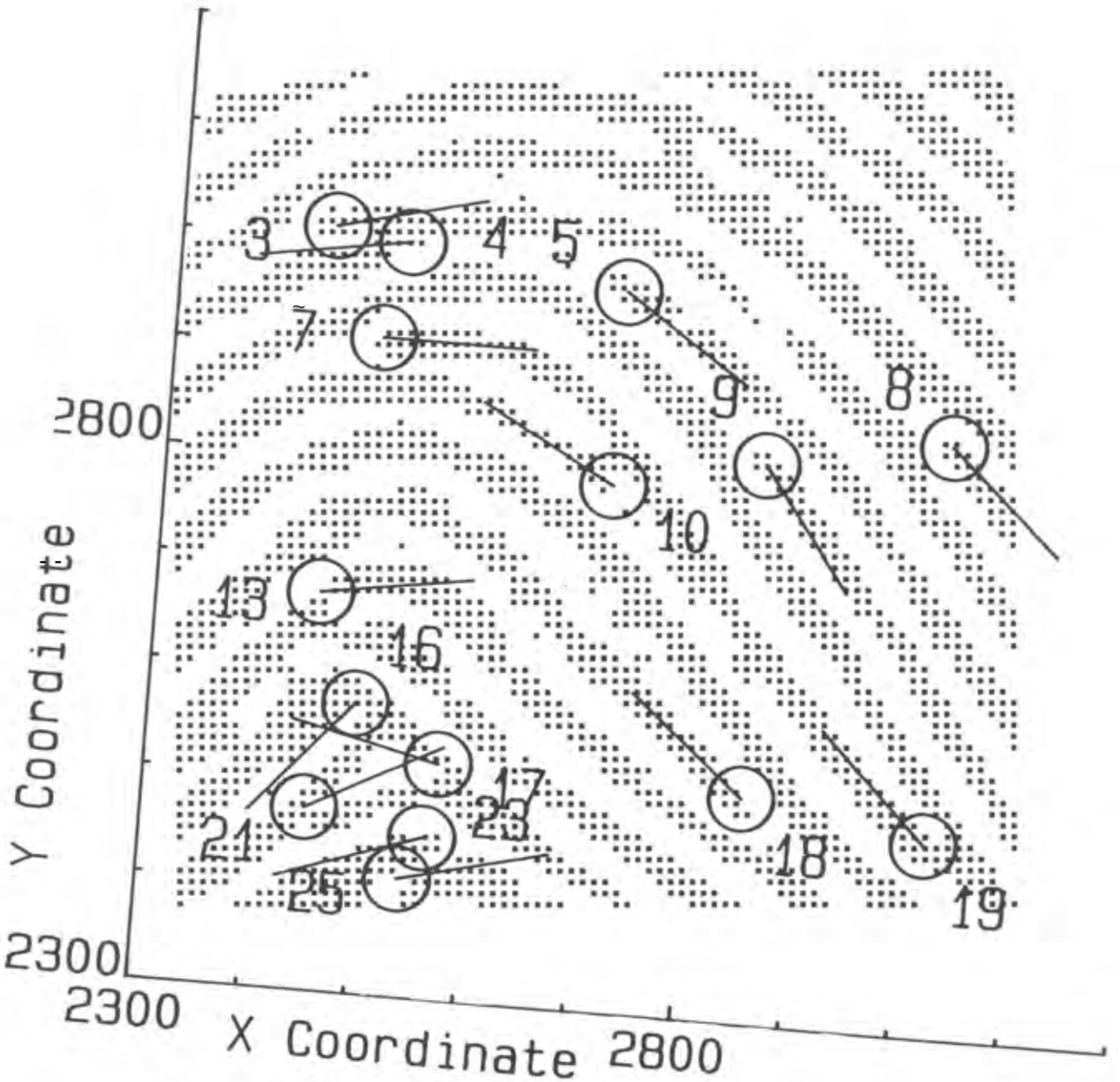

Figure D3
Expanded View of Fingerprint

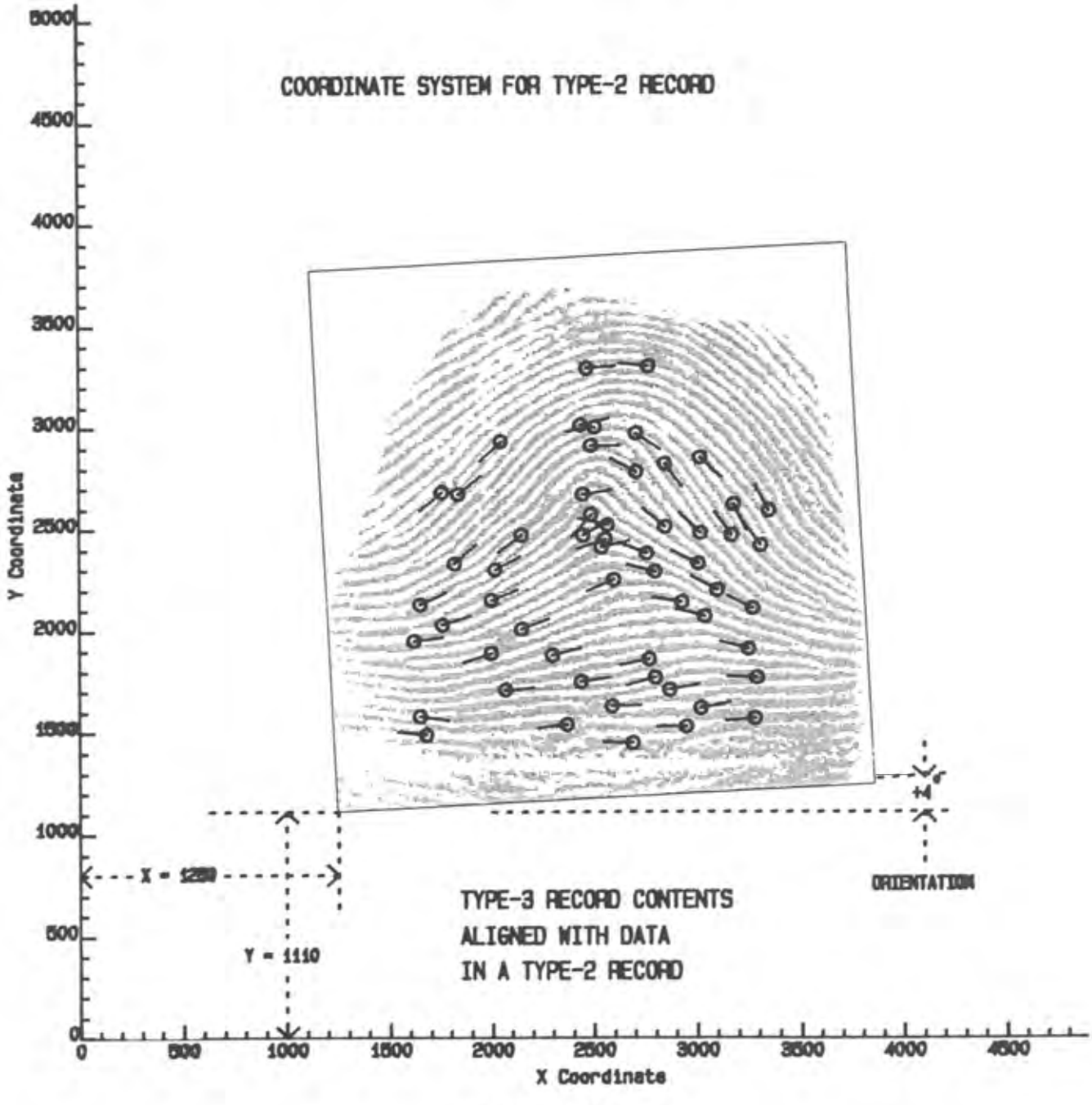

Figure D4
Relationship of the Image Data to the
Coordinate System of the Type-2 Record

X3.115-1984 Unformatted 80 Megabyte Trident Pack for Use at 370 tpi and 6000 bpi (General, Physical, and Magnetic Characteristics)

X3.116-1986 Recorded Magnetic Tape Cartridge, 4-Track, Serial 0.250 Inch (6.30 mm) 6400 bpi (252 bpmm), Inverted Modified Frequency Modulation Encoded

X3.117-1984 Printable/Image Areas for Text and Facsimile Communication Equipment

X3.118-1984 Financial Services – Personal Identification Number – PIN Pad

X3.119-1984 Contact Start/Stop Storage Disk, 158361 Flux Transitions per Track, 8.268 Inch (210 mm) Outer Diameter and 3.937 inch (100 mm) Inner Diameter

X3.120-1984 Contact Start/Stop Storage Disk

X3.121-1984 Two-Sided, Unformatted, 8-Inch (200-mm), 48-tpi, Double-Density, Flexible Disk Cartridge for 13 262 ftpr Two-Headed Application

X3.124-1985 Graphical Kernel System (GKS) Functional Description

X3.124.1-1985 Graphical Kernel System (GKS) FORTRAN Binding

X3.125-1985 Two-Sided, Double-Density, Unformatted 5.25-inch (130-mm), 48-tpi (1,9-tpmm), Flexible Disk Cartridge for 7958 bpr Use

X3.126-1986 One- or Two-Sided Double-Density Unformatted 5.25-inch (130-mm), 96 Tracks per Inch, Flexible Disk Cartridge

X3.128-1986 Contact Start-Stop Storage Disk – 83 000 Flux Transitions per Track, 130-mm (5.118-in) Outer Diameter and 40-mm (1.575-in) Inner Diameter.

X3.129-1986 Intelligent Peripheral Interface, Physical Level

X3.130-1986 Intelligent Peripheral Interface, Logical Device Specific Command Sets for Magnetic Disk Drive

X3.131-1986 Small Computer Systems Interface

X3.136-1986 Serial Recorded Magnetic Tape Cartridge for Information Interchange, Four and Nine Track

X3.140-1986 Open Systems Interconnection – Connection Oriented Transport Layer Protocol Specification

X11.1-1977 Programming Language MUMPS

IEEE 416-1978 Abbreviated Test Language for All Systems (ATLAS)

IEEE 716-1982 Standard C/ATLAS Language

IEEE 717-1982 Standard C/ATLAS Syntax

IEEE 770X3.97-1983 Programming Language PASCAL

IEEE 771-1980 Guide to the Use of ATLAS

ISO 8211-1986 Specifications for a Data Descriptive File for Information Interchange

MIL-STD-1815A-1983 Reference Manual for the Ada Programming Language

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X3/TRI-82 Dictionary for Information Processing Systems (Technical Report)