American National Standard for Information Systems —

WORKING DRAFT Version 0.2

Data Format for the Interchange of Extended Fingerprint and Palmprint Features

An Addendum to ANSI/NIST-ITL 1-2007
Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information

18 January 2008

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Change History

- Working Draft 0.1, 23 March 2007
  - First public release of document
  - Defined new Type-18 record type, subsequently removed
- Working Draft 0.2, 3 January 2008
  - Redefined all fields in the existing Type-9 record instead of the proposed new Type-18 record, for ease in implementation and transition, after extensive discussion in CDEFFS group
  - Added fields to define Corresponding Features
  - Added base-64 representation and optional PNG format for skeletonized images
  - Reorganized document, incorporating a variety of minor revisions
  - Draft 0.1 referred to a future “Guidance” document. That content has been incorporated into this document, in Section 7, *Guidance in the Definition of Extended Friction Ridge Features*.

Foreword

(This informational foreword is not part of the American National Standard ANSI/NIST ITL 1a-200X.)

At the ANSI/NIST ITL 1-2000 Standard Workshop I in April 2005, the Scientific Working Group on Friction Ridge Analysis, Study, and Technology (SWGFAST) was tasked to identify, define and provide guidance on additional fingerprint features beyond the traditional ending ridges and bifurcations currently defined in the ANSI/NIST ITL-2000 standard (which is the basis for the FBI's EFTS, and Interpol's INT-I). SWGFAST drafted a memo to NIST in response[1], enumerating the features used by expert human latent examiners that are not currently addressed in fingerprint feature standards. SWGFAST stated its concern: "AFIS [Automated Fingerprint Identification System] technology, since its onset, has utilized a very limited amount of fingerprint detail. Latent print experts must rely on far more information in effecting individualizations/exclusions than just ending ridges and bifurcations, i.e., the Type-9 minutiae record. SWGFAST is attempting to educate and provide to the vendor community the additional features and how they are utilized by these experts."

In response to SWGFAST, Steve Meagher (FBI) and Austin Hicklin (Mitretek, later renamed Noblis) gave a presentation at the ANSI/NIST ITL 1-2000 Standard Workshop II in December 2005, entitled "Extended Fingerprint Feature Set", and proposed that a committee be convened to define an Extended Fingerprint Feature Set as an Addendum to the next ANSI/NIST ITL standard. The ANSI/NIST Committee to Define an Extended Fingerprint Feature Set (CDEFFS) was chartered for that purpose. The committee includes representatives from various Federal Agencies, SWGFAST and the latent fingerprint community, and engineers from a variety of AFIS vendors.

This addendum to the standard is the result of agreements reached among the members of CDEFFS during workshops held in April, May, and July 2006, and extensive electronic interactions and document reviews from December 2005 through December 2007.

Suggestions for the improvement of this standard are welcome. They should be sent to the attention of Austin Hicklin (CDEFFS Chair), Noblis, 3150 Fairview Park Drive South, Falls Church VA 22042, hicklin@noblis.org.

[1] Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST); Memo to Mike McCabe (NIST) Regarding ANSI/NIST ITL 1-2000; November, 2005; (http://fingerprint.nist.gov/standard/cdeffs/Docs/SWGFAST_Memo.pdf)

The following individuals were members of CDEFFS and worked on defining this standard. Inclusion in this list does not necessarily imply that the affiliated organizations concur with the submittal of the proposed standard to ANSI. Members who changed affiliations are listed with all affiliations.

Behnam Bavarian	(Motorola/ABC)	Davide Maltoni	(University of Bologna)
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		Stephen Wood	(NIST)

1 Introduction

The Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information (ANSI/NIST-ITL 1-2007) is the most recent revision of a series of standards that began in 1983. These ANSI/NIST standards have been extensively used as the primary method of communicating biometric information for law enforcement and other large-scale identification purposes.

In the 2005 ANSI/NIST workshops, various participants noted that the fingerprint feature definitions in the ANSI/NIST standards (and extended by the FBI's Electronic Fingerprint Transmission Specification (EFTS)) are oversimplifications of the more extensive set of features used by human fingerprint experts. Use of the feature definitions in ANSI/NIST Type-9 records limits the performance of automated fingerprint matching systems, and limits the value of ANSI/NIST files as a format for communication between human fingerprint examiners. In response, the ANSI/NIST Committee to Define an Extended Fingerprint Feature Set (CDEFFS) was chartered, consisting of representatives from various Federal Agencies, SWGFAST and the latent fingerprint community, and engineers from a variety of AFIS vendors. This addendum is the result of more than a year of detailed interactions among the members of CDEFFS.

This is an addendum to the ANSI/NIST-ITL 1-2007 standard. This addendum defines a series of updated fields for the Type-9 record that includes a broader, more complete, and more detailed set of friction skin features than any other fingerprint features standard.

2 Scope, purpose, and conformance

2.1 Scope

This addendum defines the content, format, and units of measurement for the exchange of friction ridge feature information that may be used in the identification of a subject based on fingerprint or palmprint image information. This information is intended for interchange between criminal justice administrations or organizations that use fingerprints or palmprints for identification purposes.

2.2 Purpose

The purpose of this addendum is to define a quantifiable, repeatable, and clear method of characterizing the information content of a fingerprint or other friction ridge image.

This addendum defines a broader and more complete set of friction ridge features than has previously been defined in the ANSI/NIST standards or any other fingerprint standard. The features defined in this addendum are used to define the information content or features of latent or exemplar images from fingerprints, palmprints, or other friction ridge skin.

Uses may include, but are not limited to, fully automated searches of fingerprint or palmprint systems, human-initiated searches of automated fingerprint or palmprint systems, information exchange between human examiners, or definitions of information content of fingerprints or palmprints. Note that different uses will require different subsets of the features defined in this addendum. It should also be noted that automated algorithms can use the extended features defined for a latent search without explicitly computing them for the exemplar image, and thus it must be emphasized that automated extraction of the extended features on the exemplar is not necessarily the only nor the best way to use this information.

2.3 Conformance

A system or data record claiming conformance to this addendum shall implement the requirements for structure and content of the Type-9 record as described herein.

3 References

The following standards contain provisions that, through reference in this text, constitute provisions of this American National Standard addendum. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties that utilize this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

3.1 Normative References

This is an addendum to the existing standard:

- ANSI/NIST-ITL 1-2007, Information systems – Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information. (http://fingerprint.nist.gov/standard/)

This addendum extends the existing standard without otherwise changing any requirements or definitions within that standard.

3.2 Informative References

Federal Bureau of Investigation, Criminal Justice Information Services; *Electronic Fingerprint Transmission Specification (EFTS)*; Version 7.1 (IAFIS-DOC-0178-7.1, 2 May 2005).

Federal Bureau of Investigation, Criminal Justice Information Services; *Electronic Biometric Transmission Specification (EBTS)*; Version 8.0 (IAFIS-DOC-0178-8.0, 31 August 2007).

Federal Bureau of Investigation; *The Science of Fingerprints*; Rev 12-84; ISBN 0-16-076078-X

SWGFAST, Glossary - Consolidated 09-09-03 version. 1.0.

4 Definitions

The following definitions and those given in ANSI/NIST-ITL 1-2007 apply to this addendum. Many of these definitions are derived from those in the SWGFAST Glossary.

Complete friction ridge exemplars	A set of exemplar images of all finger and palm friction skin for an individual. Complete friction ridge exemplars include full palm print images, as well as rolled fingerprints, plain fingerprints, entire joint images, and rolled tips for all fingers. Also known as major case prints.
Distal segment	The segment of a finger or thumb farthest from the palm.
Entire joint image	An exemplar image containing all four full finger views (cf.) for a single finger. A set of major case prints (cf.) includes entire joint images for all fingers.
Exemplar	An impression or image of friction ridge skin purposely collected with the knowledge of the subject; a non-latent friction ridge image.

Fingerprint	A latent print or exemplar of the distal segment of a finger.
Flat fingerprint	A fingerprint image resulting from the touching of a single finger to a livescan platen or paper fingerprint card without any rolling motion. Also known as a single-finger plain impression.
Friction ridge skin	The papillary skin surface of the palmar surfaces of the hands and fingers, and the plantar surfaces of the feet and toes.
Full finger view	A full finger view is a rolled or plain image of a full-length finger showing all segments. An entire joint image (cf.) includes four full finger view images: one rolled; left, center, and right plain.
Incipient ridge	A friction ridge not fully developed that may appear shorter and thinner in appearance than fully developed friction ridges.
Interdigital area	The portion of the palm along the base of the fingers. See Figure A - 7.
Latent print	An impression or image of friction ridge skin left inadvertently on a surface, especially if not readily visible to the eye; a non-exemplar friction ridge image.
Level-1 features	Friction ridge flow and general morphological information. Level-1 features include (but are not limited to) pattern classifications.
Level-2 features	Individual friction ridge paths and friction ridge events, e.g., bifurcations, ending ridges, dots. Level-2 features include (but are not limited to) minutiae and the interrelationships between minutiae.
Level-3 features	Friction ridge dimensional attributes, e.g., width, edge shapes, and pores.
Major case prints	See complete friction ridge exemplars. Note that the term Major Case Prints is deprecated for some uses because in legal contexts it can be incorrectly be viewed as making an implication regarding the severity of the case.
Medial segment	The middle segment of the finger. The thumb does not have a medial segment.
Palm print	An exemplar or latent friction ridge image from the palm (side and underside) of the hand. A full palm print includes the area from the wrist to the tips of the fingers. A lower palm print includes the area from the wrist to the base of the fingers, including the entire interdigital area. An upper palm print includes the area from the tips of the fingers to the interdigital area, and must include enough of the interdigital area to be able to determine that upper and lower palm images are from the same hand.
Plain fingerprint	A fingerprint image resulting from the touching of one or more fingers to a livescan platen or paper fingerprint card without any rolling motion.
Proximal segment	The segment of the finger or thumb closest to the palm.
Valley	A lowered portion of the epidermis on the palmar or plantar skin, consisting of those areas between ridges.
Ridge	A raised portion of the epidermis on the palmar or plantar skin, consisting of one or more connected ridge units of friction ridge skin.

Ridge tracing	See skeletonized image.
Ridge unit	A portion of a ridge that contains one pore.
Rolled fingerprint	A fingerprint image collected by rolling the finger edge to edge across a livescan platen (or paper fingerprint card) from nail to nail. Rolls may be from livescan devices or scanned from paper fingerprint cards.
Skeletonized image	A representation of a friction skin image in which all pixels are white except for a 1-pixel-wide thinned black skeleton following the midpoint of each ridge. Also known as a ridge tracing.
Slap fingerprint	Slap fingerprints (slaps) are taken by simultaneously pressing the four fingers of one hand onto a scanner or fingerprint card. Slaps are also known as four-finger simultaneous plain impressions.

5 File description

This addendum defines new fields to be included in the Type-9 logical record, which is already defined in the ANSI/NIST-ITL 1-2007 standard. This new group of fields will be collectively described as the "Extended Friction Ridge Feature Set." to be added to the records. The complete list of the types of logical records together with the identifier for each type is shown in Table A - 1. The Extended Friction Ridge Features will generally correspond to a latent fingerprint or palmprint image in a Type-13 record, a fingerprint image in a Type-14 record, or a palmprint image in a Type-15 record.

Table A - 1: Logical record types

Record Identifier	Logical record contents	Type of data
1	Transaction information	ASCII
2	User-defined descriptive text	ASCII
3	Low-resolution grayscale fingerprint image	Binary
4	High-resolution grayscale fingerprint image	Binary
5	Low-resolution binary fingerprint image	Binary
6	High-resolution binary fingerprint image	Binary
7	User-defined image	Binary
8	Signature image	Binary
9	**Friction ridge feature data (was minutiae data)**	**ASCII**
10	Facial & SMT image	ASCII/Binary
11	Reserved for future use	-
12	Reserved for future use	-
13	Variable-resolution latent image	ASCII/Binary
14	Variable-resolution fingerprint image	ASCII/Binary
15	Variable-resolution palmprint Image	ASCII/Binary
16	User-defined variable-resolution testing Image	ASCII/Binary
17	Iris image	ASCII/Binary
18-98	Reserved for future use	ASCII/Binary
99	CBEFF Biometric data record	ASCII/Binary

5.1 File contents

Table A - 2 updates Table 13 from the ANSI/NIST-ITL 1-2007 standard to include the extended friction ridge feature set block.

Table A - 2: Registered feature blocks

Fields	Implementations
1-4	ALL
5-12	Standard Format Features
13-30	IAFIS Features
31-55	Cogent Systems Features
56-70	Motorola Features
71-99	Sagem Morpho Features
100-125	NEC Features
126-150	M1-378 Features
151-175	Identix Features
300-399	**Extended Friction Ridge Feature Set**

6 Record description

The following replaces ANSI/NIST ITL-1 2007 Section 8.1.6, “Type-9 Minutiae data record”.

Type-9 Friction ridge feature data record

Each Type-9 logical record shall contain and be used to exchange friction ridge feature data derived from a fingerprint, palm, or latent image. Uses may include, but are not limited to, fully automated searches of fingerprint or palmprint systems, human-initiated searches of automated fingerprint or palmprint systems, information exchange between human examiners, or definitions of information content of fingerprints or palmprints.

Note: this addendum does not otherwise change the record format specifications from ANSI/NIST ITL-1 2007.

7 Guidance in the Definition of Extended Friction Ridge Features

7.1 Region of Interest

The Region of Interest (ROI) is a rectangle or polygon that bounds the area of the original image containing a single friction ridge impression, and separates it from the background and any other friction ridge data present in the image. All other features in the Extended Friction Ridge Feature Set are in relation to the Region of Interest, not to the original image. The Region of Interest may encompass all or part of the original image. An optional polygon can further define the friction ridge area under consideration within the Region of Interest, in which case the ROI rectangle shall be the bounding box for the polygon.

Use of a Region of Interest polygon is strongly recommended when the overall image contains multiple impressions, or when it is difficult to differentiate between the friction ridge detail and the background.

A region of interest shall only include one impression made by a single or contiguous portion of friction ridge skin – multiple impressions that are not contiguous shall be defined using different regions of interest. For example, a region of interest may be limited to a single distal fingerprint, or include multiple

fingers as part of a single full palm impression, but may not include impressions of different fingers that are not connected by a common interdigital impression. In the case of overlapping fingerprints, the region of interest may include superimposed impressions.

Note that the fields that are maps of image characteristics (such as the Ridge Quality Map or the Skeletonized Image) are limited to the size of the Region of Interest, and therefore defining a Region of Interest that is smaller than the overall image may substantially reduce the size of the Type-9 record.

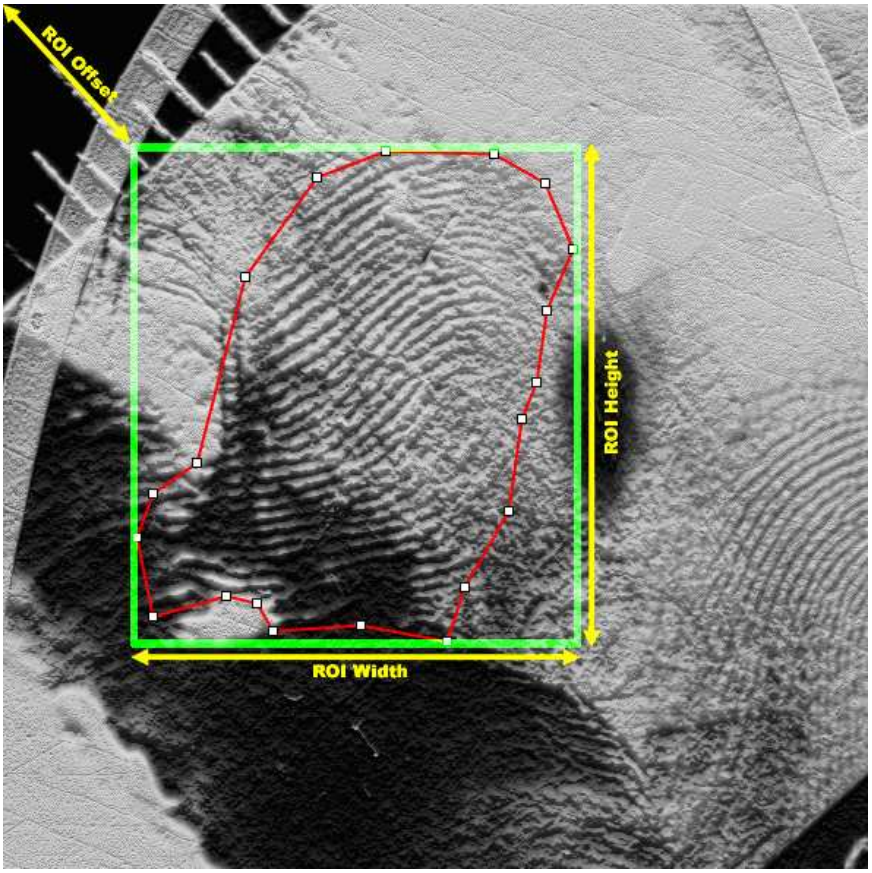

Figure A - 1: Fingerprint image with Region of Interest rectangle and polygon

7.2 Orientation

The orientation of the image shall be noted if known in the Orientation field. If the original image is not upright, digital rotation to upright is permitted but not recommended, because any method of rotation (not divisible by 90°) will degrade image quality. An alternative that will not degrade image quality (if the vertical and horizontal resolutions are the same) is to rotate in steps of 90° until the orientation is within ±45° of upright.

7.3 Comparison Features

When images are compared as candidates for individualization (potential mates), the corresponding areas and points can be retained in fields 9.360-9.361.

Comparison features are especially appropriate in transactions in which one latent image is bundled with one or more candidate/potential match images in order to show which areas and points in the latent

image correspond to areas and points in the candidate images. Such transactions may be useful for exchanges between examiners, or for communicating results back from AFIS searches. See Figure A - 2 for an example. Note that the latent has two different areas of correspondence, one for each of the exemplars.

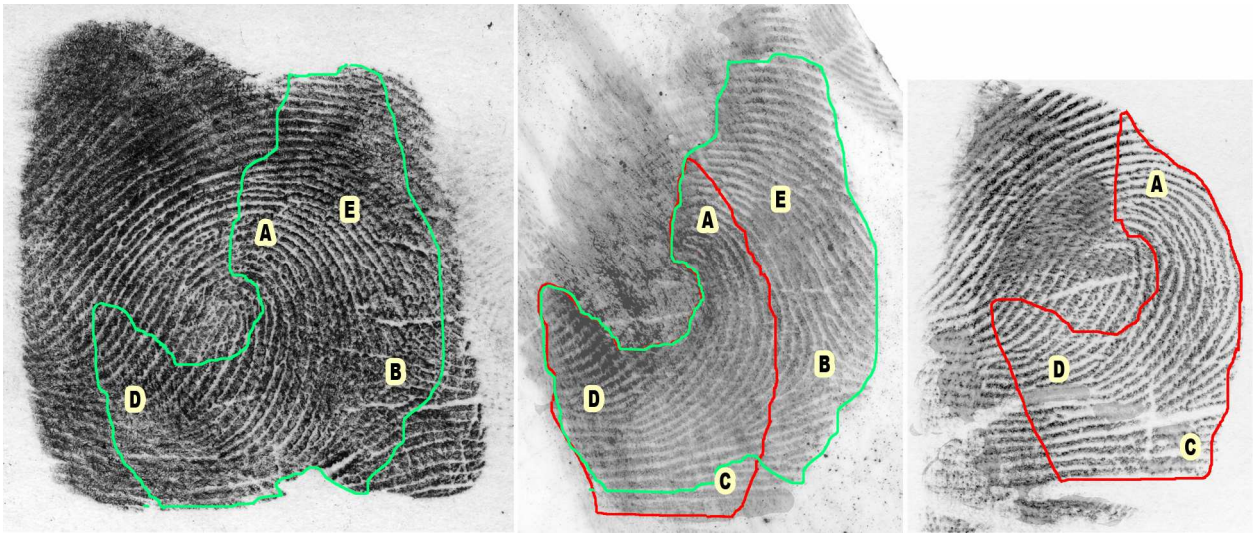

Figure A - 2: Examples of areas and points of correspondence in rolled exemplar, latent, and plain exemplar images

7.4 Skeletonized Image

A skeletonized image, also known as a ridge tracing, is a simplified representation of the ridges in the image. A skeletonized image is a rich method of conveying information, especially feature placement and interrelationships, and ridge direction and wavelength. Note that the skeleton does not replace the image: it is a clear way of defining the understanding of ridge flow and definition, both for a human examiner and an automated extractor.

A skeletonized image is a 2-tone image with a white background and a black single-pixel-wide thinned representation of each ridge. In the skeletonized image, each black pixel can have 1, 2, or 3 neighboring black pixels (1,2,3-connexity); other values (0, 4-8) are errors.

- 1 neighboring black pixel denotes a ridge ending
- 2 neighboring black pixels denote a continuing ridge
- 3 neighboring black pixels denote a bifurcation

If humans create or modify the skeletons, software must post-process their input to enforce these rules.

Incipient ridges, dots, ridge discontinuities, and protrusions are not included in the skeleton.

Flaws in the human or machine understanding of ridge flow will result in inaccuracies in the ridge skeleton. For this reason, effective use of skeletonized images requires the marking of any areas in which the skeleton is postulated rather than definitive, such as in poor-quality or debatable regions. The Ridge Flow Map field is used for this purpose: areas in the skeletonized image shall be ignored if they have a Ridge Quality Map (RQM) value of 0 (unusable); the skeletonized image shall be regarded as an estimate in areas with a Ridge Quality Map value of 1 (poor). Figure A - 3 shows an example of a skeletonized image with a quality map: the red areas are unusable areas (quality 0) and have no skeleton; the orange areas are poor (quality 1) and the skeleton information is not definitive.

Figure A - 3: Examples of fingerprint, skeletonized representation, and overlay of original / skeleton / quality map

A ridge skeleton can represent sophisticated interrelationships between features. For example, Figure A - 4 shows that the bifurcation in red shares the same ridge with the three minutiae in green. The human latent fingerprint comparison process relies heavily on such feature interrelationships.

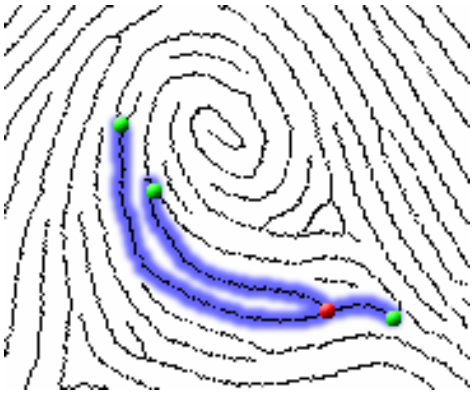

Figure A - 4: Example of interrelationships between minutiae represented in a skeletonized image

7.5 Virtual Features

Cores, deltas, and center points of reference can be defined as “Virtual” features. By marking a feature as Virtual, the position can be outside the area of ridge detail. The position of a virtual feature is marked at the best estimate of its position, with a radius of uncertainty denoting the area of other possible locations. Virtual features should only be marked if a reasonable estimate of location can be made. The X,Y location of a virtual feature must still be within the bounds of the original image, but may be located outside of the region of interest (and therefore may be a negative value). The direction of a virtual feature is optional, and may be omitted (left empty) if unknown.

8 Extended friction ridge feature set fields

The Type-9 tagged-field logical record shall contain ASCII text fields describing friction ridge feature data from a latent or exemplar image of a fingerprint, palmprint, or other area of friction ridge skin.

8.1 Notes on Representations

8.1.1 Coordinate system

The relative position of all Extended Friction Ridge Features shall be expressed as positive integers in units of 10 micrometers (0.01 mm or 0.00039 in), with the origin in the top left of the region of interest. In this coordinate system, values of X increase from left to right and values of Y increase from top to bottom. All positions must be in the range (0,0)-(ROI.width-1,ROI.height-1).[2]

Note that this is the origin used in EFTS and the IAFIS Type-9 fields, but not in the original ANSI/NIST Type-9, which uses a bottom left origin.

There are no specific maximum dimensions in the coordinate system, because dimensions are limited by the image dimensions, and ANSI/NIST ITL-1 2007 does not have stated maximum dimensions for Type 13, 14, or 15 images. Note, however, that dimensions for a single impression will always fall well within an upper bound of 50cm (19.7", or 50000 units).[3]

In all cases throughout this document in which specific distances are specified, the distances are stated in terms that correspond to an integer number of pixels at 500 pixels per inch, and the metric equivalents are rounded to two significant digits (0.01 mm).

8.1.2 Angles

All angles are measured in positive integer degrees counterclockwise from the right, from 0 to 359 degrees, as shown in Figure A - 5. (This corresponds to ANSI/NIST-ITL 1-2007, Section 14.1.4.)

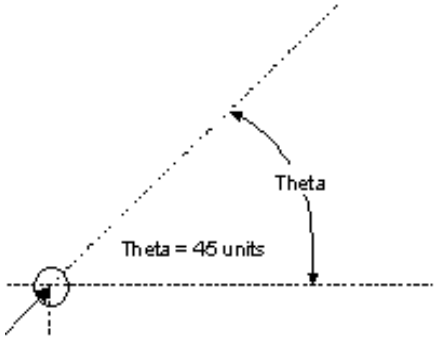

Figure A - 5: Measurement of angles

8.1.3 Polygons

A polygon is a set of 3 to 99 vertices. The order of the vertices must be in their consecutive counterclockwise order around the perimeter of the polygon. No two vertices may occupy the same location. The polygon side defined by the last subfield and the first subfield shall complete the polygon.

[2] With the exception of virtual features: see section 7.2.

[3] While most palms are less than 21 cm long (8.3") and most feet are less than 33 cm long (13"), in extreme cases palms may be 32.4 cm long (12.75") and feet may be 47 cm long (18.5"). [Robert Pershing Wadlow, *Guinness Book of World Records Online*, www.guinnessworldrecords.com/]

The polygon must be a simple, plane figure with no sides crossing and no interior holes.

Each polygon is stored as a single information item, with a comma separating the X and Y coordinates for a given vertex, and a dash separating consecutive vertices. For example:

```
X1,Y1-X2,Y2-X3,Y3
```

8.1.4 Unknown, omitted, or non-applicable values

Unknown, omitted, or non-applicable values are left empty in the Extended Friction Ridge Feature fields. If values are not known or are not applicable, a simple field without information items shall not be included in the file; a field with multiple information items shall have adjacent separators: <us><us> or <us><gs>.

8.2 Extended friction ridge feature set fields

The following sections describe the data contained in each of the Extended Friction Ridge Feature fields. Within a Type-9 logical record, entries shall be provided in numbered fields. It is required that the first two fields of the record are ordered. Table A - 3 shows the names and acronyms for fields and information items within the fields.

- The Condition Code indicates whether the field is mandatory (“M”) or optional (“O”). For information items, the Condition Code indicates when the field is present whether the information item is mandatory (“– m”) or can be left empty (“– o”). Note that the Condition Code only defines those fields that are mandatory for all transactions that use this record: specific transactions that use Extended Friction Ridge Features may require a superset of the fields to be mandatory.
- “Character type” indicates N = Numeric; A = Alphabetic; AN = Alphanumeric. All fields are ASCII text fields.
- As is true for all ASCII ANSI/NIST records, information items are separated by *US* characters, and data entries (subfields) are separated by *RS* characters.
- “Field size per occurrence” includes the size for one occurrence of the field, including (if applicable) all information items and *US* separators, as well as the *RS* separator at the end of each occurrence. (For information items, the field size per occurrence does not include any separators.)
- Note that some fields do not have maximum field sizes or number of occurrences, to accommodate palmprint requirements.
- Note that there are multiple blocks of fields that are reserved for future definition, so that similar fields can continue to be grouped together even as new fields are added to this standard.

Table A - 3: Record layout for extended friction ridge feature fields

Ident	Cond code	Field #	Field name —*Information Items*	Char type	# Inf Items	Field size per occurrence (Min/Max)		Number of occurrences (Min/Max)	
ANSI/NIST Legacy Fields (Section 8.2.1)									
LEN	M	9.001	Logical Record Length	N	0	4	8	1	1
IDC	M	9.002	Image Designation Character	N	0	2	5	1	1
IMP	M	9.003	Impression Type	N	0	2	3	1	1
FMT	M	9.004	Minutiae Format	A	0	2	2	1	1
Location and Orientation Fields (Section 8.2.2)									
ROI	M	9.300	Region of Interest	N	5	6	1024	1	1
	— m		*— Width*	*N*		*1*	*5*		
	— m		*— Height*	*N*		*1*	*5*		
	— o		*— Horizontal offset*	*N*		*0*	*5*		
	— o		*— Vertical offset*	*N*		*0*	*5*		
	— o		*— Polygon*	*N*		*0*	*1000*		
ORT	O	9.301	Orientation	N	2	3	8	0	1
	— m		*— Direction*	*N*		*1*	*4*		

Ident	Cond code	Field #	Field name —*Information Items*	Char type	# Inf Items	Field size per occurrence (Min/Max)		Number of occurrences (Min/Max)	
	— m		*— Uncertainty*	*N*		*1*	*3*		
FPP	M	9.302	Finger/Palm Position(s)	A/N	6	6	30	0	20
	— m		*— Position Code*	*AN*		*1*	*2*		
	— o		*— Finger Segment*	*A*		*0*	*3*		
	— o		*— Left*	*N*		*0*	*5*		
	— o		*— Right*	*N*		*0*	*5*		
	— o		*— Top*	*N*		*0*	*5*		
	— o		*— Bottom*	*N*		*0*	*5*		
RSV		9.303 9.306	Reserved for future definition						
Overall Image Characteristics (Section 8.2.3)									
PAT	O	9.307	Pattern Classification	A	3	3	6	0	3
	— m		*— General Classification*	*A*		*1*	*1*		
	— o		*— Subclassification*	*A*		*0*	*2*		
	— o		*— Delta Relationship*	*A*		*0*	*1*		
RQM	O	9.308	Ridge Quality Map	N	0	2	n/a	0	n/a
RQF	O	9.309	Ridge Quality Map Format		2	5	6	0	1
	— o		*— Grid size*	*N*		*1*	*2*		
	— o		*— Data format*	*A*		*3*	*3*		
RFM	O	9.310	Ridge Flow Map	AN	0	3	n/a	0	n/a
RFF	O	9.311	Ridge Flow Map Format		2	5	6	0	1
	— o		*— Sampling frequency*	*N*		*1*	*2*		
	— o		*— Data format*	*A*		*3*	*3*		
RWM	O	9.312	Ridge Wavelength Map	N	0	2	n/a	0	n/a
RWF	O	9.313	Ridge Wavelength Map Format		2	5	6	0	1
	— o		*— Sampling frequency*	*N*		*1*	*2*		
	— o		*— Data format*	*A*		*3*	*3*		
INV	O	9.314	Inverted Image	N	0	1	1	0	1
DOD	O	9.315	Degree of Distortion	N	0	1	1	0	1
FQM	O	9.316	Friction Ridge Quality Metric		4	11	18	0	20
	— m		*— Position code*	*N*		*1*	*2*		
	— m		*— Quality metric value*	*N*		*1*	*3*		
	— m		*— Quality algorithm vendor code*	*AN*		*4*	*4*		
	— m		*— Quality algorithm product code*	*N*		*1*	*5*		
RSV		9.317 9.319	Reserved for future definition						
Reference Points (Section 8.2.4)									
COR	O	9.320	Cores	A/N	5	7	23	0	n/a
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
	— o		*— Direction*	*N*		*1*	*3*		
	— o		*— Radius of position uncertainty*	*N*		*0*	*5*		
	— o		*— Virtual*	*A*		*0*	*1*		
DEL	O	9.321	Deltas	A/N	8	12	33	0	n/a
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
	— m		*— Direction up*	*N*		*1*	*3*		
	— m		*— Direction left*	*N*		*1*	*3*		
	— m		*— Direction right*	*N*		*1*	*3*		
	— m		*— Type*	*A*		*0*	*1*		
	— o		*— Radius of position uncertainty*	*N*		*0*	*5*		
	— o		*— Virtual*	*A*		*0*	*1*		

Ident	Cond code	Field #	Field name —*Information Items*	Char type	# Inf Items	Field size per occurrence (Min/Max)		Number of occurrences (Min/Max)	
CDR	O	9.322	Core-Delta Ridge Counts	N	4	6	11	0	n/a
	— *m*		— *Core Index*	*N*		*1*	*2*		
	— *m*		— *Delta Index*	*N*		*1*	*2*		
	— *m*		— *Min ridge count*	*N*		*1*	*2*		
	— *o*		— *Max ridge count*	*N*		*0*	*2*		
CPR	O	9.323	Center Point of Reference	A/N	6	8	23	0	3
	— *m*		— *Method*	*A*		*1*	*1*		
	— *m*		— *X*	*N*		*1*	*5*		
	— *m*		— *Y*	*N*		*1*	*5*		
	— *o*		— *Horizontal center only*	*A*		*0*	*1*		
	— *o*		— *Radius of position uncertainty*	*N*		*0*	*5*		
	— *o*		— *Virtual*	*A*		*0*	*1*		
DIS	O	9.324	Distinctive Characteristics		3	23	2012	0	n/a
	— *m*		— *Type*	*A*		*4*	*10*		
	— *m*		— *Polygon*	*N*		*17*	*1000*		
	— *o*		— *Comment*	*AN*		*0*	*1000*		
RSV		9.325 9.329	Reserved for future definition						
Minutiae (Section 8.2.5)									
NMN	M	9.330	Number of Minutiae	N	0	2	4	1	1
MIN	O	9.331	Minutiae		7	10	29	0	n/a
	— *m*		— *X*	*N*		*1*	*5*		
	— *m*		— *Y*	*N*		*1*	*5*		
	— *m*		— *Theta*	*N*		*1*	*3*		
	— *m*		— *Type*	*A*		*1*	*1*		
	— *m*		— *Confidence in existence*	*N*		*0*	*3*		
	— *m*		— *Confidence in direction*	*N*		*0*	*3*		
	— *m*		— *Confidence in location*	*N*		*0*	*3*		
MRA	O	9.332	Minutiae Ridge Count Algorithm	N	0	1	1	0	1
MRC	O	9.333	Minutiae Ridge Counts	N	5	9	14	0	n/a
	— *m*		— *Minutia Index A*	*N*		*1*	*3*		
	— *m*		— *Minutia Index B*	*N*		*1*	*3*		
	— *m*		— *Ridge Count*	*N*		*1*	*2*		
	— *o*		— *Reference number*	*N*		*1*	*1*		
	— *o*		— *Residual*	*N*		*1*	*1*		
RSV		9.334 9.339	Reserved for future definition						
Secondary Features (Section 8.2.6)									
DOT	O	9.340	Dots		4	6	18	0	n/a
	— *m*		— *X1*	*N*		*1*	*5*		
	— *m*		— *Y1*	*N*		*1*	*5*		
	— *o*		— *Length*	*N*		*1*	*5*		
INR	O	9.341	Incipient Ridges		4	7	23	0	n/a
	— *m*		— *X1*	*N*		*1*	*5*		
	— *m*		— *Y1*	*N*		*1*	*5*		
	— *m*		— *X2*	*N*		*1*	*5*		
	— *m*		— *Y2*	*N*		*1*	*5*		
CLD	O	9.342	Creases and Linear Discontinuities		5	8	27	0	n/a
	— *m*		— *X1*	*N*		*1*	*5*		
	— *m*		— *Y1*	*N*		*1*	*5*		
	— *m*		— *X2*	*N*		*1*	*5*		
	— *m*		— *Y2*	*N*		*1*	*5*		

Ident	Cond code	Field #	Field name —*Information Items*	Char type	# Inf Items	Field size per occurrence (Min/Max)		Number of occurrences (Min/Max)	
	— o		*— Type*	*A*		*0*	*3*		
REF	O	9.343	Ridge Edge Features		3	5	13	0	n/a
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
	— m		*— Type*	*A*		*1*	*1*		
APC	O	9.344	Area of Pore Characterization	N	0	17	1000	0	4
POR	O	9.345	Pores		2	3	11	0	n/a
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
RSV		9.346 9.349	Reserved for future definition						
Annotations (Section 8.2.7)									
MFD	O	9.350	Method of Feature Detection		5	19	254	0	n/a
	— m		*— Field(s)*	*AN*		*3*	*99*		
	— m		*— Method*	*A*		*3*	*4*		
	— m		*— Algorithm/Examiner*	*AN*		*1*	*40*		
	— m		*— Date*	*N*		*8*	*8*		
	— o		*— Notes*	*AN*		*0*	*99*		
COM	O	9.351	Comments	AN	0	1	200	0	n/a
RSV		9.352 9.359	Reserved for future definition						
Corresponding Features (Section 8.2.8)									
AOC	O	9.360	Area of Correspondence	N	3	23	1111	0	n/a
	— m		*— IDC Reference*	*N*		*4*	*10*		
	— m		*— Polygon*	*N*		*17*	*1000*		
	— o		*— Label*	*AN*		*0*	*99*		
POC	O	9.361	Points of Correspondence	N	4	6	114	0	n/a
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
	— m		*— Index*	*AN*		*1*	*2*		
	— o		*— Label*	*AN*		*0*	*99*		
RSV		9.362 9.369	Reserved for future definition						
Skeletonized Image (Section 8.2.9)									
SIS	O	9.370	Skeletonized Image Scale	N	2	3	7	0	1
	— m		*— Scale*	*N*		*1*	*5*		
	— m		*— Units*	*N*		*1*	*1*		
SIF	O	9.371	Skeletonized Image Format	A	0	3	3	0	1
SIM	O	9.372	Skeletonized Image	AN	0	n/a	n/a	0	n/a
RSV		9.373 9.399	Reserved for future definition						

8.2.1 ANSI/NIST Legacy Fields

These fields are required for all Type-9 records, in accordance with ANSI/NIST ITL-1 2007.

Field 9.001: Logical record length (LEN)

This mandatory ASCII field shall contain the total count of the number of bytes in the Type-9 logical record. Field 9.001 shall specify the length of the record including every character of every field contained in the record and the information separators, including the *"FS"* character at the end of the

record.

Field 9.002: Image designation character (IDC)

This mandatory ASCII field shall be used to identify the image data contained in the record. This IDC shall match the IDC found in the file content (CNT) field of the Type-1 record. If the image corresponding to the features in the Type-9 record is included in the same ANSI/NIST file, the Type-9 record and the corresponding image record (Type-13, 14, or 15) shall contain the same IDC.

When the Extended Friction Ridge Features are used, the corresponding image will generally be included in the same ANSI/NIST file. Including the image in the same file with the Type-9 feature record is strongly recommended but not required; transactions that use this addendum may choose to require inclusion of the image.

Field 9.003: Impression type (IMP)

This mandatory one- or two-byte ASCII field shall indicate the manner by which the image information was obtained. The appropriate code choice selected from Table A - 4 shall be entered in this field. If the image record (Type-13, 14, or 15) is present in the file, field 9.003 shall be identical to field 003 from that image record. (This table is identical to ANSI/NIST-ITL 1-2007 Table 11.)

Table A - 4: Finger and palm impression types

Description	Code
Live-scan plain	0
Live-scan rolled	1
Nonlive-scan plain	2
Nonlive-scan rolled	3
Latent impression	4
Latent tracing	5
Latent photo	6
Latent lift	7
Live-scan vertical swipe	8
Live-scan palm	10
Nonlive-scan palm	11
Latent palm impression	12
Latent palm tracing	13
Latent palm photo	14
Latent palm lift	15
Live-scan optical contact plain	20
Live-scan optical contact rolled	21
Live-scan non-optical contact plain	22
Live-scan non-optical contact rolled	23
Live-scan optical contactless plain	24
Live-scan optical contactless rolled	25
Live-scan non-optical contactless plain	26
Live-scan non-optical contactless rolled	27
Other	28
Unknown	29

If further descriptive information on the image or capture method is available, such as the latent lifting technique, it may be included as text in the Comments field (COM – 9.351).

Field 9.004: Minutiae format (FMT)

This mandatory one-byte field shall contain a "U" to indicate that the features are not formatted in the legacy “Standard” fields 9.005-9.012.

8.2.2 Location and Orientation Fields

These fields define where the impression is located in the image, how it is oriented, and the type of impression(s) present.

Field 9.300 Region of Interest (ROI)

This mandatory field defines a rectangle (and an optional polygon) that bounds the region of the image that contains the fingerprint of interest and separates it from the background and any other fingerprints present in the image. As discussed in Section 7.1, ***all*** other Extended Friction Ridge Features are in relation to the Region of Interest rectangle, ***not*** to the original image.

This field contains the following information items:

Width: The width of the region of interest in units of 10 micrometers (0.01mm).

Height: The height of the region of interest in units of 10 micrometers (0.01mm).

Horizontal offset: The horizontal distance in units of 10 micrometers from the left edge of the original image to the left edge of the region of interest. This information item is mandatory if the original image is present in the ANSI/NIST file (in a Type-13, 14, or 15 record), and optional otherwise.

Vertical offset: The vertical distance in units of 10 micrometers from the top edge of the original image to the top edge of the region of interest. This information item is mandatory if the original image is present in the ANSI/NIST file (in a Type-13, 14, or 15 record), and optional otherwise.

Polygon A polygon that further defines the friction ridge area under consideration within the Region of Interest. The format of polygons is described in Section 8.1.3. If the polygon is defined, the ROI rectangle shall be the bounding box for the polygon. The vertices of the polygon are relative to the ROI rectangle.

Field 9.301 Orientation (ORT)

This optional field allows the orientation (deviation from upright) and its uncertainty to be specified. As discussed above (in Section 7.2), rotation of the image is not recommended due to image degradation concerns.

If this field is omitted, the direction shall default to 0 (upright) and uncertainty shall default to 30, indicating that the image is rotated 0±30°.

If orientation cannot be determined, the uncertainty subfield shall be set to 180.

This field contains the following information items:

Direction: This information item contains the deviation of the region of interest from upright (fingertip up) in integer degrees. Positive angles are counterclockwise, negative

angles are clockwise. A value of “0” indicates an upright direction. Valid values range from “-179” through “180”.

Uncertainty: This information item contains the uncertainty of the orientation direction, in non-negative integer degrees. Valid values range from “0” to “180”: a value of “0” indicates a certain direction, while a value of “180” indicates an unknown orientation.

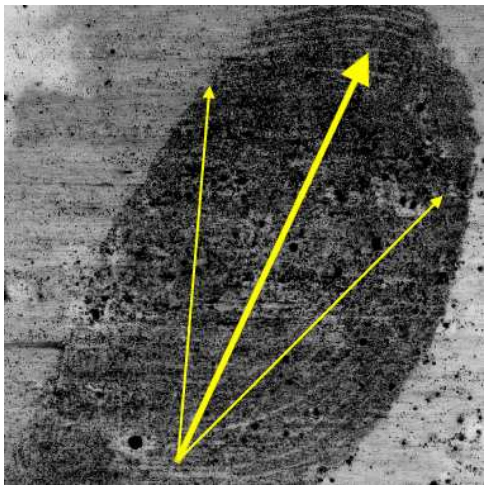

Figure A - 6: Example of orientation: -25 ± 20 degrees

Field 9.302 Finger/palm position(s) (FPP)

This mandatory field shall contain one or more of the possible physical positions that correspond to the region of interest. Multiple data entries may be used to note the presence of more than one position in the image: bounding boxes are required in this case to delineate the locations of the positions. For example, a region of interest that includes a finger’s medial and proximal segment can note those as multiple data entries.

Table A - 5: Position codes for friction ridge skin

	Position	Code
Finger	Unknown fingerprint	0
	Right thumb	1
	Right index finger	2
	Right middle finger	3
	Right ring finger	4
	Right little finger	5
	Left thumb	6
	Left index finger	7
	Left middle finger	8
	Left ring finger	9
	Left little finger	10
Finger Sets	Plain right thumb	11
	Plain left thumb	12
	Plain right four fingers	13
	Plain left four fingers	14
	Left & right thumbs	15

	Position	Code
Palm	Unknown palm	20
	Right full palm	21
	Right writer’s palm	22
	Left full palm	23
	Left writer’s palm	24
	Right lower palm	25
	Right upper palm	26
	Left lower palm	27
	Left upper palm	28
	Right other	29
	Left other	30
	Right interdigital	31
	Right thenar	32
	Right hypothenar	33
	Left interdigital	34
	Left thenar	35

	Position	Code
Foot	Unknown sole of foot	37
	Sole of right foot	38
	Sole of left foot	39
Toe	Unknown toe	40
	Right big toe	41
	Right second toe	42
	Right middle toe	43
	Right fourth toe	44
	Right little toe	45
	Left big toe	46
	Left second toe	47
	Left middle toe	48
	Left fourth toe	49
	Left little toe	50
Foot	Front/Ball of right foot	51
	Back/Heel of right foot	52

	Left hypothenar	36		Front/Ball of left foot	53
				Back/Heel of left foot	54

This field contains the following six information items:

Position Code — This information item contains the decimal code number corresponding to the known or most probable position shall be taken from Table A - 5 and entered as a one- or two-character ASCII subfield. In the unusual case that the friction skin image is from a foot or toe, codes 37 through 50 have been added to the codes 0 through 36, which are unchanged from Tables 12 and 35 in ANSI/NIST-ITL 1-2007. If the physical position for the image cannot be determined, the following fields shall be used:

- If the image is from a finger (including the lower joints) but the finger position is unknown, the code “0” shall be used.
- If the image is from a palm but the location cannot be determined, the code “20” shall be used.
- If the type of friction skin is unknown, each of the possible positions shall be included as separate data entries. Codes “0” and “20” together address all friction ridge areas on the hands; codes “37” and “40” together address all friction ridge areas on the feet.

If the image is an exemplar Entire Joint Image or Full Finger View (from a set of Major Case Prints), it shall be marked with the finger number (0-10), and shall have the individual segments marked with bounding boxes, using the next information items.

Finger Segment — This optional information item contains the 3-character code from Table A - 6 indicating the finger segment position. This field shall only be used if the Position Code indicates a finger and the region of interest contains the lower finger joint(s) or the tip of the finger.

Left, Right, Top, Bottom — These four optional information items define a bounding box that delineates the portion of the region of interest corresponding to the Position Code/Finger Segment codes. See Figure A - 8 for an example. The dimensions are in units of 10 micrometers (0.01mm). If the bounding box is not defined, the Position Code/Finger Segment codes are assumed to apply to the entire region of interest.

Table A - 6: Finger segment positions

Name	Code	Description
Tip	TIP	The plain or rolled tip of the image
Distal Segment	DST	The segment of the finger or thumb farthest from the palm
Medial Segment	MED	The middle segment of the finger (the thumb does not have a medial segment)
Proximal Segment	PRX	The segment of the finger or thumb closest to the palm

Figure A - 7 shows the location divisions for a palm, and the segment locations for the fingers.

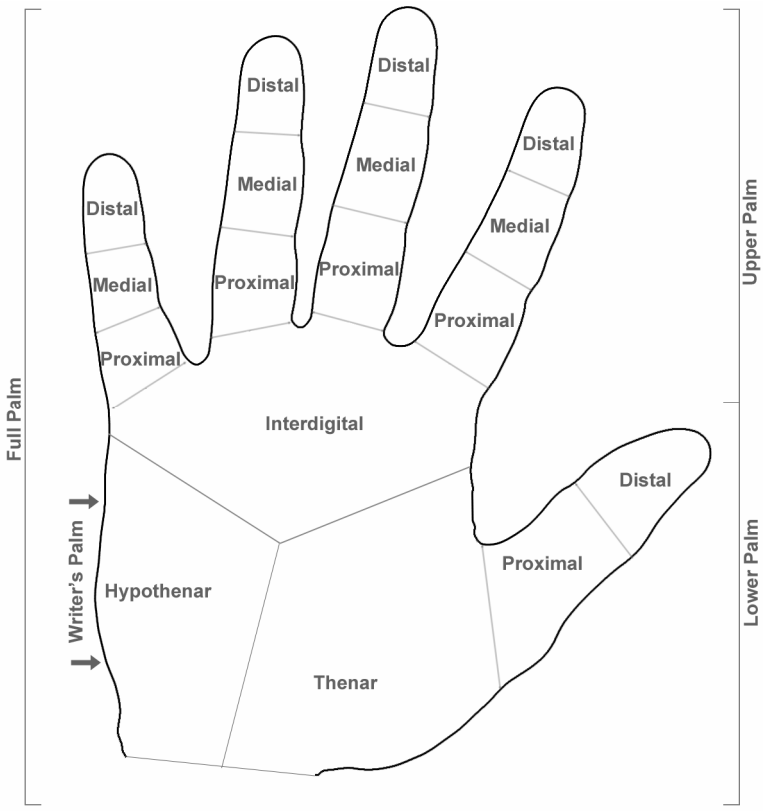

Figure A - 7: Palm and finger segment positions

Figure A - 8 shows an example of how bounding boxes can be used to mark the locations of multiple finger segments in an image.

Figure A - 8: Use of bounding boxes to mark multiple finger segments

Fields 9.303-9.306: Reserved for future definition (RSV)

These fields are reserved for definition of additional location or orientation information, for inclusion in future revisions of this standard. None of these fields is to be used at this revision level. If any of these fields are present, they are to be ignored.

8.2.3 Overall Image Characteristics

These fields serve to define the overall content and quality of the impression.

Field 9.307 Pattern Classification (PAT)

This field contains fingerprint classification information for the image. This field shall only be used for fingerprints, and shall be omitted (left empty) for palmprints or images of non-distal finger segments. The field consists of three information items, which are detailed in Table A - 7:

- ***General Classification*** includes the general set of pattern classifications (arch, whorl, left & right loop) used by most current automated systems.
- ***Subclassification*** may optionally be used by a human examiner or automated system to provide the detailed subclassification of arches and whorls. This information item shall only be included for arches or whorls, and only if the subclassification can be determined precisely.
- ***Whorl Delta Relationship*** (also known as Whorl Tracing) may optionally be used by a human examiner or automated system to provide the relationship between the deltas in a whorl. This information item shall only be included for whorls if the subclass is known, and only if the whorl delta relationship can be determined precisely. This information item shall be set to I (Inner), O (Outer), or M (Meeting), following the guidelines from The Science of Fingerprints[4] (p 60):

  When the deltas have been located, the ridge emanating from the extreme left delta is traced until the point nearest or opposite the extreme right delta is reached. The number of ridges intervening between the tracing ridge and the right delta are then counted. If the ridge traced passes inside of (above) the right delta, and three or more ridges intervene between the tracing ridge and the delta, the tracing is designated as an "inner" […] If the ridge traced passes outside of (below) the right delta, and three or more ridges intervene between the tracing ridge and the delta, the tracing is designated as an "outer" […] All other tracings are designated as "meeting."

This field may include up to three data entries: a primary pattern and (optionally) up to two reference patterns. Classification must be conservative: if the pattern is known precisely, only the primary pattern shall be used; if there is any doubt as to the precise classification, a reference pattern shall be included. If the pattern cannot be classified, but a pattern type can be definitively excluded, then that should be indicated by referencing two or three of the basic classes (AU, WU, RS, LS). For example, a latent that contains a left delta but no core can exclude arches and left loops, so it would use WU;RS.

Note that the pattern classification can be further defined through the use of the Core-Delta Ridge Counts field (CDR – 9.322).

[4] Federal Bureau of Investigation; *The Science of Fingerprints*; Rev 12-84; ISBN 0-16-076078-X

Table A - 7: Pattern classification codes

	Pattern Classification	General Class	Subclass	Whorl Delta Relationship
Arches	Arch, type not designated	AU		
	- Plain Arch		PA	
	- Tented Arch		TA	
Whorls	Whorl, type not designated	WU		
	- Plain Whorl		PW	I, O, or M
	- Central Pocket Loop		CP	I, O, or M
	- Double Loop		DL	I, O, or M
	- Accidental Whorl		AW	I, O, or M
Loops	Right Slant Loop	RS		
	Left Slant Loop	LS		
Unable to print	Amputation	XX		
	Temporarily unable to print (e.g., bandaged)	UP		
Unable to classify	Unable to Classify	UC		
	- Complete Scar	SR		
	- Dissociated Ridges/Dysplasia	DR		

Field 9.308 Ridge Quality Map (RQM)

For every cell in a grid superimposed on the Region of Interest, this field notes the local ridge quality of the friction ridge detail within that cell. Local ridge quality defines clarity in terms of the ability to discern detail in a given location. The quality of each cell will be represented with a value 0 through 3 representing the quality of ridge detail in that cell, as specified in Table A - 8.

The storage format is specified in the Ridge Quality Map Representation (RQR) field. The size of the grid is specified in the Ridge Quality Map Format (RQF) field.

Table A - 8: Local ridge quality codes

Code	Name	Description
0	Unusable	No usable image data: no usable ridges or fingerprint features. No Extended Friction Ridge Features shall be marked in “Unusable” areas, except for virtual features. The skeletonized image and ridge flow map shall be ignored in “Unusable” areas.
1	Poor	Usable but debatable image data. Ridge detail is present but unclear. The ridge direction may be determined, but placement of the ridge is not definitive. Minutiae may be marked but the presence, absence, and location of minutiae in a “Poor” area is not definitive. The skeletonized image and ridge flow map may be used in “Poor” areas, but are not definitive.
2	Satisfactory	Ridge detail is adequate to correctly mark minutiae: the presence, absence, and location of minutiae are definitive. The skeletonized image and ridge flow map are definitive. Some ridge width or edge shape information may be inferred but is not clearly discernable.
3	Good	Ridge width and edge shape are clearly discernable. All features are definitive in “Good” areas.

Field 9.309 Ridge Quality Map Format (RQF)

This optional field permits setting the grid size or data representation format used in the Ridge Quality Map (RQM) field to values other than the defaults. This field consists of two information items:

- ***Grid size:*** The grid size (both the horizontal and vertical dimensions of a single cell in the grid) is set by default to 0.41mm (0.016" – note this is 8 pixels at 500ppi, or 16 pixels at 1000ppi). This

information item may be used to define grid sizes no larger than the default: valid settings range from "1" (0.01mm) through "41" (0.41mm).

- ***Data format:*** This optional field defines the format used in the Ridge Quality Map (RQM) field, as defined in Table A - 9. The default is the "UNC" format. For all formats:
  - The first cell starts at the top left corner of the Region of Interest, with cells in order left to right.
  - All of the quality values for each row are stored in one data entry, with rows separated by a GS character.
  - If the width and/or height of the Region of Interest are not evenly divisible by the Grid Size, partial cells shall be included at the right and/or bottom of the ridge flow map.
  - The number of data entries in the field is the same as the number of cells in one column: the Region of Interest's height divided by the Grid Size, rounded up.

Table A - 9: Ridge quality map data representation format options

Code	Type	Description
UNC	Uncompressed (concatenated decimal)	The values for each grid cell in the Ridge Quality Map field are single-character integer values as defined in Table A - 8, with one character per cell. All quality values for one row are concatenated left to right, with one data entry for each row, separated by a RS character. The number of characters in one data entry is the same as the number of cells in one row: the Region of Interest's width divided by the Grid Size, rounded up.
B64	Bit-packed base 64	The values for each grid cell in the Ridge Quality Map field are values as defined in Table A - 8, bit-packed left to right into the base-64 character set so that the values for three cells (two bits each) can be contained in each base-64 character. This reduces storage for the Ridge Quality Map by 67%. All quality values for one row are bit-packed left to right, with one data entry for each row, separated by a RS character. The number of characters in one data entry is one third of the number of cells in one row.

Field 9.310 Ridge Flow Map (RFM)

This field contains the direction of friction ridges at various sampling points throughout the region of interest. This field is based on a uniform sampling frequency that defaults to 0.41 mm (0.016 in – note this is 8 pixels at 500ppi, or 16 pixels at 1000ppi). The sampling frequency may optionally be set to a higher resolution in Field 9.311 (Ridge Flow Map Format). The first sampling point in the image is the top left-most point in the region of interest. The same sampling frequency is used both horizontally and vertically. Values shall be included for all sampling points in the region of interest, even if the sampling points are at the edge of the region of interest.

For each sampling point, angles shall be reported in integer degrees, with 0 degrees to the right (horizontal), increasing counterclockwise to a maximum value of 179° (since 180°=0°). Undefined angles are recorded as noted in Field 9.311 (Ridge Flow Map Format).

Note that the area used for determining direction (window size) may be larger or smaller than the sampling frequency. Different window sizes may be used within a single image, at the discretion of the implementer. For example, an implementer may choose to use a uniform window size except in areas of high curvature, in which a smaller window size may be used.

Interrelationships with other fields:

- If this field is present, the Ridge Quality Map (RQM) is strongly recommended: the Ridge Quality Map values may be used as confidence measures for the Ridge Flow Map. Transactions based on this addendum may choose to make this a requirement.

Field 9.311 Ridge Flow Map Format (RFF)

This optional field permits setting the sampling frequency or data representation format used in the Ridge Flow Map (RFM) field to values other than the defaults. This field consists of two information items:

- ***Sampling frequency:*** The sampling frequency for the Ridge Flow Map is set by default to 0.41mm (0.016"). This information item may be used to define higher resolution sampling frequencies than the default: valid settings range from “1” (0.01mm) through “41” (0.41mm).
- ***Data format:*** This optional field defines the format used in the Ridge Flow Map field, as defined in Table A - 10. The default is the uncompressed (“UNC”) format.

Table A - 10: Ridge flow map data representation format options

Code	Type	Description
UNC	Uncompressed (concatenated hexadecimal)	Each ridge flow value is a 2-character hexadecimal value. The angles are stored in 2-character hexadecimal representation with leading zeros, so valid values range from “00” (0dec) to “B3” (179dec). If the direction cannot be determined at a given location, the location at that point shall be marked as “XX”. All of the ridge flow values for a given row shall be concatenated in order left to right and saved as a separate data entry, delimited by an RS separator. The number of characters in one data entry is twice the number of cells in one row.
B64	Base 64	Each ridge flow value is a 1-character base-64 value. The angles are divided by three to enable storing in a single base-64 character, which has the effect of quantizing to three degrees. If the direction cannot be determined at a given location, the location at that point shall be marked as “X”. All of the ridge flow values for a given row shall be concatenated in order left to right and saved as a separate data entry, delimited by an RS separator. The number of characters in one data entry is the number of cells in one row.

Field 9.312 Ridge Wavelength Map (RWM)

This field contains the peak-to-peak distance between ridges at various sampling points throughout the region of interest. This field is based on a uniform sampling frequency that defaults to 0.41 mm (0.016 in – note this is 8 pixels at 500ppi, or 16 pixels at 1000ppi). The sampling frequency may optionally be set to a higher resolution in the Ridge Wavelength Map Format (RWF) field. The first sampling point in the image is the top left-most point. The same sampling frequency is used both horizontally and vertically. Values shall be included for all sampling points in the image, even if the sampling points are at the edge of the image.

For each sampling point in the Region of Interest, distances between ridge peaks, measured perpendicular to ridge flow, shall be reported in 2-character decimal format using units of 10 micrometers (0.01mm). The size of the area around the sampling point (window size) used to determine measurements is left to the discretion of the implementer, and may vary within an image. Unknown values shall be set to “XX”. Valid values are therefore “01” (0.01mm) through “99” (0.99mm or greater). (In practice, the actual stored values are likely to be “30” to “70” in most cases (0.3 – 0.7 mm).

The 2-character decimal wavelength values for each sampling point are concatenated left to right for all sampling points in a row, with one data entry for each row, separated by a GS character. The number of characters in one data entry is twice the number of sampling points in one row.

Field 9.313 Ridge Wavelength Map Format (RWF)

This optional field permits setting the sampling frequency or data representation format used in the Ridge Wavelength Map (RWM) field to values other than the defaults. This field consists of two information items:

- ***Sampling frequency:*** The sampling frequency for the Ridge Wavelength Map is set by default to 0.41mm (0.016"). This information item may be used to define higher resolution sampling frequencies than the default: valid settings range from “1” (0.01mm) through “41” (0.41mm).
- ***Data format:*** This optional field defines the format used in the Ridge Wavelength Map field. The default (and currently the only setting) is the uncompressed (“UNC”) format. *(Note: This information item is a placeholder. Because of the possibly very large size of RWM, this provides for future, more compressed formats.)*

Field 9.314 Negative image (NEG)

Ridges in friction ridge images shall be represented by default as dark areas, with valleys as light areas. This 1-character optional field indicates whether the image is inverted black-for-white, using the codes from Table A - 11. For some methods of processing latent images, only a portion of the image is negative; in this case, the Distinctive Characteristics field (DIS – 9.324) can be used to define the negative area.

Table A - 11: Negative image codes

Code	Description
P	Positive: Ridges in the image are dark; valleys are light. (Default)
N	Negative: Ridges in the image are light; valleys are dark.

Field 9.315 Degree of distortion (DOD)

This 1-character optional field indicates the overall degree of distortion (ridge flow deformation) in the image, as defined in Table A - 12. Note that this field contains an overall assessment of distortion: localized distortion can be marked in the Distinctive Characteristics field (DIS – 9.324).

Table A - 12: Degree of distortion codes

Code	Type	Description
1	No obvious distortion	No evidence of compression or stretching of ridges.
2	Some distortion	Minimal or moderate compression or stretching of ridges; no evidence of twisting of ridges.
3	Significant distortion	Extreme, uneven, or unusual compression or stretching of ridges, or any twisting of ridges.

Field 9.316 Friction ridge quality metric

This optional field is used to specify one or more different metrics of image quality for the image stored in this record. The meaning attributed to this metric must be defined and interpreted by the producer of the scoring algorithm or by the person or system used to assign the metric to the latent image. The metric may be a predictor of AFIS matcher accuracy performance or a different metric to indicate a value associated with the quality of the latent image for a particular function.

This field corresponds to fields 13.024, 14.024, and 15.024: if the image record (Type-13, 14, or 15) is present in the file, field 9.316 shall either be omitted or be identical to field 13.024, 14.024, or 15.024 from that image record.

This field identifies a quality score and the algorithm used to create the quality score. This information is useful to enable the recipient of the quality score to differentiate between quality scores generated by different algorithms and adjust for any differences in processing or analysis as necessary.

This field may contain one or more data entries, each consisting of four information items separated by the "US" separator character. Multiple data entries shall be used if multiple data entries are present in the Finger/palm position(s) field (FPP -- 9.306).

- The first information item is the code from Table A - 5, corresponding to each value in the Finger/palm position(s) field (FPP -- 9.306).
- The second information item shall be a quantitative expression of the predicted matching performance of the biometric sample. This item contains the ASCII representation of the integer image quality score between 0 and 100 assigned to the image data by a quality algorithm. Higher values indicate better quality. An entry of “255” shall indicate a failed attempt to calculate a quality score. An entry of “254” shall indicate that no attempt to calculate a quality score was made. The use of additional values to convey other information should be harmonized with ISO/IEC 19794 standards.
- The third information item shall specify the integer value that is the ID of the vendor of the quality algorithm used to calculate the quality score. The IBIA shall maintain the Vendor Registry of CBEFF Biometric Organizations that will map the value in this field to a registered organization.
- The fourth information item shall specify a numeric product code assigned by the vendor of the quality algorithm, which may be registered with the IBIA, but registration is not required. It indicates which of the vendor’s algorithms was used in the calculation of the quality score. This field contains the ASCII representation of the integer product code and should be within the range 1 to 65535. This data entry is repeated for each latent image and quality algorithm used, separated by the “RS” character.

Fields 9.317-9.319: Reserved for future definition (RSV)

These fields are reserved for definition of additional overall image characteristics, for inclusion in future revisions of this standard. None of these fields is to be used at this revision level. If any of these fields are present, they are to be ignored.

8.2.4 Reference Points

These fields define primary reference points or areas, such as cores, deltas, and scars.

Field 9.320 Cores (COR)

A core is located at the focus of the innermost recurving ridgeline of a ridge pattern: if the ridge is viewed as a section of a circle, the core is the center of that circle; if the ridge is viewed as an ellipse or parabola, the core is the focal point of that curve. The direction of the core is away from the center of the curve. Figure A - 9 shows an example of how the core is placed. Note that the core is not on the innermost recurving ridgeline itself.

Figure A - 9: Placement of the core at the focus of the innermost recurving ridgeline

The core or cores of a fingerprint are defined for all pattern classifications other than plain arches, as shown in Table A - 13.

- Cores may be marked on tented arches if an innermost recurving ridge is present.
- Plain or central pocket loop whorls will only have one core if the innermost recurving ridge is circular, or two cores if elliptical. A whorl with only one core does not have a defined direction.
- Accidentals may have any number of cores.

For palmprints or other non-fingerprint friction ridge images, core-like patterns may be defined using this field if such structures are present.

Table A - 13: Number of cores and deltas by pattern class

	Pattern Classification	Cores	Deltas
Arches	- Plain Arch	0	0
	- Tented Arch	0 or 1	0 or 1
Whorls	- Plain Whorl	1 or 2	2
	- Central Pocket Loop	1 or 2	2
	- Double Loop	2	2
	- Accidental Whorl	N	N
Loops		1	1

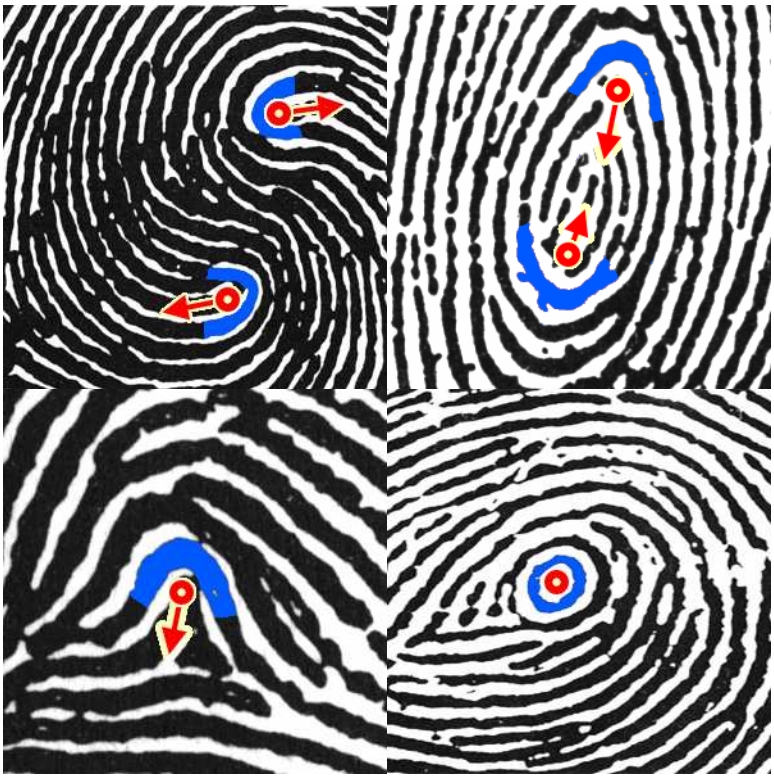

Figure A - 10: Examples of core locations for a double loop whorl, plain whorl, tented arch, and central pocket loop whorl

This field consists of six information items:

- ***X, Y:*** The location of the core, in units of 10 micrometers (0.01mm)
- ***Direction:*** The direction of the core. This set to the average tangent direction of the two closest ridges as measured 1.63mm (0.064 inches) from the focal point. This is approximately the same as the direction of the directrix of the best fitting parabola. The direction must be omitted (left empty) for circular whorls, or if the direction is unknown.
- ***Radius of position uncertainty:*** This optional information item defines the radius of a circle centered at the location (X,Y) of the core; the circle is sized to include the area of other possible locations of the core, if the precise location cannot be determined (such as due to poor clarity). If the location is known precisely, the radius of position uncertainty may be omitted or set to 0. The radius of uncertainty is measured in integer units of 10 micrometers (0.01mm), and may overlap the edge of the image.
- ***Direction uncertainty:*** This optional information item contains the uncertainty of the direction of the core, in non-negative integer degrees. Valid values range from “0” to “180”: a value of “0” (default) indicates a certain direction, while a value of “180” indicates an unknown orientation.
- ***Virtual:*** Virtual cores shall have the value “V” in this information item, which shall be omitted (left empty) otherwise. Virtual features are described in Section 7.2.

Interrelationships with other fields:

- If this field is present and the image is a fingerprint, Pattern Class (PAT) is strongly recommended; transactions based on this addendum may choose to make this a requirement. Note that this does not mean that the classification has to be known definitively, but must at least be known to the extent of excluding plain arches.

Field 9.321 Deltas (DEL)

The delta or deltas of a fingerprint are defined for all pattern classifications other than plain arches, as shown in Table A - 13. Note that tented arches should have deltas marked if such a structure is present. Accidentals may have any number of deltas. Delta-like patterns may be defined using this field if such structures are present in palmprints or other non-fingerprint friction ridge images.

This field consists of eleven information items:

- ***X, Y:*** These two mandatory information items define the location of the delta, in units of 10 micrometers (0.01mm).
- ***Direction A, B, C:*** These three optional information items define the three directions of the delta, in degrees counterclockwise from the right. The three angles shall be reported in order by increasing angle, which for fingerprint deltas with known orientation will result in the order up, left, then right. These three information items may be omitted (left empty).
- ***Type:*** This optional information item defines whether the fingerprint delta is a left, right, or unknown type, depending on its relation to the core. For an accidental with more than two deltas, deltas other than the leftmost and rightmost are considered unknown. Palmprint deltas are considered unknown. This information item shall contain “L” or “R” for right or left deltas, and shall be omitted (left empty) otherwise.
- ***Radius of position uncertainty:*** This optional information item defines the radius of a circle centered at the location (X,Y) of the delta; the circle is sized to include the area of other possible locations of the delta, if the precise location cannot be determined (such as due to poor clarity). If the location is known precisely, the radius of position uncertainty may be omitted or set to 0. The radius of uncertainty is measured in integer units of 10 micrometers (0.01mm), and may overlap the edge of the image.
- ***Direction uncertainty A, B, C:*** These three optional information items contain the uncertainty of the three delta angles, in non-negative integer degrees. Valid values range from “0” to “180”: a value of “0” (default) indicates a certain direction, while a value of “180” indicates an unknown orientation.
- ***Virtual:*** This optional information item defines whether the fingerprint delta is virtual: virtual deltas shall have the value “V” in this information item, which shall be omitted (left empty) otherwise. Virtual features are described in Section 7.2.

Interrelationships with other fields:

- If this field is present and the image is a fingerprint, Pattern Class (PAT) is strongly recommended; transactions based on this addendum may choose to make this a requirement. Note that this does not mean that the classification has to be known definitively, but must at least be known to the extent of excluding plain arches.

Field 9.322 Core-delta ridge counts (CDR)

This field contains the count of intervening ridges between each core and delta. Each ridge count has a minimum and maximum value, so that a range can be noted. If the exact value is known, then that value should be put in the minimum and maximum fields. If only a minimum is known, such as when a delta is not visible, the maximum value shall be omitted. Ridge counts can be any non-negative integer.

When this field is used for fingerprints, ridge counts shall be provided between each core and each delta, unless there are more than two cores or two deltas in an accidental whorl, in which case only the leftmost and rightmost of the cores and deltas need be used for ridge counts.

This field consists of four information items:

- ***Core Index:*** The index (1-based data entry/subfield number) of the core corresponding to this count. Shall be set to “1” if only one core is defined.
- ***Delta Index:*** The index (1-based data entry/subfield number) of the delta corresponding to this count. Shall be set to “1” if only one delta is defined.

- ***Min ridge count:*** If the ridge count is known precisely, this information item contains that value; otherwise, the minimum of the range of ridge count values.
- ***Max ridge count:*** If the ridge count is known precisely, this information item contains that value; otherwise, the maximum of the range of ridge count values. If there is no known maximum, this field shall be omitted (left empty).

Interrelationships with other fields:

- If this field is present, then the Cores (COR) and Deltas (DEL) fields are required. If this field is present and the image is a fingerprint, Pattern Class (PAT) is strongly recommended; transactions based on this addendum may choose to make this a requirement.

Field 9.323 Center point of reference (CPR)

This field contains the location of a center point of reference of a fingerprint, which can be used to define how centered a fingerprint is, as a feature, for registration or orientation, and for quality measurements. While the core may serve some of the same purposes, a center point of reference is defined for arches and provides a single center location for complex whorls, unlike cores.

The location of a center point of reference can be determined using different algorithms, as stored in the Method information item.

The center point of reference can only be defined for fingerprints, not for other types of friction ridge images.

This field consists of six information items:

- ***Method:*** The method of determining the X,Y location, selected from Table A - 14.
- ***X, Y:*** The location of the center point of reference, as defined in Method, in units of 10 micrometers (0.01mm)
- ***Lateral center only:*** In some cases, particularly with arches, the center location can be determined with reasonable accuracy in one dimension (laterally, or across the finger) but is only approximate in the other dimension (longitudinally, or along the finger). In this case, this information item shall be set to “Y” (Yes); otherwise it shall be omitted (left empty).
- ***Radius of position uncertainty:*** The radius of position uncertainty is 0 (default) if the location is known precisely; if the precise location cannot be determined (such as due to poor clarity), the position is marked at the best estimate of position, with a radius including the area of other possible locations, in integer units of 10 micrometers (0.01mm). The radius of uncertainty can overlap the edge of the image.
- ***Virtual:*** Virtual features shall have the value “V” in this information item, which shall be omitted (left empty) otherwise. Virtual features are described in Section 7.2.

Table A - 14: Methods of determining center point of reference locations

Code	Name	Description
0	Uppermost point of the ridge with greatest curvature	For a fingerprint with a known or estimated orientation, the center point is determined by finding the highest point of each ridge that is convex pointing upward, and measuring the curvature/peak angle by following the ridge 1.63mm (0.064in) in both directions from that point, as shown in Figure A - 11. The point with the minimum angle (greatest curvature) is the center point of reference.
1	Overall fingerprint focal point	The overall fingerprint focal point is the point where the lines perpendicular to ridge flow converge, as shown in Figure A - 12. The point of convergence is determined in terms of least squares (see, e.g., Novikov and Kot (1998)[5])

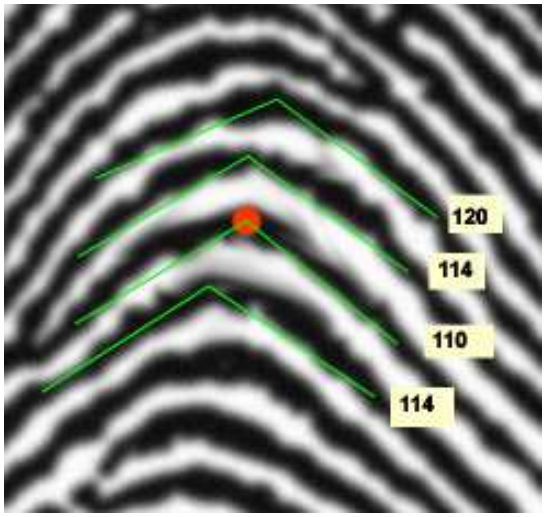

Figure A - 11: Uppermost point of the ridge with greatest curvature. Measurements are angles (degrees)

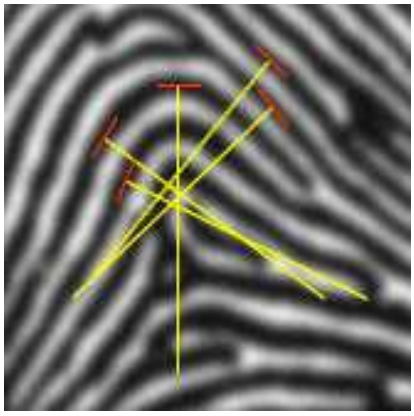

Figure A - 12: Overall fingerprint focal point

[5] Novikov S.O and Kot V.S.; "Singular Feature Detection and Classification of Fingerprints using Hough Transform"; *Proc. Of SPIE (Int. Workshop on Digital Image Processing and Computer Graphics (6th): Applications in Humanities and Natural Sciences)*; vol 3346, pp 259-269, 1998

Field 9.324 Distinctive characteristics (DIS)

This field is used to define one or more areas containing unusually discriminating characteristics or localized quality issues that are not fully defined using other Extended Friction Ridge Features.

This field consists of three information items:

- ***Type:*** The type of distinctive feature, selected from Table A - 15
- ***Polygon:*** A polygon outlining the area of the distinctive feature, defined as stated in Section 8.1.3
- ***Comment:*** Optional text describing the feature

Table A - 15: Types of distinctive features

Code	Description
CORE	Unusual core area
DELTA	Unusual delta area
SCAR	Scar
DYSPLASIA	Dissociated ridges/ Dysplasia
MINUTIA	Unusual minutia
MINGROUP	Group or cluster of minutiae in close proximity
COMPRESSED	Distorted area with compressed ridges
STRETCHED	Distorted area with stretched ridges
TWISTED	Distorted area with twisted ridges
OVERLAP	Area in which another fingerprint is superimposed over the fingerprint of interest
NEGATIVE	Used if only a portion of the fingerprint image has ridges and valleys inverted so that ridges appear white and valleys appear black. Note that the Negative Image (NEG) field is used if the entire image is negative.
OTHER	Other unusual features not characterized elsewhere

Fields 9.325-9.329: Reserved for future definition (RSV)

These fields are reserved for definition of additional reference point features, for inclusion in future revisions of this standard. None of these fields is to be used at this revision level. If any of these fields are present, they are to be ignored.

8.2.5 Minutiae

These fields define the minutiae and minutiae-related data in the impression.

Field 9.330 Number of minutiae (NMN)

This field is used to define the number of minutiae in the region of interest. This value shall correspond to the number of data entries in the Minutiae (MIN) field.

This field shall only be set to “0” if there are no minutiae in the region of interest. If the number of minutiae has not been ascertained (such as in an image search), this field shall be omitted.

Interrelationships with other fields:

- If this field contains a positive value, then the Minutiae (MIN – 9.331) field is required. Otherwise, the Minutiae (MIN – 9.331) field must be omitted.

Field 9.331 Minutiae (MIN)

This field is used to define the characteristics of all minutiae in the region of interest. The number of data entries in this field shall correspond to the value of the Number of Minutiae (NMN) field.

There are three confidence values used to define how precisely the minutia can be defined: confidence in existence, direction, and location. Each of these optional information items contains a positive integer value from “1” to “100” indicating the percentage confidence in the existence of the minutia. If the confidence value is determined by a human examiner, the only valid values shall be “100” (certain) or “50” (debatable); automated algorithms may use the full range.

This field consists of seven information items:

- ***X, Y:*** The location of the minutia, in units of 10 micrometers (0.01mm). Ridge endings are located at the fork of the tracing (midpoint) of the valley, and bifurcations are at the fork of the tracing of the ridge.
- ***Theta:*** The direction of the minutia, in degrees. The angle of the minutiae is determined by constructing three virtual rays originating at the minutia and extending 1.93mm (0.064”) along each ridge (for a bifurcation) or valley (for a ridge ending). The smallest of the three angles formed by the rays is bisected to indicate the minutiae direction.
- ***Type:*** The type of minutia, selected from Table A - 16. All complex minutiae types (crossovers/trifurcations etc) should be marked as combinations of bifurcation/endings. The “either” type shall be used only for minutiae that are not clearly distinguishable as either a ridge ending or a ridge bifurcation.
- ***Confidence in existence:*** This optional information item contains a positive integer value from “1” to “100” indicating the percentage confidence in the existence of the minutia. Examples of cases in which confidence in existence may be low include short bifurcations that may be considered protrusions, short ridges that may be considered dots, or endings on ridges that may be incipient.
- ***Radius of position uncertainty:*** This optional information item defines the radius of a circle centered at the location (X,Y) of the minutia; the circle is sized to include the area of other possible locations of the minutia, if the precise location cannot be determined (such as due to poor clarity). If the location is known precisely, the radius of position uncertainty may be omitted or set to 0. The radius of uncertainty is measured in integer units of 10 micrometers (0.01mm), and may overlap the edge of the image.
- ***Direction uncertainty:*** This optional information item contains an integer value from “0” (default) to “180” indicating the precision in the direction (theta) of the minutia, measured in degrees. Examples of cases in which confidence in direction may be low include cases when the ridge stops or bends close to the minutia so that a good angle measurement cannot be taken, or cases with three equally spaced legs.

Table A - 16: Minutia types

Code	Description
E	Ridge ending
B	Ridge bifurcation
X	Either ridge ending or bifurcation, not clearly distinguishable

Interrelationships with other fields:

- This field shall be present if and only if the Number of Minutiae (NMN) field contains a positive value.
- If this field is present, then the Ridge Quality Map (RQM) field is required. The Ridge Quality Map is used to determine whether the absence of a minutia is definitive or unknown.

Field 9.332 Minutiae ridge count algorithm (MRA)

This field defines the algorithm used in determining how neighboring minutiae are selected for use in the ridge counts in the Minutiae Ridge Counts (MRC) field. The value for this field shall be selected from Table A - 17.

Table A - 17: Minutiae ridge count algorithms

Code	Description
EFTS (default)	The minutiae used for ridge counts are the nearest neighbors in eight octants, with the center of the 0th octant defined by the current minutia's theta, and the 1st through 7th octants proceeding counterclockwise. See [EFTS][6] for further details.

Note: This is a placeholder. Other values will presumably be defined in the future.

Field 9.333 Minutiae ridge counts (MRC)

This field contains the counts of intervening ridges between specified minutiae. The Minutiae Ridge Count Algorithm (MRA) field governs how the minutiae are selected for ridge counts, and the details of how the ridges are counted.

While this field is arguably unnecessary if the Skeletonized image (SIM – 9.999) is present, but is included for backwards compatibility, of for cases in which the Skeletonized image is unavailable.

This field consists of five information items:

- ***Minutia Index A:*** The index (1-based data entry/subfield number) of the first minutia.
- ***Minutia Index B:*** The index (1-based data entry/subfield number) of the second minutia.
- ***Ridge Count:*** The number of intervening ridges between Minutia A and B. Unknown ridge counts shall be omitted (left empty). Other details or special cases (if any) are governed by the Minutiae Ridge Count Algorithm (MRA) field.
- ***Reference number:*** An optional reference number specific to the ridge count algorithm. For example, for the EFTS ridge count algorithm, this information item specifies the octant.
- ***Residual:*** An optional information item specific to the EFTS ridge count algorithm, specifying the half of the octant in which the neighboring minutia lies.

Fields 9.334-9.339 Reserved for future definition (RSV)

These fields are reserved for definition of additional minutiae-related features, for inclusion in future revisions of this standard. None of these fields is to be used at this revision level. If any of these fields are present, they are to be ignored.

8.2.6 Secondary Features

These fields define a variety of Level-2 and Level-3 features.

Field 9.340 Dots (DOT)

A dot is a single or partial ridge unit that is shorter than 0.5mm (0.02"). Longer ridge units are considered standard ridges and should be marked as such, with two ridge endings. Potential dots that are substantially thinner than local ridge width should be marked as incipient ridges.

A dot is marked by its center point. Elongated dots may optionally have their length marked along the longest dimension.

This field consists of three information items:

- ***X, Y:*** The location of the center of the dot, in units of 10 micrometers (0.01mm).

[6] Federal Bureau of Investigation, "Electronic Fingerprint Transmission Standard", Version 7.1.

- ***Length:*** . An optional information item containing the length of the dot along its longest dimension.

Field 9.341 Incipient Ridges (INR)

An incipient is a thin ridge unit, substantially thinner than local ridge width. An incipient is marked with the X,Y endpoints along its longest dimension. If the incipient is a series of clearly separate (thin) dots, they should be marked as separate incipients. If an unbroken incipient curves, it should be marked as a series of adjoining line segments.

This field consists of four information items:

- ***X1, Y1:*** The location of one endpoint, in units of 10 micrometers (0.01mm).
- ***X2, Y2:*** The location of the other endpoint.

Field 9.342 Creases and linear discontinuities (CLD)

Linear discontinuities are creases, cracks, cuts, and thin or non-permanent scars. Linear discontinuities result in small gaps in two or more ridges. If a continuous discontinuity curves, it should be marked as a series of adjoining line segments. If a crease is feathered or composed of a series of crisscross creases, each of the short creases shall be marked separately.

The permanent flexion creases are the named creases that separate the joints of the fingers and divide the palm. The crease name shall be noted for permanent flexion creases.

This field consists of five information items:

- ***X1, Y1:*** The location of one endpoint, in units of 10 micrometers (0.01mm).
- ***X2, Y2:*** The location of the other endpoint.
- ***Type:*** For permanent flexion creases the type shall be noted, using the codes from Table A - 18 (illustrated in Figure A - 13). For fingerprints, the only permanent flexion creases are DIP and TIC (the distal interphalangeal crease separating the distal and medial segments of the finger, and the thumb interphalangeal crease between the proximal and distal segments of the thumb); all other permanent flexion creases relate to the palms or lower finger joints. For a feathered crease, multiple line segments may all share the same flexion crease label.

Table A - 18: Major flexion creases

Code	Name	Location
PDC PDC##	Proximal digital crease	Finger/Thumb at Palm. The 2-digit fingerprint position code may optionally be appended (e.g. PDC01-PDC10)[7]
PIP	Proximal interphalangeal crease	Finger between proximal and medial segments
DIP	Distal interphalangeal crease	Finger between medial and distal segments
TIC	Thumb interphalangeal crease	Thumb between proximal and distal segments
RLC	Radial longitudinal crease	Palm around base of thumb (thenar)
PTC	Proximal Transverse crease	Diagonal across palm
DTC	Distal Transverse crease	Palm at base of interdigital area
WC	Wrist crease	Wrist

[7] Indicating which proximal digital crease is present is helpful in defining the location for partial interdigital latents.

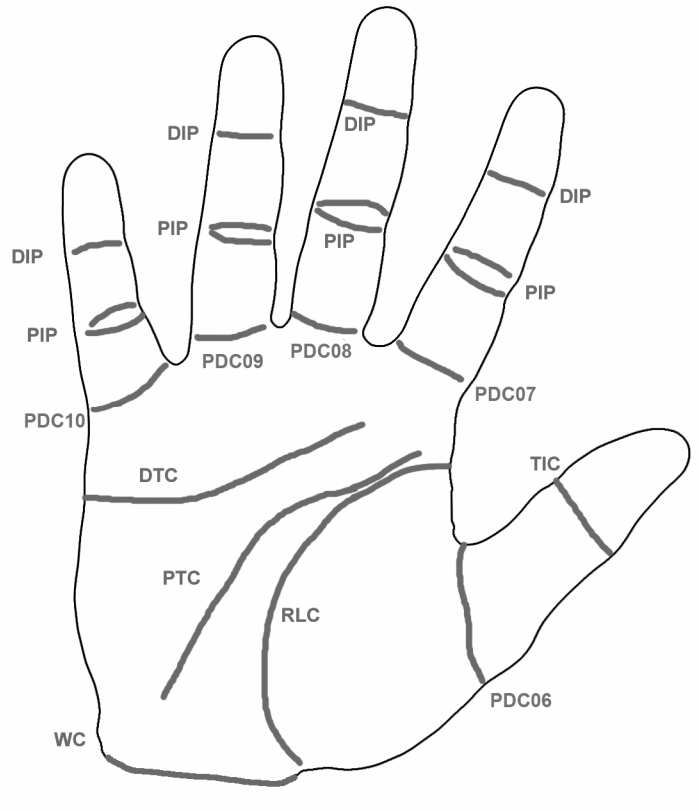

Figure A - 13: Locations of major flexion creases

Field 9.343 Ridge edge features (REF)

Ridge edge features include Protrusions (abrupt increases in ridge width), Indentations (abrupt decreases in ridge width), and Discontinuities (points where a ridge stops briefly):

- A protrusion is an abrupt increase in ridge width that is not long enough to be called a bifurcation. An event on a ridge longer than 0.5mm (0.02") shall be marked as a standard bifurcation with a ridge ending; a shorter event shall be marked as a protrusion if the increase in ridge width is abrupt (increasing by at least 50% in less than 0.25mm (0.01"). Protrusions are marked by the center location. Protrusions off one side of a ridge are marked at the center of the protruding area, not the center of the ridge.
- An indentation is an abrupt decrease in ridge width. An event is determined to be an indentation if the width decreases by at least 50% in less than 0.25mm (0.01"). Indentations are marked at the center of the gap in the ridge.
- A discontinuity is a point where the ridge stops briefly (no more than 0.5mm (0.02"), and restarts again without shifting. A wider gap in the ridge flow, or where the ridges do not line up across the divide, should be marked as two ridge endings, not a discontinuity. A series of discontinuities in a line (such as a cut or crack) should be marked as a linear discontinuity, using the Creases and Linear Discontinuities (CLD) field. A discontinuity is marked at the center of the gap in the ridge.

This field consists of three information items:

- ***X, Y:*** The location of the feature.
- ***Type:*** The type of feature: either P (Protrusion), I (Indentation), or D (Discontinuity).

Field 9.344 Area of pore characterization (APC)

This field contains one or more polygons of the area(s) in which pores are marked. All of the existing pores falling inside the polygon(s) shall be marked in the Pores (POR) field.

Each polygon is defined as stated in Section 8.1.3.

Interrelationships with other fields:

- This field shall be present if and only if the Pores (POR) field is present.

Field 9.345 Pores (POR)

Each pore within the areas marked in the Area of Pore Characterization (APC) field is marked by its center point.

This field consists of two information items:

- ***X, Y:*** The center of the pore.

Interrelationships with other fields:

- This field shall be present if and only if the Area of Pore Characterization (APC) field is present.

Fields 9.346-9.349: Reserved for future definition (RSV)

These fields are reserved for definition of additional secondary features, for inclusion in future revisions of this standard. None of these fields is to be used at this revision level. If any of these fields are present, they are to be ignored.

8.2.7 Annotations

These fields provide means to store the methods by which the other features were defined, and allow for further comments regarding the impression.

Field 9.350 Method of feature detection (MFD)

This field states the method(s) by which the Extended Friction Ridge features were detected and/or edited. Each time that fields are created or modified, the date and name of the automated algorithm or human examiner is noted in a new data entry in this field.

This field consists of 8 information items:

- ***Field(s):*** This information item indicates which fields correspond to the method noted: it contains a single field (e.g. “9.331”), a comma-separated list of fields without spaces (e.g. “9.340,9.341,9.343”), or “ALL”.
- ***Method:*** The method by which the fingerprint features were detected and encoded, from Table A - 19.
- ***Algorithm Vendor:*** For methods other than “MAN”, this information item shall identify the vendor of the encoding algorithm. If the algorithm vendor is registered with the IBIA[8], this information item shall contain the prefix “IBIA” followed by the vendor’s hexadecimal IBIA vendor ID. If an IBIA ID is not available, this shall just contain the name of the vendor or organization.

[8] The IBIA shall maintain the Vendor Registry of CBEFF Biometric Organizations that will map this value to a registered organization.

- ***Algorithm:*** For methods other than “MAN”, this information item shall identify the algorithm by name and version. If the algorithm is registered with the IBIA, this information item shall contain the prefix “IBIA” followed by the hexadecimal IBIA product type ID.
- ***Examiner last name:*** For methods other than “AUTO”, this information item shall contain the surname (last name) of the fingerprint examiner.
- ***Examiner first name:*** For methods other than “AUTO”, this information item shall contain the first name (or first and middle names) of the fingerprint examiner.
- ***Date:*** The date, in CCYYMMDD format (e.g. 20070215).
- ***Notes:*** This optional information item shall contain free text with additional information regarding the detection or modification of features.

Table A - 19: Methods of feature detection

Code	Usage
AUTO	The fingerprint features were detected and encoded by an automated process without any possibility of human editing. The algorithm shall be noted in the appropriate information item.
REV	The fingerprint features were detected and encoded by an automated process, and manually reviewed without the need for manual editing. The algorithm and examiner’s name shall be noted in the appropriate information items.
EDIT	The fingerprint features were detected and encoded by an automated process, but manually edited. The algorithm and examiner’s name shall be noted in the appropriate information items.
MAN	The fingerprint features were manually detected and encoded. The examiner’s name shall be noted in the appropriate information item.

When features are created or edited on multiple occasions, the new data entries should be added to this field without deleting the original data entries. For example, if minutiae are manually encoded by an examiner, then subsequently a second examiner modifies the minutiae, there would be two “MAN” entries for the Minutiae field (9.331).

Field 9.351 Comments (COM)

This text field contains additional information not noted in other fields. This may include unformatted text information such as substrate, processing technique, background information, or descriptive information.

Fields 9.352-9.359: Reserved for future definition (RSV)

These fields are reserved for definition of additional annotations, for inclusion in future revisions of this standard. None of these fields is to be used at this revision level. If any of these fields are present, they are to be ignored.

8.2.8 Corresponding Features

These fields are used to define the areas or points that correspond between two or more of the images contained in the current ANSI/NIST file, as described in Section 7.3.

Field 9.360 Area of Correspondence (AOC)

This field is to be used only when two or more images contained in a single ANSI/NIST file are compared as candidates for individualization (potential mates), as described in Section 7.3. The area of correspondence is a polygon enclosing the region of usable ridge detail present in both images being compared. If the corresponding areas are discontinuous, more than one area of correspondence may be defined for a pair of images.

One type-9 record may have multiple AOCs defined that correspond to different images, as shown in Figure A - 14. For example, a latent could have areas of correspondence with both the rolled and plain exemplars from one subject, or a latent could have areas of correspondence with candidate exemplars from two different subjects.

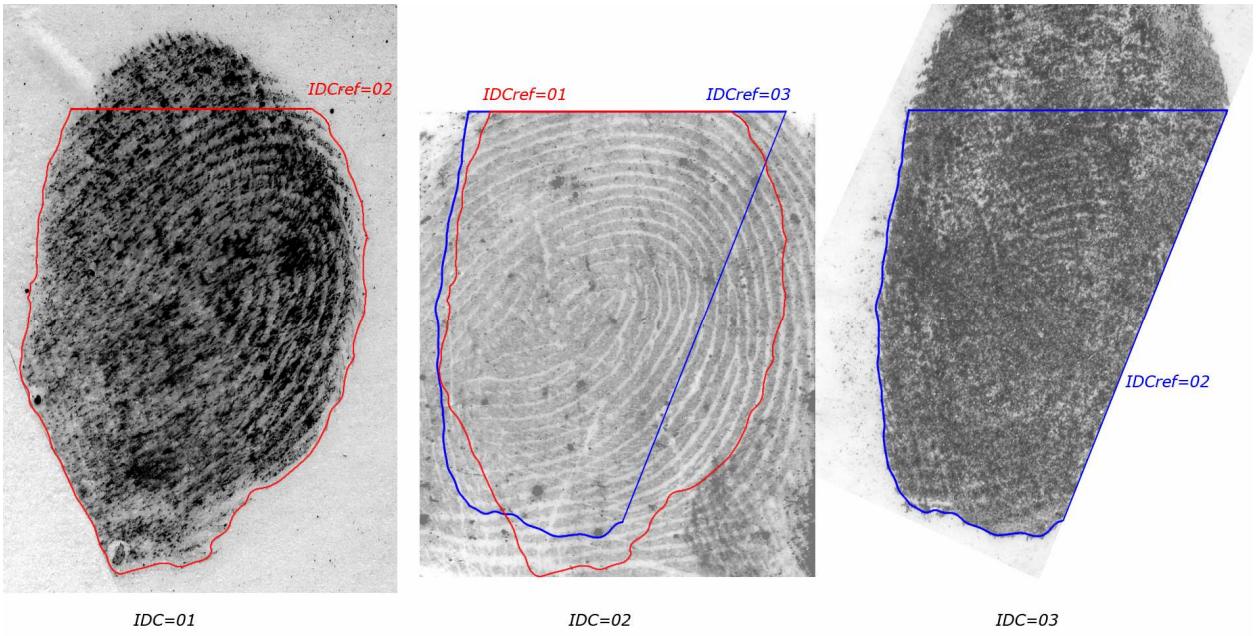

Figure A - 14: Examples of the use of IDC references in Areas of Correspondence for more than 2 images

This field consists of 3 information items:

- ***IDC Reference:*** The IDC Reference information item indicates the target image for a given AOC. Figure A - 14 shows examples of the use of IDC references in Areas of Correspondence. The first image (IDC 01) has a single AOC, corresponding to the second image, so IDCref=02; the second image (IDC 02) has AOCs corresponding to each of the other images, with IDCref=01 and IDCref=03; the third image (IDC 03) has a single AOC, corresponding to the second image, so IDCref=02.
- ***Polygon:*** The Polygon information item defines the outline of the corresponding area. The format of polygons is described in Section 8.1.3.
- ***Label:*** The optional Label information item allows a free text comment or description related to the AOC.

Field 9.361 Points of Correspondence (POC)

This field is to be used only when two or more images contained in a single ANSI/NIST file are compared as candidates for individualization (potential mates), as described in Section 7.3. For each of the two images being compared, specific points or features that can be found in both images are marked in each of the two type-9 records, with correspondence indicated by the use of the same index. Indices within a single Type-9 record shall be unique.

Examples of Points of Correspondence are shown in Figure A - 2. In that example, note that points A and D are present in all three images, while the other points only link two of the three images.

Points of Correspondence may be marked using any type of feature, and are not limited to minutiae.

This field consists of 3 information items:

- ***X,Y:*** These two information items define the location of the POC, in units of 10 micrometers (0.01mm).
- ***Index:*** This 1-2 character alphanumeric index is used to indicate correspondence between POCs in different type-9 records. Indices within a single Type-9 record shall be unique.
- ***Label:*** This optional information item allows a free text comment or description related to the POC.

Fields 9.362-9.369: Reserved for future definition (RSV)

These fields are reserved for definition of additional corresponding features, for inclusion in future revisions of this standard. None of these fields is to be used at this revision level. If any of these fields are present, they are to be ignored.

8.2.9 Skeletonized Image

These fields define the skeletonized image (ridge tracing), which is a black and white (2-tone) image in which each ridge is represented as a black single-pixel-wide line. Guidelines for the use of the Skeletonized Image are included in Section 7.6.

Field 9.370 Skeletonized image scale (SIS)

This field shall specify the pixel density used for the skeletonized image, also known as resolution or sampling frequency. Note that the skeletonized image may be a different resolution than the original image.

This field consists of 2 information items:

- ***Scale:*** This information item shall specify the integer pixel density used for the skeletonized image. The units used are specified in the Units (SRU) information item.
- ***Units:*** This information item shall specify the units for the Scale information item. A “1” in this field indicates pixels per inch, or a “2” indicates pixels per centimeter.

Field 9.371: Skeletonized image format (SIF)

This ASCII field shall specify the algorithm used to compress the skeletonized image in 9.999. This field shall contain the code from Table A - 20 to indicate the compression method.

Table A - 20 lists the codes for the available compression schemes that can be used for encoding binary image data described by this standard.

Table A - 20: Skeletonized image format codes

Algorithm Name	ASCII Code	Notes
Uncompressed, base-64 encoded	**UNC**	Uncompressed image, bit-packed 6 pixels per character using base-64 representation. All values for one row are concatenated left to right, with one data entry for each row, separated by a RS character. (Default)
1-bit PNG, base-64 encoded	**PNG**	1-bit grayscale PNG compressed image, bit-packed 6 bits per character using base-64 representation. The entire PNG-formatted image file is included as a single data entry. Interlacing, alpha transparency, and color palettes shall not be used.

Note that in addition to or instead of compression, storage space may be conserved by storing the skeletonized image at a lower resolution than the original image, as defined in the Skeletonized image scale (SIS) field.

Field 9.372: Skeletonized image data (SIM)

The skeletonized image, also known as a ridge tracing, is a 2-tone image with a white background and a black single-pixel-wide thinned representation of each ridge. Its dimensions shall be identical to the Region of Interest (ROI) field. The scale (resolution) is defined by the Skeletonized Image Scale (SIS) field. The format is defined by the Skeletonized image format (SIF) field.

Guidelines for the use of the Skeletonized Image are included in Section 7.4.

Interrelationships with other fields:

- If this field is present, the Skeletonized Image Scale (SIS) field is mandatory.
- If this field is present, the Ridge Quality Map (RQM) is mandatory. The ridge quality map values are used to determine the locations in which the skeletonized image is definitive (Quality 2 or above), debatable (Quality 1), or should be ignored (Quality 0).

Fields 9.373-9.399: Reserved for future definition (RSV)

These fields are reserved for definition of additional features, for inclusion in future revisions of this standard. None of these fields is to be used at this revision level. If any of these fields are present, they are to be ignored.

8.3 Additional extended friction ridge feature set records

Additional Type-9 records may be included in the file; all records in the file shall be regarded as belonging to a single individual.

If the images associated with the Type-9 records are included in the file, each Type-9 record shall have an IDC equal to the IDC of the corresponding Type-13, 14, or 15 image. If the images associated with the Type-9 records are not included in the file, each Type-9 record shall have a different Image Designation Character (IDC – 9.002).

It is permissible for multiple Type-9 records to be associated with a single image, for example in the case of a simultaneous latent impression in which the entire image is regarded as evidence and therefore cannot be cropped into multiple images. Each of the Type-9 records must have a different Region of Interest (ROI – 9.300) within the original image, and must have a different Finger/Palm Position (FPP – 9.306). In this case, all of the Type-9 records would share the same IDC as the image.