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Data Format for the Interchange of Extended Friction Ridge Features

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

10 May 2010

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Change History

- Working Draft 0.1, 23 March 2007
  - *First public release of document*
  - *Defined new Type-18 record type (fields subsequently defined within Type-9 record)*
- Working Draft 0.2, 18 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.*
- Working Draft 0.3, 20 February 2009
  - *Many changes were made to this draft, in response to lessons learned in developing software to the specification, and in response to latent examiner feedback during the development of reference datasets.*
  - *The following list all substantive changes, but do not note additional/changed illustrations or minor wording changes.*
  - *Overall*
    - Title changed from Data Format for the Interchange of Extended Fingerprint and Palmprint Features to Data Format for the Interchange of Extended Friction Ridge Features.
    - Guidance section removed into its own document so that all of the user-centric guidance is in a separable document. The guidance document is designed specifically to be usable for practitioners (e.g., latent examiners), but is also informative background for all users of this specification.
  - *Foreword, Section 1 Introduction, Section 2 Scope, purpose, and conformance*
    - Revised text to emphasize that this specification is intended for an individual examiner to define the content of a single impression or comparison of two impressions, as well as for data transmission or interchange with criminal justice administrations or organizations that use fingerprints or palmprints for identification purposes.
  - *Section 3 References*
    - Reference to Guidance document moved from Section 3.1 Normative References to Section 3.2 Informative References.
  - *Section 7.1 Notes on Representations*
    - Section 7.1.4 changed from Polygons to Closed and Open Paths, and expanded to provide additional information, including applicable fields for each. Polygons (Closed Path) no longer are required to have vertices in counterclockwise order.
  - *Section 7.2 Extended friction ridge feature set fields*
    - Table 5

- Polygon (Closed Path) fields changed to add character type Special (S) to provide for usage of commas and hyphens.
- Condition Codes changed to include “conditional (C).” This code is applied to those fields whose presence in the transaction is dependent on the presence of another field that may be optional. The following fields are changed from optional to conditional: Field 9.309 Ridge Quality Map Format (RQF), Field 9.311 Ridge Flow Map Format (RFF), and Field 9.313 Ridge Wavelength Map Format (RWF).
- Table 5 changes include additional various corrections and additions of fields.

- Fields Reserved for Future Definition (RSV) have been updated due to the addition of new fields.
- Field 9.003: Impression Type (IMP) tables have been restructured and explanatory text added.
- Field 9.302 Finger/Palm/Plantar Position (FPP):
  - Added “Grasp” impressions (left and right hand)
  - Divided table into separate table for Position Codes for Fingers, Palms, and Feet
  - Grasp and Foot/Toe codes marked as TBD until NIST can make a number range available.
  - Added information item for off-center fingerprint positions: Tip, Left, Right (moved Tip from Finger segment codes to Off-center fingerprint positions)
- Field 9.308 Ridge Quality/Confidence Map (RQM)
  - Renamed Ridge Quality/Confidence Map (was Ridge Quality Map)
  - Revised to correspond with the findings of the FBI-Lab/Noblis Latent Quality Study, with standard colorcoding and descriptions for 6 levels of confidence (previously 4).
- Field 9.309 Ridge Quality Map Format (RQF):
  - This format no longer has a default value: the format for the quality map must be specified explicitly. The grid size of 0.20mm (0.008”) is recommended based on experience in the FBI-Lab/Noblis Latent Quality Study, because larger grid sizes cannot cleanly follow fingerprint ridges without interference.
  - The B64 (bit-packed base-64) compression method was removed, since its efficiency was based on having 4 levels of confidence.
  - RLE (run-length encoded) format was added.
- Removed field “Degree of Distortion”: this purpose is handled within Field 9.357 Local Quality Issues (LQI).
- Renamed Field 9.314 Tonal Reversal (TRV): was previously “Inverted Image”; changed to only be set if image is tonally reversed.

- Added Field 9.315 Possible Lateral Reversal (PLR). Note that when this field is set to U (Image may be laterally reversed), it is incumbent on the recipient (software system or examiner) to search/compare the impression and features both as presented and flipped left-right.

- In Field 9.320 Cores (COR), Field 9.321 Deltas (DEL), and Field 9.323 Center Point of Reference (CPR) the “Virtual” information items were removed as redundant with the Ridge Quality/Confidence map values. If a core/delta/CPR is in a red/black area, it is implicitly virtual.

- Field 9.321 Deltas (DEL): codes for palm deltas were added in a new table.

- In Field 9.322 Core-Delta Ridge Counts (CDR), allowed ridge counts to undefined cares and deltas to permit minimum ridge counts for images missing cores or deltas in the region of interest.

- Field 9.324 Distinctive Characteristics and Quality Issues (DIS) previously contained both features specific to the friction ridge skin, and quality issues specific to the impression. Since features would be expected in compared impressions and quality issues would not, this field was separated into two fields, Field 9.324 Distinctive Features (DIS) and Field 9.357 Local Quality Issues (LQI).

- Field 9.324 Distinctive Features (DIS), characteristics WART (Wart or blister), CREASE (Distinctive crease) and CLEAR (Clear field of ridges) were added to Table 24.

- Field 9.330 Number of Minutiae was removed; its purpose was more explicitly handled by Field 9.334 No Minutiae Present (NMP)

- Field 9.331 Minutiae (MIN): removed Information item 5, Confidence in existence. During data markup, “Confidence in existence” was unclear to examiners and confused with the confidence measures in Field 9.308 Ridge Quality Map (RQM). The examples of uses (short bifurcations that may be considered protrusions, short ridges that may be considered dots) can be assessed through proximity of minutiae.

- Field 9.332 Minutiae Ridge Count Algorithm (MRA) values changed to include Octant (default) and EFTS7.

- For Field 9.342, Creases and linear discontinuities, TIC (Thumb interphalangeal crease) was removed, and the definition of DIP (Distal interphalangeal crease) was modified to “Finger between medial and distal segments, or Thumb between proximal and distal segments.” The reason for this is to allow marking the crease when the finger position is unknown.

- Field 9.344, Area of Pore Characterization, is deleted. Field 9.344 is Reserved for Future Definition.

- For Field 9.350 Method of Feature Detection (MFD), added information item for Examiner’s organizational affiliation.

- Added Field 9.352 Latent Processing Method (LPM)

- Added Field 9.353 Examiner Analysis Assessment (EAA)

- Added Field 9.354 Evidence of Fraud (EOF)

- Field 9.357 Local Quality Issues (LQI) the following quality/transfer issues were added to Table 35: BACKGROUND (Interference with background), OVERDEV (Overdeveloped area). TWISTED (Distorted are with twisted ridges) was removed based on examiner feedback. And replaced by DISTORT (Miscellaneous distortion).

- Added "Presence of" indicator fields to indicate whether the absence of features should be taken as definitive (see section 7.1.6):

  - Field 9.325 No Cores Present (NCR)

  - Field 9.326 No Deltas Present (NDL)

  - Field 9.327 No Distinctive Features Present (NDF)

  - Field 9.334 No Minutiae Present (NMP)

  - Field 9.347 No Incipient Ridges Present (NIR)

  - Field 9.348 No Creases Present (NCR)

  - Field 9.349 No Ridge Edge Features Present (NRE)

- Field 9.361 Points of Correspondence renamed Corresponding Points or Features. Information items added to permit labeling existing features in addition to arbitrary points.

- Added Field 9.362 Examiner Comparison Determination (ECD).

- Field 9.370 Skeletonized image scale (SIS) was removed: rescaling a skeletonized image is problematic due to the need to maintain the (1,2,3)-connexity of the 2-tone image: standard rescaling algorithms are not applicable, and custom algorithms are unnecessarily complex. Rescaling path representations is handled clearly using vector representation (Field 9.373: Ridge Path Segments (RPS)) instead of a skeletonized image. The image in Field 9.372: Skeletonized image (SIM) must have the same resolution as the original image.

- Field 9.371 Skeletonized image format (SIF) was removed: 1-bit PNG, base-64 encoded was found to be effective and simple to implement, and is now the only recommended format.

- Field 9.373: Ridge Path Segments (RPS) added based on feedback from implementation: the data structures are more conducive to efficient internal storage as vector paths, therefore speeding processing.

- Working Draft 0.4

  - *Adjusted wording to underscore that this document is a <u>Proposed</u> Addendum/Revision to (or revision of) ANSI/NIST-ITL 1-2007, and removed header page reference to ANSI — this document should not make assumptions or implications regarding the ANSI approval process.*

  - *Modified text in Section 6 Record description to be inclusive of plantar (foot) prints.*

  - *Added clarifying text to Section 7.1.2 Region of interest and Field 9.300 Region of Interest (ROI) on the relationship between the ROI rectangle and polygon.*

  - *Table 5 changes:*

    - Corrected Field 9.314 Tonal Reversal (TRV) and Field 9.315 Possible Lateral Reversal (PLR) in Table 5 to reflect values as Alpha instead of Numeric characters. Also corrected 9.314 abbreviation from INV to TRV.

- Changed the Character Type for Field 9.322 Core-Delta Ridge Counts (CDR) from N to A.
- Field 9.333 Minutiae Ridge Counts (MRC), information item 3, Ridge count, was made optional: unknown ridge counts shall be omitted.
- For Field 9.350 Method of Feature Detection (MFD), appropriate subfields changed to conditional (C).
- Changed Character Type for code subfield of Field 9.355 Latent Substrate (LSB) to AN
- Name for Field 9.361 changed to Corresponding Points or Features (CPF) to match text
- Added Field 9.344 No Pores Present (NPP)
- The Character Type for all "Comments" or "Notes" information items to ANS: these fields should accept any keyboard character.

- *Changed Field 9.301 Orientation (ORT) to indicate that uncertainty defaults to ±15° (not ±30°) if the entire field or the uncertainty subfield is omitted.*
- *Field 9.302 Finger/Palm/Plantar Position (FPP): added Unknown Finger Segment for use when the image is an unknown segment of a finger or thumb.*
- *Changed Field 9.307 Pattern Classification (PAT) to permit up to seven pattern classifications, (instead of three) which is appropriate for better indications of exclusions for latents. For example, a common situation is a latent that shows only a triradius (delta) and therefore can be either loop, any whorls, or a tented arch: this requires 4 patterns.*
- *Field 9.311 Ridge Flow Map Format (RFF): for undefined angles (if the direction cannot be determined at a given location), the location at that point shall be marked as "*" (asterisk). Previously the undefined value was given as "X", which is a valid value in Base64.*
- *Field 9.311 Ridge Flow Map Format (RFF) and Field 9.372: Skeletonized image (SIM) references to base-64 were footnoted "Base-64 is a method of representing binary data as text, as specified in IETF RFC 2045 (http://tools.ietf.org/html/rfc2045)."*
- *Field 9.317 Possible growth or shrinkage (PGS) was added: this field is to be used in the unusual circumstance that the friction ridge impression is believed to have changed size or scale from potential comparisons.*
- *Field 9.331 Minutiae (MIN): the text for the Type information item was changed to read "The type of minutia shall be set if the examiner/encoding process is confident as to type: the "either" type shall be used for all minutiae that are not clearly identifiable as a ridge ending or a bifurcation. Because of the frequency with which minutiae appear to be ridge endings in one impression and bifurcation in another, even in clear images, it is recommended that the minutiae type be used as supporting evidence rather than as a basis for exclusion." Previously the text read "The type of minutia shall only be set if it is certain."*
- *Added Field 9.335 Ridge Count Confidence (RCC): This field provides a means to save state when only a portion of ridge counts have been manually checked.*
- *Field 9.357 Local Quality Issues (LQI): added TAPE Lifting tape artifacts (crease, bubble, etc.); operational lessons learned were that lifting tape creases and bubbles were frequently encountered.*

- Draft 0.5
  - *Table 5: Field 9.307 Pattern Classification (PAT) maximum number of occurrences changed to 7 to correspond with text.*

- *Field 9.301 Orientation (ORT) includes note that rotation of the image in multiples of 90° can be performed without image degradation and is acceptable.*
- *Changed Field 9.314 Tonal Reversal (TRV) to include "P" – Partial tonal reversal in which ridges are light and valleys are dark only in portions of the image.*
- *Field 9.324 Distinctive Features (DIS) renamed from Distinctive Characteristics since "Characteristics" is used by SWGFAST and the community to mean specifically Level-2 features. (see SWGFAST Glossary) Field 9.327 No Distinctive Features Present (NDF) also renamed for the same reason – note the name and abbreviation both changed.*
- *Field 9.353 Examiner Analysis Assessment (EAA) definition clarified to read "The impression is of limited, marginal, value. It is not of value for individualization, but may be appropriate for exclusion."*
- *Field 9.361 Corresponding Points or Features (CPF) information item type was expanded to include not just definitive correspondence but lack of correspondence.*
- *Field 9.362 Examiner Comparison Determination (ECD), added INC_D, (Inconclusive, but with dissimilar features noted)*

Foreword

(This informational foreword is not part of the Proposed Addendum/Revision to American National Standard ANSI/NIST-ITL 1-2007.)

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 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 Proposed Addendum/Revision 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 the present.

Suggestions for the improvement of this draft specification 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.

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.

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[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)

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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))[2] 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 years 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. A companion document to this addendum, entitled "Guidelines for Extended Feature Set Markup of Friction Ridge Images," provides guidance to examiners in using the additional features in this addendum as well as guidance to technologists to aid in implementation of the standard.

2 Scope, purpose, and conformance

2.1 Scope

This addendum defines the content, format, and units of measurement for the definition and/or 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 an individual examiner to define the content of a single impression or comparison of two impressions, as well as 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.

[2] In June, 2007, the EFTS was renamed the Electronic Biometric Transmission Specification (EBTS).

Uses may include, but are not limited to,

- Definition of the information content of a single friction ridge impression as discerned by an examiner during analysis, for archiving, interchanges with other examiners, validation and quality assurance processing, and quantitative analysis.
- Definition of the information content and determination of a comparison of two friction ridge impressions as discerned by an examiner during comparison and evaluation, for archiving, interchanges with other examiners, validation and quality assurance processing, and quantitative analysis.
- Interoperable interchange format for automated fingerprint or palmprint systems, for human-initiated searches, fully automated searches, data interchange between automated systems, and feedback to examiners from automated processing.

Note that different uses may require different subsets of the features defined in this addendum.

Note 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 a proposed addendum/revision 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/revision 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 8.1 (IAFIS-DOC-0178-8.1, 19 November 2008).

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.

Guidelines for Extended Feature Set Markup of Friction Ridge Images, March 2009.

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.
Impression	A mark containing friction ridge detail produced on a surface by pressure.
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 5.
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 misinterpreted as making an implication regarding the severity of the case.
Matrix	The substance deposited by the finger that forms the impression.
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.
Palmar	Having to do with the friction ridge skin on the hands (fingers and toes)
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.
Plantar	Having to do with the friction ridge skin on the feet (soles and toes)
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.
Recurving ridge	A ridge whose path begins in one direction, curves and continues in a path parallel or nearly parallel to its start.
	An innermost recurving ridge is a recurving ridge that encloses no other recurving 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 segment	A section of a ridge that connects two minutiae; a single non-intersecting portion of a skeletonized image.
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 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.
Substrate	Surface upon which a friction ridge impression is deposited.

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 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 1: Logical record types[3]

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

[3] This table is identical to ANSI/NIST-ITL 1-2007 Table 4, except for the revised wording for Record 9.

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

Table 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 plantar (foot) 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 friction ridge images.

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

7 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.

7.1 Notes on Representations

7.1.1 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 (see Section 7.1.2). 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).

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).[4]

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).

[4] A 99th percentile adult male hand (wrist to fingertip) is 8.4” (213 mm) long; a 99th percentile adult male foot is 11.7” (298 mm) long. [A. R. Tilley, *The Measure of Man and Woman: Human Factors in Design, Revised Edition*; Wiley; 2002] In extreme cases palms may be 32.4 cm long (12.75”) and feet may be 47 cm long (18.5”). (e.g., Robert Pershing Wadlow [*Guinness Book of World Records Online*, www.guinnessworldrecords.com/])

7.1.2 Region of interest

Field 9.300 Region of Interest (ROI) is a single rectangle (including an optional 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 Extended Friction Ridge Features are in relation to the Region of Interest, not to the original image: all coordinates are relative to the top left corner of the ROI, and may not equal or exceed the width and height of the ROI.

When the ROI is a polygon, the ROI rectangle is simply a bounding box around that polygon: the ROI offset is defined as the minimum of the X and Y coordinates of all ROI vertices, and the ROI width and height are defined as the range (maximum – minimum) of the X and Y coordinates of all ROI vertices. See Figure 1 for an example.

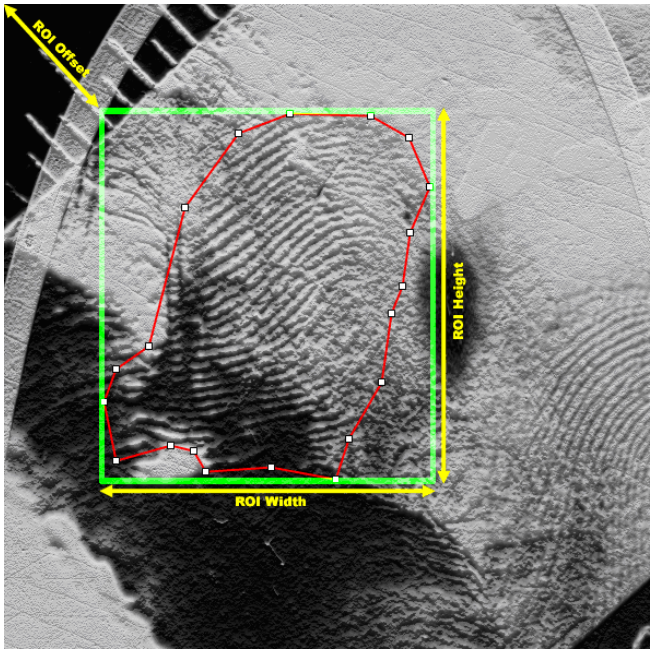

Figure 1: Region of interest

There can only be one region of interest for a given feature set. If there are multiple impressions within a single image, more than one feature set can be marked for the image, resulting in multiple Type-9 records associated with a single image, differentiated by the region of interest. (See Section 7.3.)

7.1.3 Angles

All angles are measured in positive integer degrees counterclockwise from the right, from 0 to 359 degrees, as shown in Figure 2. (This corresponds to ANSI/NIST-ITL 1-2007, Section 14.1.4.)

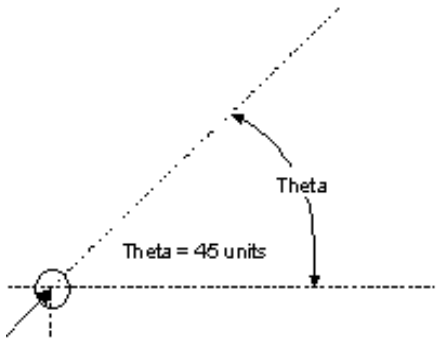

Figure 2: Measurement of angles

7.1.4 Paths and polygons

A path is an ordered set of 2 to 99 vertices. The order of the vertices must be in their consecutive order along the length of the path. No two vertices may occupy the same location. A path may not have any sides crossing. Each vertex is expressed as an (X,Y) pair of positive integers in units of 0.01mm.

A closed path, or polygon, completes a circuit: the polygon side defined by the last vertex and the first vertex shall complete the polygon. A polygon must contain at least 3 vertices. Polygons are used in

- Field 9.300 Region of Interest (ROI)
- Field 9.324 Distinctive Features (DIS)
- Field 9.357 Local Quality Issues (LQI)

An open path is a series of connected points in which there is not an implicit connection between the last and first vertices. Open paths are used in

- Field 9.373: Ridge Path Segments (RPS)

Each path is stored as a single data entry, 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
```

If multiple paths are present in the same field, they are stored as separate data entries (occurrences), separated by the <RS> character:

```
X1,Y1-X2,Y2-X3,Y3<RS>X4,Y4-X5,Y5-X6,Y6
```

7.1.5 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>.

7.1.6 No features present fields

The following fields are used in this specification to indicate whether the absence of a particular type of feature means that there are no instances of that type of field present, as opposed to simply not having been marked.

For example, if there are no cores included in Field 9.320 Cores (COR), then Field 9.325 No Cores Present (NCR) would be set to “Y” if analysis determined that there were no cores discernable, but would have been omitted if analysis had not been conducted for cores.

Table 3: Correspondence of Features and Presence Fields

Feature fields	Presence Fields
Field 9.320 Cores (COR)	Field 9.325 No Cores Present (NCR)
Field 9.321 Deltas (DEL)	Field 9.326 No Deltas Present (NDL)
Field 9.324 Distinctive Features (DIS)	Field 9.327 No Distinctive Features Present (NDF)
Field 9.331 Minutiae (MIN)	Field 9.334 No Minutiae Present (NMP)
Field 9.340 Dots (DOT)	Field 9.346 No Dots Present (NDT)
Field 9.341 Incipient Ridges (INR)	Field 9.347 No Incipient Ridges Present (NIR)
Field 9.342 Creases and Linear Discontinuities (CLD)	Field 9.348 No Creases Present (NCR)
Field 9.343 Ridge Edge Features (REF)	Field 9.349 No Ridge Edge Features Present (NRE)
Field 9.345 Pores (POR)	Field 9.344 No Pores Present (NPP)

If the “No <Features> Present” field is included, it will be populated with a “Y” indicating the analysis of the image has positively determined that there are no instances of that feature present in the image. If the analysis has not been performed for that particular feature, or if the analysis has determined there are a number of those features present in the image, the “No <Features> Present” field will be omitted from the transaction.

7.1.7 Definitions of feature confidence and local quality

Local friction ridge quality (Field 9.308 Ridge Quality/Confidence Map (RQM)) is an assessment of confidence in small local areas within an image. The local quality map is used to define the confidence in all other features, and therefore is key information. In addition, when the quality map indicates a high-quality region in which features are not marked, that information can be used as “negative features” or definitive absence of features, which can be used for exclusion.

Accurate and consistent markup of local quality is essential, and the guidelines in Table 4 and Figure 3 should be followed as closely as possible. The names and color-coding indicated here are the result of extensive research and user feedback and are normative.

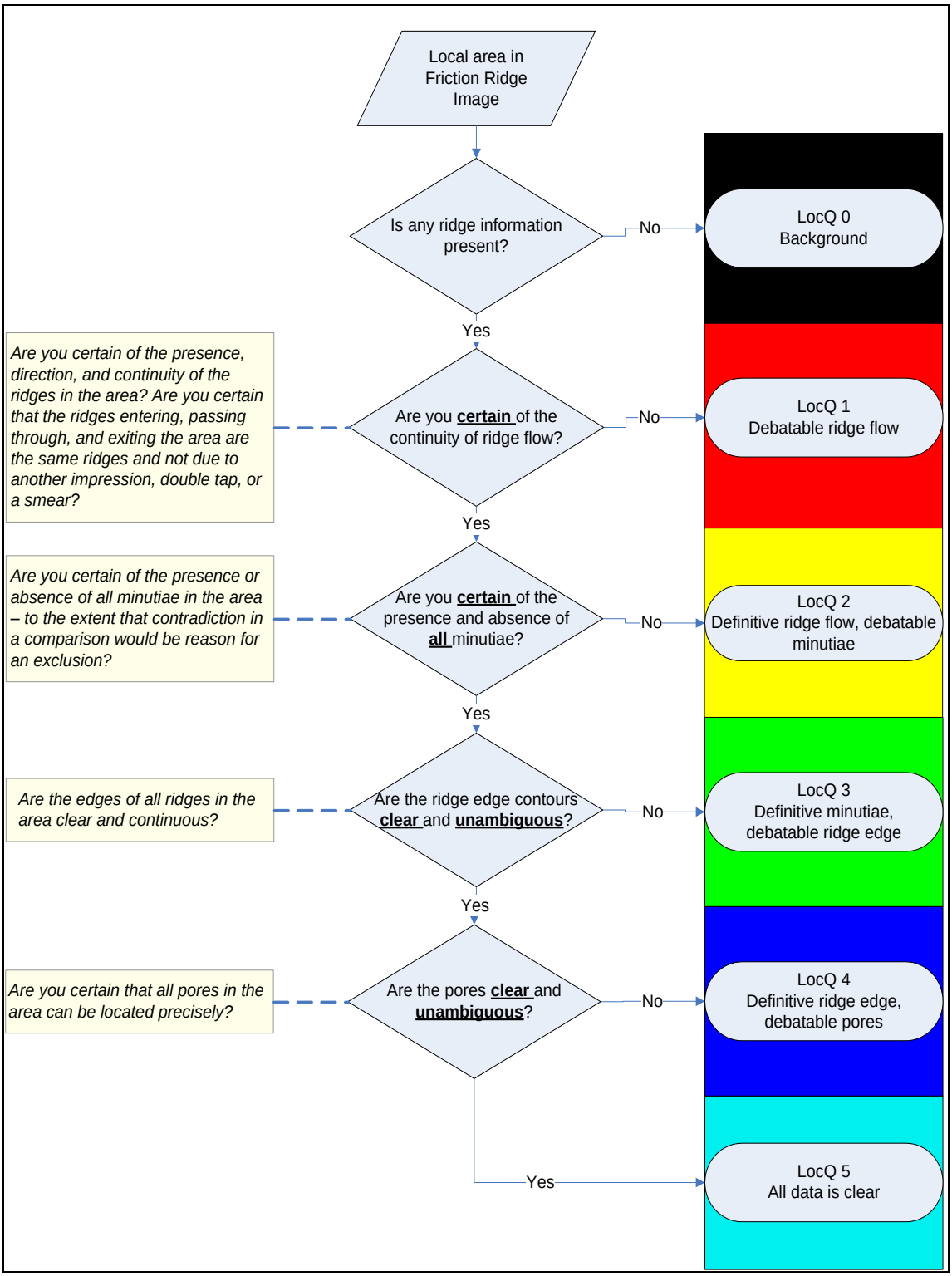

Figure 3: Decision process for local friction ridge quality

Table 4: Definitions for ridge quality map values

<table>
<tr><th></th><th></th><th></th><th>Ridge flow</th><th>Minutiae</th><th>Dots</th><th>Incipients</th><th>Ridge edge features</th><th>Pores</th><th></th></tr>
<tr><td>Black</td><td>0</td><td>Background</td><td colspan="6">✕</td><td>Black (0,0,0)</td></tr>
<tr><td>Red</td><td>1</td><td>Debatable ridge flow</td><td>?</td><td colspan="5">✕</td><td>Red (255,0,0)</td></tr>
<tr><td>Yellow</td><td>2</td><td>Definitive ridge flow, debatable minutiae</td><td>✔</td><td>?</td><td colspan="4">✕</td><td>Yellow (255,255,0)</td></tr>
<tr><td>Green</td><td>3</td><td>Definitive minutiae, debatable ridge edges</td><td colspan="2">✔</td><td colspan="3">?</td><td>✕</td><td>Green (0,255,0)</td></tr>
<tr><td>Blue</td><td>4</td><td>Definitive ridge edges, debatable pores</td><td colspan="5">✔</td><td>?</td><td>Blue (0,0,255)</td></tr>
<tr><td>Aqua</td><td>5</td><td>All features definitive</td><td colspan="6">✔</td><td>Aqua (0,240,240)</td></tr>
</table>

Legend:

✔	Definitive and unambiguous.	Presence and absence of features are definitive. Location of features is definitive unless specifically noted otherwise (such as by radius of uncertainty). Contradictory presence or absence of features in a comparison is cause for exclusion.
?	Debatable or ambiguous.	Features may be marked, but presence, absence, and location are debatable. Corresponding/contradictory features in a comparison are supporting evidence for individualization/exclusion.
✕	Not discernable or unreliable	Features should not be marked and will be ignored if present. No evidence for individualization or exclusion in a comparison.

7.1.8 Date and time

The date and time are stored in terms of universal Greenwich Mean Time (GMT) units. Date and time together are saved in a single information item, represented as “YYYYMMDDHHMMSSZ,” a 15-charater string that is the concatenation of the date with the GMT and concludes with “Z.” The “YYYY” characters shall represent the year of the transaction, the “MM” characters shall be the tens and units values of the month, and the “DD” characters shall be the tens and units values of the day of the month, the “HH” characters represent the hour, the “MM” the minute, and the “SS” represents the second. The complete date and time shall not exceed the current date and time (Example: 08:48:28 AM, March 19, 2009 EST (US Eastern Standard Time) = 20090319134828Z. Note that EST = GMT -5).

Date and time are included as information items in these fields:

- Field 9.350 Method of Feature Detection (MFD)

- Field 9.353 Examiner Analysis Assessment (EAA)
- Field 9.362 Examiner Comparison Determination (ECD)

7.2 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 5 shows the names and acronyms for fields and information items within the fields.

- The Condition Code indicates whether the field is mandatory ("M"), optional ("O"), or conditional ("C"). For information items, the Condition Code indicates when the field is present whether the information item is mandatory ("– m"), can be left empty ("– o"), or is conditional ("– c"). 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. Details of Conditional situations are explained in the field information item descriptions.
- "Character type" indicates N = Numeric; A = Alphabetic; AN = Alphanumeric; S = Special characters (e.g., commas, hyphens). 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 5: 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 7.2.1)									
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 7.2.2)									
ROI	M	9.300	Region of Interest		5	6	1024	1	1
	— m		*— Width*	*N*		*1*	*5*		
	— m		*— Height*	*N*		*1*	*5*		
	— c		*— Horizontal offset*	*N*		*0*	*5*		
	— c		*— Vertical offset*	*N*		*0*	*5*		
	— o		*— Polygon (Closed Path)*	*NS*		*11*	*1000*		
ORT	O	9.301	Orientation		2	3	8	0	1
	— m		*— Direction*	*N*		*1*	*4*		
	— m		*— Uncertainty*	*N*		*1*	*3*		
FPP	M	9.302	Finger/Palm Position(s)		4	4	1009	1	20
	— m		*— Position Code*	*N*		*1*	*2*		
	— o		*— Finger Segment*	*A*		*3*	*3*		
	— o		*— Off-center Fingerprint Position*	*A*		*1*	*1*		

Ident	Cond code	Field #	Field name —*Information Items*	Char type	# Inf Items	Field size per occurrence (Min/Max)		Number of occurrences (Min/Max)	
	— o		*— Polygon (Closed Path)*	*NS*		*11*	*1000*		
RSV		9.303 9.306	Reserved for future definition						
Overall Image Characteristics (Section 7.2.3)									
PAT	O	9.307	Pattern Classification		3	3	6	0	7
	— m		*— General Classification*	*A*		*2*	*2*		
	— c		*— Subclassification*	*A*		*2*	*2*		
	— c		*— Delta Relationship*	*A*		*1*	*1*		
RQM	O	9.308	Ridge Quality Map	N	0	2	n/a	0	n/a
RQF	C	9.309	Ridge Quality Map Format		2	5	6	0	1
	— c		*— Grid size*	*N*		*1*	*2*		
	— c		*— Data format*	*A*		*3*	*3*		
RFM	O	9.310	Ridge Flow Map	AN	0	3	n/a	0	n/a
RFF	C	9.311	Ridge Flow Map Format		2	5	6	0	1
	— c		*— Sampling frequency*	*N*		*1*	*2*		
	— c		*— Data format*	*A*		*3*	*3*		
RWM	O	9.312	Ridge Wavelength Map	N	0	2	n/a	0	n/a
RWF	C	9.313	Ridge Wavelength Map Format		2	5	6	0	1
	— c		*— Sampling frequency*	*N*		*1*	*2*		
	— c		*— Data format*	*A*		*3*	*3*		
TRV	O	9.314	Tonal Reversal	A	0	1	1	0	1
PLR	O	9.315	Possible Lateral Reversal	A	0	1	1	0	1
FQM	O	9.316	Friction Ridge Quality Metric		3	11	18	0	20
	— m		*— Quality metric value*	*N*		*1*	*3*		
	— m		*— Quality algorithm vendor code*	*AN*		*4*	*4*		
	— m		*— Quality algorithm product code*	*N*		*1*	*5*		
PGS	O	9.317	Possible Growth or Shrinkage		0	1	2	0	1
	— m		*— Type*	*A*		*1*	*1*		
	— o		*— Comment*	*ANS*		*0*	*1000*		
RSV		9.318 9.319	Reserved for future definition						
Reference Points (Section 7.2.4)									
COR	O	9.320	Cores		5	5	24	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		*— Direction uncertainty*	*N*		*0*	*3*		
DEL	O	9.321	Deltas		10	9	44	0	n/a
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
	— o		*— Direction up*	*N*		*1*	*3*		
	— o		*— Direction left*	*N*		*1*	*3*		
	— o		*— Direction right*	*N*		*1*	*3*		
	— o		*— Type*	*A*		*0*	*3*		
	— o		*— Radius of position uncertainty*	*N*		*0*	*5*		
	— o		*— Direction uncertainty up*	*N*		*0*	*3*		
	— o		*— Direction uncertainty left*	*N*		*0*	*3*		
	— o		*— Direction uncertainty right*	*N*		*0*	*3*		
CDR	O	9.322	Core-Delta Ridge Counts		4	6	11	0	n/a
	— m		*— Core Index*	*AN*		*1*	*2*		

Ident	Cond code	Field #	Field name —*Information Items*	Char type	# Inf Items	Field size per occurrence (Min/Max)		Number of occurrences (Min/Max)	
	— m		*— Delta Index*	*AN*		*1*	*2*		
	— m		*— Min ridge count*	*N*		*1*	*2*		
	— o		*— Max ridge count*	*N*		*0*	*2*		
CPR	O	9.323	Center Point of Reference		4	5	19	0	3
	— m		*— Method*	*A*		*1*	*1*		
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
	— o		*— Radius of position uncertainty*	*N*		*0*	*5*		
DIS	O	9.324	Distinctive Features		3	23	2012	0	n/a
	— m		*— Type*	*A*		*4*	*10*		
	— m		*— Polygon (Closed Path)*	*NS*		*17*	*1000*		
	— o		*— Comment*	*ANS*		*0*	*1000*		
NCR	O	9.325	No Cores Present	A	0	1	1	0	1
NDL	O	9.326	No Deltas Present	A	0	1	1	0	1
NDF	O	9.327	No Distinctive Features Present	A	0	1	1	0	1
RSV		9.328 9.330	Reserved for future definition						
Minutiae (Section 7.2.5)									
MIN	O	9.331	Minutiae		6	7	26	0	n/a
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
	— m		*— Theta*	*N*		*1*	*3*		
	— m		*— Type*	*A*		*1*	*1*		
	— o		*— Radius of position uncertainty*	*N*		*0*	*3*		
	— o		*— Direction uncertainty*	*N*		*0*	*3*		
MRA	O	9.332	Minutiae Ridge Count Algorithm	A	0	1	1	0	1
MRC	O	9.333	Minutiae Ridge Counts		5	9	14	0	n/a
	— m		*— Minutia Index A*	*N*		*1*	*3*		
	— m		*— Minutia Index B*	*N*		*1*	*3*		
	— o		*— Ridge Count*	*N*		*1*	*2*		
	— o		*— Reference number*	*N*		*0*	*1*		
	— o		*— Residual*	*N*		*0*	*1*		
NMP	O	9.334	No Minutiae Present	A	0	1	1	0	1
RCC	O	9.335	Ridge Count Confidence		6	11	28	0	n/a
	— m		*— X1*	*N*		*1*	*5*		
	— m		*— Y1*	*N*		*1*	*5*		
	— m		*— X2*	*N*		*1*	*5*		
	— m		*— Y2*	*N*		*1*	*5*		
	— m		*— Method of Ridge Counting*	*A*		*1*	*1*		
	— m		*— Confidence Value*	*N*		*1*	*2*		
RSV		9.336 9.339	Reserved for future definition						
Additional Features (Section 7.2.6)									
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*		

Ident	Cond code	Field #	Field name —*Information Items*	Char type	# Inf Items	Field size per occurrence (Min/Max)		Number of occurrences (Min/Max)	
	— 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*		
	— o		*— Type*	*A*		*2*	*5*		
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*		
NPP		9.344	No Pores Present	A	0	1	1	0	1
POR	O	9.345	Pores		2	3	11	0	n/a
	— m		*— X*	*N*		*1*	*5*		
	— m		*— Y*	*N*		*1*	*5*		
NDT	O	9.346	No Dots Present	A	0	1	1	0	1
NIR	O	9.347	No Incipient Ridges Present	A	0	1	1	0	1
NCR	O	9.348	No Creases Present	A	0	1	1	0	1
NRE	O	9.349	No Ridge Edge Features Present	A	0	1	1	0	1
Annotations (Section 7.2.7)									
MFD	O	9.350	Method of Feature Detection		9	27	477	0	n/a
	— m		*— Field(s)*	*AN*		*3*	*99*		
	— m		*— Method*	*A*		*3*	*4*		
	— o		*— Algorithm vendor*	*AN*		*1*	*40*		
	— o		*— Algorithm*	*AN*		*1*	*40*		
	— o		*— Examiner Last Name*	*AN*		*1*	*40*		
	— o		*— Examiner First Name*	*AN*		*1*	*40*		
	— m		*— Examiner Affiliation*	*AN*		*1*	*99*		
	— m		*— Date and time*	*AN*		*15*	*15*		
	— o		*— Notes*	*ANS*		*0*	*99*		
COM	O	9.351	Comments	ANS	0	1	200	0	n/a
LPM	O	9.352	Latent Processing Method	A	0	4	4	0	9
EAA	O	9.353	Examiner Analysis Assessment		6	20	139	0	20
	— m		*— Value*	*A*		*5*	*7*		
	— m		*— Examiner Last Name*	*AN*		*1*	*40*		
	— m		*— Examiner First Name*	*AN*		*1*	*40*		
	— m		*— Examiner Affiliation*	*AN*		*1*	*99*		
	— m		*— Date/Time*	*N*		*15*	*15*		
	— o		*— Comment*	*ANS*		*1*	*200*		
EOF	O	9.354	Evidence of Fraud		2	*5*	*204*	0	n/a
	— m		*— Fraud Type*	*A*		*3*	*3*		
	— o		*— Comment*	*ANS*		*1*	*200*		
LSB	O	9.355	Latent Substrate		2	3	1003	0	3
	— m		*— Code*	*AN*		*2*	*2*		
	— o		*— Comment*	*ANS*		*0*	*1000*		
LMT	O	9.356	Latent Matrix		2	3	1003	0	3
	— m		*— Code*	*N*		*1*	*2*		
	— o		*— Comment*	*ANS*		*0*	*1000*		

Ident	Cond code	Field #	Field name —*Information Items*	Char type	# Inf Items	Field size per occurrence (Min/Max)		Number of occurrences (Min/Max)	
LQI	O	9.357	Local quality issues		3	23	2012	0	n/a
	— m		*— Type*	*A*		*4*	*10*		
	— m		*— Polygon (Closed Path)*	*NS*		*17*	*1000*		
	— o		*— Comment*	*ANS*		*1*	*1000*		
RSV		9.358 9.359	Reserved for future definition						
Corresponding Features (Section 7.2.8)									
AOC	O	9.360	Area of Correspondence		3	21	2006	0	n/a
	— m		*— IDC Reference*	*N*		*2*	*4*		
	— m		*— Polygon (Closed Path)*	*NS*		*17*	*1000*		
	— o		*— Comment*	*ANS*		*0*	*1000*		
CPF	O	9.361	Corresponding Points or Features		7	7	1026	0	n/a
	— m		*— Label*	*AN*		*1*	*3*		
	— m		*— Type of correspondence*	*A*		*1*	*2*		
	— c		*— Field Number*	*AN*		*3*	*3*		
	— c		*— Field Occurrence*	*N*		*1*	*3*		
	— c		*— X*	*N*		*1*	*5*		
	— c		*— Y*	*N*		*1*	*5*		
	— o		*— Comment*	*ANS*		*0*	*1000*		
ECD	O	9.362	Examiner Comparison Determination		8	36	1232	0	n/a
	— m		*— IDC reference*	*N*		*2*	*4*		
	— m		*— Determination*	*A*		*4*	*16*		
	— m		*— Work in progress*	*A*		*5*	*11*		
	— m		*— Examiner Last Name*	*AN*		*1*	*40*		
	— m		*— Examiner First Name*	*AN*		*1*	*40*		
	— m		*— Examiner Affiliation*	*AN*		*1*	*99*		
	— m		*— Date and Time*	*AN*		*15*	*15*		
	— o		*— Comment*	*ANS*		*0*	*1000*		
RSV		9.363 9.371	Reserved for future definition						
Ridge Path (Section 7.2.9)									
SIM	O	9.372	Skeletonized Image	ANS	0	n/a	n/a	0	n/a
RPS	O	9.373	Ridge Path Segments	NS	0	17	1000	0	n/a
RSV		9.374 9.399	Reserved for future definition						

7.2.1 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 selected from Table 6, Table 7, or Table 8 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. The contents of these tables are identical to ANSI/NIST-ITL 1-2007 Table 11, but have been reorganized, with explanatory text added for latent definitions.

If further descriptive information on the image or capture method is available, such as the latent lifting technique, it may be included in Field 9.352 Latent Processing Method (LPM).

Table 6: Exemplar Impression Types

Description		Code		
		Plain Fingerprint	**Rolled Fingerprint**	**Palm**
Live-scan	Livescan type unknown or unspecified	0	1	10
	Vertical swipe	8		
	Optical contact	20	21	
	Non-optical contact	22	23	
	Optical contactless	24	25	
	Non-optical contactless	26	27	
Nonlive-scan[5]		2	3	11

[5] E.g. Inked prints on paper.

Table 7: Latent Impression Types

Description	Code		Usage
	Fingerprint	Palm	
Latent impression	4	12	The digital image of the latent impression was acquired directly from a latent impression, using a flatbed scanner or digital camera.
Latent tracing	5	13	The digital image is of a drawn tracing of the impression, not the impression itself.
Latent photo	6	14	The digital image was acquired from a paper photograph that had been taken of a latent impression; the paper photograph was then digitized using a flatbed scanner or digital camera.
Latent lift	7	15	The digital image was acquired from a lift of the latent impression, using a flatbed scanner or digital camera.

Table 8: Other Impression Types

Description	Code	Usage
Other	28	Other collection method
Unknown	29	Unknown collection method

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.

7.2.2 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)

See Section 7.1.2 for a discussion of the Region of Interest and its use.

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. All other Extended Friction Ridge Features are in relation to the Region of Interest rectangle, not to the original image. Note that if the region of interest is defined as a polygon, the region of interest rectangle is simply a bounding box around the polygon, as explained in Section 7.1.2.

This field contains the following information items:

Width

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

Height

The height of the region of interest rectangle 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 rectangle. 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 rectangle. 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 (closed path) that further defines the friction ridge area under consideration within the Region of Interest. The format of polygons is described in Section 7.1.4. 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. While arbitrary rotation of the image is not recommended due to image degradation concerns, rotation of the image in multiples of 90° can be performed without image degradation and is acceptable.

If this field is omitted, the direction shall default to 0 (upright) and uncertainty shall default to 15, indicating that the image is rotated 0±15°.

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 optional information item contains the uncertainty of the orientation direction, in non-negative integer degrees, so that the resulting orientation is Direction± Uncertainty°. Valid values range from “0” to “180”: a value of “0” indicates a certain direction, while a value of “180” indicates an unknown orientation. If this information item is omitted, the uncertainty shall default to “15” (±15°).

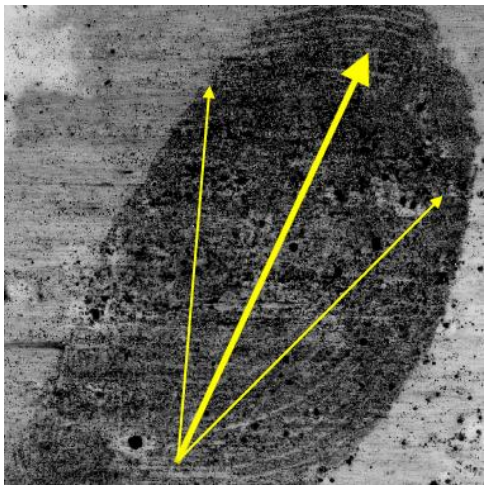

Figure 4: Example of orientation: -25 ± 20 degrees

Field 9.302 Finger/Palm/Plantar Position (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: polygons 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, with polygons to indicate the locations.

Table 9: Position codes for fingerprints[6]

Position	Code
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

Table 10: Position codes for palms[7]

Position	Code
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
Left hypothenar	36
Right Grasp[8]	TBD
Left Grasp	TBD

Table 11: Position codes for feet[9]

Position	Code
Unknown sole of foot	TBD
Sole of right foot	TBD
Sole of left foot	TBD
Unknown toe	TBD
Right big toe	TBD
Right second toe	TBD
Right middle toe	TBD
Right fourth toe	TBD
Right little toe	TBD
Left big toe	TBD
Left second toe	TBD
Left middle toe	TBD
Left fourth toe	TBD
Left little toe	TBD
Front/Ball of right foot	TBD
Back/Heel of right foot	TBD
Front/Ball of left foot	TBD
Back/Heel of left foot	TBD
Arch of right foot	TBD
Arch of left foot	TBD

This field contains the following three information items:

Position Code

This information item contains the code number corresponding to the known or most probable position shall be taken from Table 9 (fingerprints, including lower joints), Table 10 (palms), or Table 11 (feet) and entered as a one- or two-character ASCII subfield.

[6] These codes are as defined in ANSI-NIST ITL-1 2007 Table 12. Note that additional codes 11-19 are defined in ANSI-NIST ITL-1 2007 but are not applicable for these purposes.

[7] These codes are as defined in ANSI-NIST ITL-1 2007 Table 35, with the addition of grasp impressions.

[8] Grasp impressions are occasionally collected as part of a set of palm prints. The traditional method of collecting grasp impressions is to wrap a fingerprint card around a cylinder and grasp it with an inked palm: the area between the thumb and index finger is collected.

[9] These codes are being proposed as additions to ANSI-NIST ITL-1 2007.

Finger Segment

This optional information item only applies to fingerprints in which all or part of the medial or proximal segments (lower joints) are present in the image, in which case the 3-character code from Table 12 is used to indicate the finger segment position. This information item defaults to DST: if the Position Code indicates a fingerprint and the Finger Segment is not specified, the impression shall be regarded as including solely the distal segment with no substantive portions of the medial or proximal segments. See Figure 5 for more information, and Figure 6 for examples.

This information item shall be omitted if the Position Code indicates a palm or foot.

Off-center Fingerprint

This optional information item only applies to fingerprints in which the impression does not contain the central area of the fingerprint (i.e. the core or a center point of reference), in which case the 1-character code from Table 13 is used to indicate the off-center position of the fingerprint image. Figure 8 shows examples of off-center fingerprint positions.

This information item shall be omitted if the Position Code indicates a palm or foot.

Polygon

A polygon (closed path) that delineates the portion of the region of interest corresponding to the Position Code/Finger Segment codes. See Figure 6 and Figure 7 for examples. If the bounding box is not defined, the Position Code/Finger Segment codes are assumed to apply to the entire region of interest. The format of polygons is described in Section 7.1.4.

Table 12: Finger segment codes

Name	Code	Description
Distal Segment	DST	The segment of the finger or thumb farthest from the palm (default)
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
Unknown Segment	UNK	Image is an unknown segment of a finger or thumb.

Table 13: Off-center fingerprint positions

Name	Code	Description
Tip	T	The plain or rolled tip of the image
Right Side	R	The right side of the finger or thumb
Left Side	L	The left side of the finger or thumb

Figure 5 shows the location divisions for a palm, and the segment locations for the fingers.

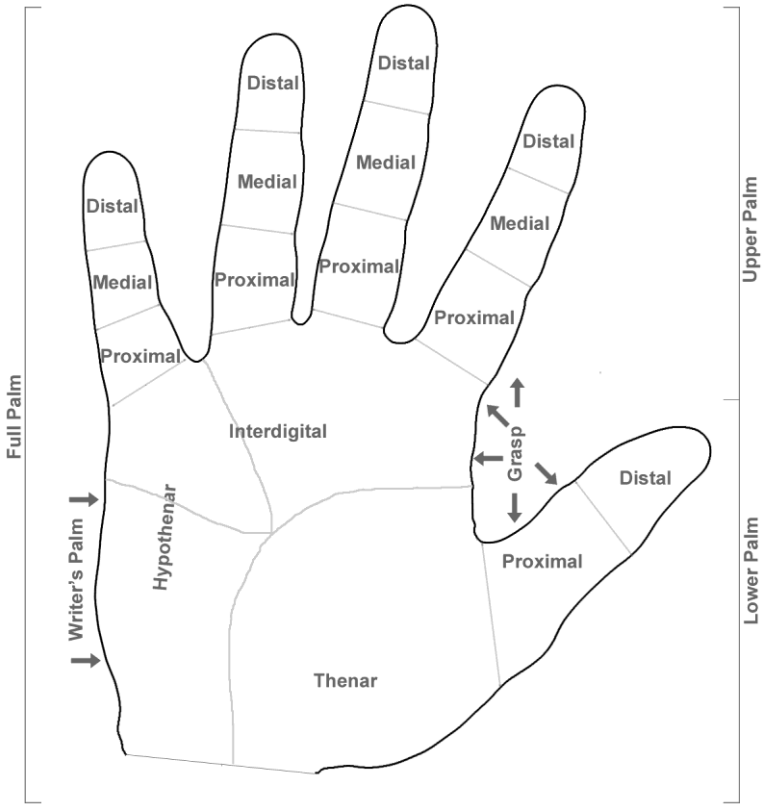

Figure 5: Palm and finger segment positions. Note that the interdigital and hypothenar areas overlap at the base of the little finger

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" (Unknown fingerprint) shall be used.
- If the image is from a palm but the location cannot be determined, the code "20" (Unknown palm) 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" (Unknown fingerprint) and "20" (Unknown palm) together address all friction ridge areas on the hands; codes "37" (Unknown sole of foot) and "40" (Unknown toe) together address all friction ridge areas on the feet.

If the image/region of interest contains multiple areas, this field allows the option to label and mark each of those areas within the region of interest. Each of the areas present shall be indicated using the appropriate Position Code/Finger Segment codes, with a polygon delineating each of the areas. Polygons may overlap if appropriate. See Figure 6 and Figure 7 for examples.

- If the image is an exemplar entire joint image or full finger view (from a set of complete friction ridge exemplars), or a latent of equivalent area, it shall be marked with the finger number (0-10), and shall have the individual segments marked with polygons.
- If the image is of a palm (or foot), each of the palm areas present shall be marked with the relevant position code and delineated with a polygon.

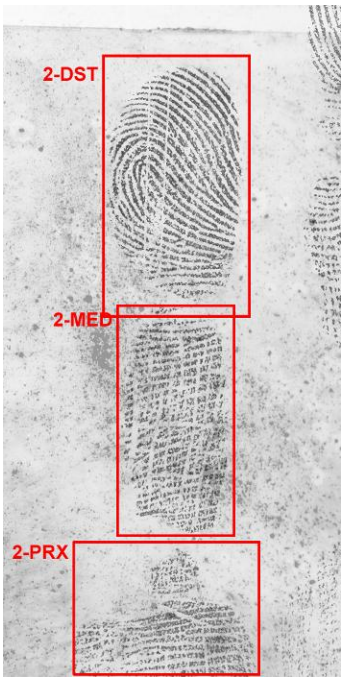

Figure 6: Use of polygons to mark multiple finger segments in a latent equivalent to a full finger view

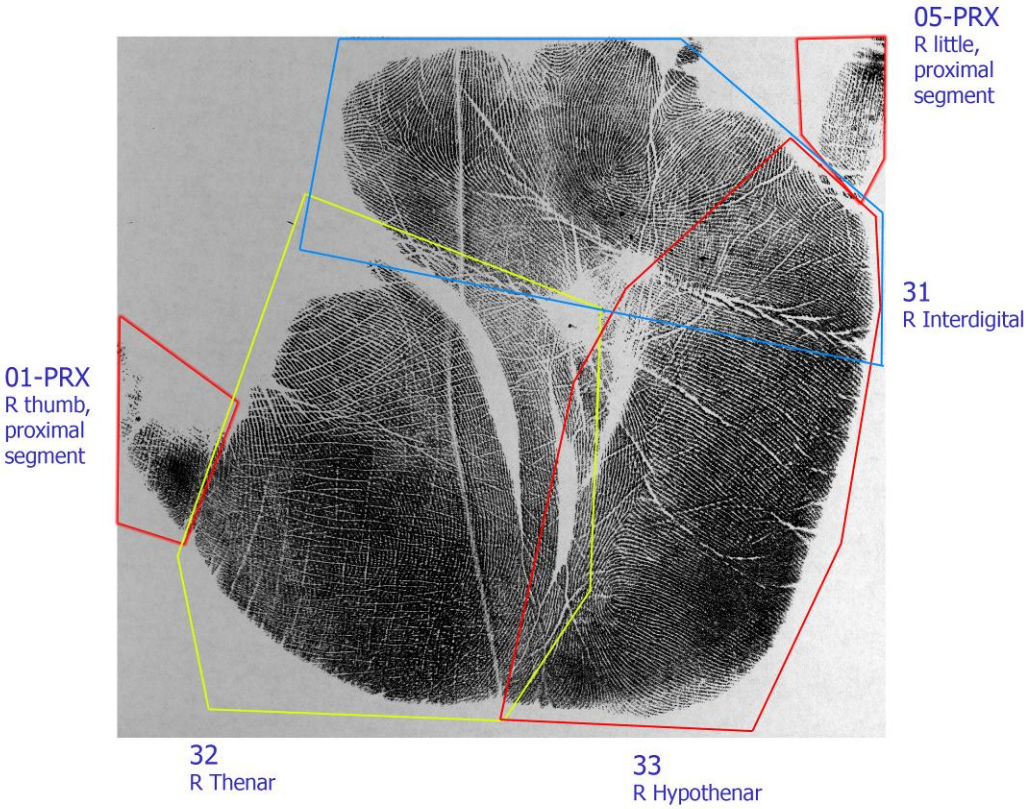

Figure 7: Use of polygons to mark multiple areas within a palm impression

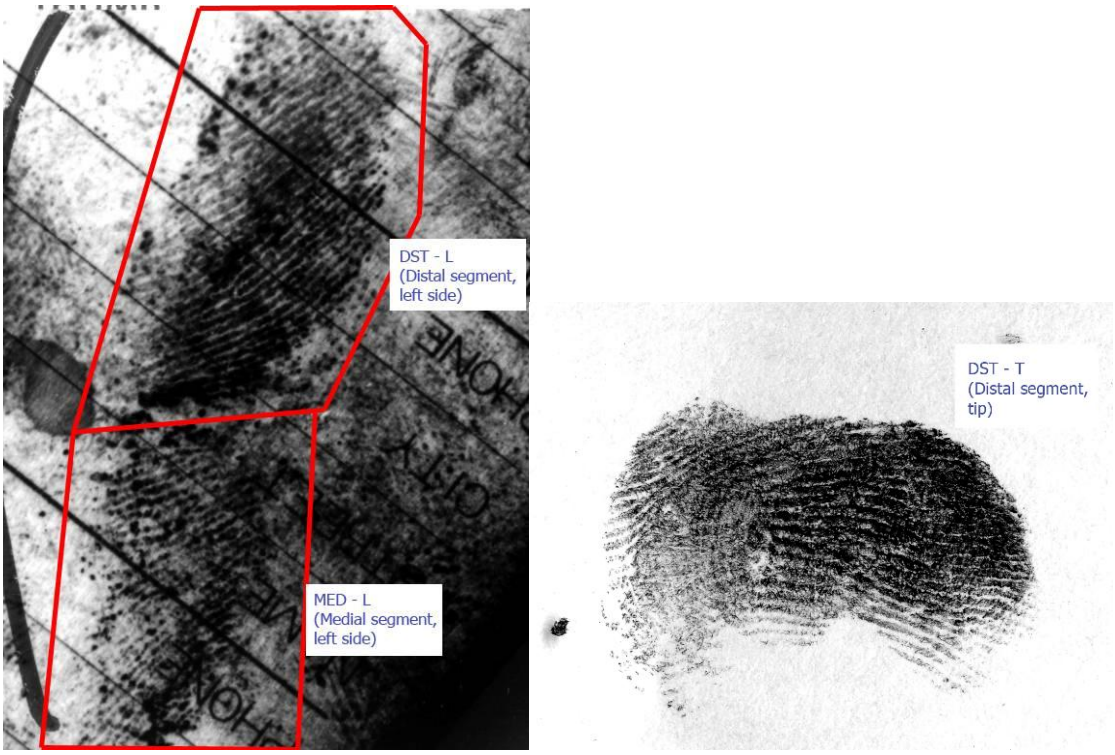

Figure 8: Examples of off-center fingerprint positions

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.

7.2.3 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 other friction ridge impressions. The field consists of three information items, which are detailed in Table 14.

General Classification

The general set of pattern classifications (arch, whorl, left & right loop) used by most current automated systems.

Subclassification

The detailed subclassification of arches and whorls may optionally be provided by a human examiner or automated system. This information item shall only be included for arches or whorls, and only if the subclassification can be determined precisely.

Whorl Delta Relationship

The 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*[10] (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 seven data entries, indicating all possible pattern classifications. Classification must be conservative: if the pattern is known precisely, only a single pattern shall be indicated; however, if there is any doubt as to the precise classification, all possible patterns shall be included. If the pattern cannot be classified, but a pattern type can be definitively excluded, then that shall be indicated by including all possible patterns. For example, a latent that contains a delta but no other pattern area information could possibly be a left loop, right loop, whorl (of any type), or tented arch, so it would indicate LS;RS;WU;AU(TA).

Complete Scar (SR) and Dissociated Ridges/Dysplasia (DR) should only be noted if the fingerprint cannot be classified. If the print can be classified and scar(s), dissociated ridges, and/or dysplasia are present, this field should note the classification(s) and the scar(s), dissociated ridges, and/or dysplasia should be noted in Field 9.324 Distinctive Features (DIS).

Note that the use of Field 9.322 Core-Delta Ridge Counts (CDR) can be used to further subcategorize pattern classification.

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

Table 14: 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/Confidence Map (RQM)

Local friction ridge quality (as defined in the Ridge Quality Map) is an assessment of confidence in small local areas within an image. The local quality map is used to define the confidence in all other features, and therefore is key information. In addition, when the quality map indicates a high-quality region in which features are not marked, that information can be used as “negative features” or definitive absence of features, which can be used for exclusion.

Accurate and consistent markup of local quality is essential, and the guidelines in this section should be followed as closely as possible. The names and color-coding indicated here should be used whenever possible. See Section 7.1.7 for more details

For every cell in a grid superimposed on the Region of Interest, this optional 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 local quality (LocQ) value 0 through 5 representing the quality of ridge detail in that cell, as specified in Table 15

The size of the grid and data format are specified in Field 9.309 Ridge Quality Map Format (RQF).

Table 15: Local ridge quality codes

Local Quality Code	Name	Shorthand description	Display color	
5	Definitive pores	Pores and ridge edges are obvious and unambiguous		Aqua [RGB=(0,240,240)]
4	Definitive ridge edges, debatable pores	Ridge edges, minutiae, and ridge flow are obvious and unambiguous; pores are either debatable or not present		Blue [RGB=(0,0,255)]
3	Definitive minutiae, debatable ridge edges	Minutiae, and ridge flow are obvious and unambiguous; ridge edges are debatable		Green [RGB=(0,255,0)]
2	Definitive ridge flow, debatable minutiae	Continuity of ridge flow is certain; minutiae are debatable		Yellow [RGB=(255,255,0)]
1	Debatable ridge flow	Continuity of ridge flow is uncertain		Red [RGB=(255,0,0)]
0	Background	No ridge information		Black or no color [RGB=(0,0,0)]

Field 9.309 Ridge Quality Map Format (RQF)

This field defines the grid size or data representation format used in Field 9.308 Ridge Quality/Confidence Map (RQM) Its use is conditional on the presence of Field 9.308 Ridge Quality/Confidence Map (RQM).

This field consists of two information items:

Grid size

This information item may be used to define grid sizes (both the horizontal and vertical dimensions of a single cell in the grid): valid settings range from “1” (0.01mm) through “41” (0.41mm). The recommended grid size is 0.20mm (0.008") – note this is 4 pixels at 500ppi, or 8 pixels at 1000ppi.

Data format

This information item defines the format used in the Field 9.308 Ridge Quality/Confidence Map (RQM), as defined in Table 16. 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 RS 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 16: 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 15, 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.
RLE	Run-Length Encoded	The unencoded values for each data entry are identical to those used in UNC format. The numeric values for each grid cell (0-5) are then replaced with alphabetic equivalents (A-F), and then any sequential runs of the same character are prefixed by the decimal count of repeated characters. Individual characters are not preceded by a count. For example: 00000000000000000000000000000000000000000000000000 (50 characters) Is saved as "50A" 00000000000011223345555555444442210000000000000000 (50 characters) Is saved as "12A2B3C2DE7F5E2CB16A" (20 characters)

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 (RFF). 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 (RFF).

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.

Field 9.311 Ridge Flow Map Format (RFF)

This field permits setting the sampling frequency or data representation format used in the Field 9.310 Ridge Flow Map (RFM) field to values other than the defaults. Its use is conditional on the presence of Field 9.310 Ridge Flow Map (RFM).

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 information item defines the format used in the Ridge Flow Map field, as defined in Table 17. The default is the uncompressed ("UNC") format.

Table 17: 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). Undefined angles: 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[11] 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. Undefined angles: If the direction cannot be determined at a given location, the location at that point shall be marked as "*" (asterisk). 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 optional 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 Field 9.313 Ridge Wavelength Map Format (RWF). 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 RS character. The number of characters in one data entry is twice the number of sampling points in one row.

[11] Base-64 is a method of representing binary data as text, as specified in IETF RFC 2045 (http://tools.ietf.org/html/rfc2045).

Field 9.313 Ridge Wavelength Map Format (RWF)

This field permits setting the sampling frequency or data representation format used in Field 9.312 Ridge Wavelength Map (RWM) to values other than the defaults. This field is conditional on the presence of Field 9.312 Ridge Wavelength Map (RWM).

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 information item defines the format used in Field 9.312 Ridge Wavelength Map (RWM). 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 Tonal Reversal (TRV)

Ridges in friction ridge images are generally represented as dark areas, with valleys as light areas. This field indicates whether the entire image is reversed tonally (black-for-white). If all or part of the image is reversed tonally, this 1-character optional field is set to the appropriate value from Table 18. Otherwise this field is omitted.

Partial tonal inversion can occur in different ways. If definable portions of the image are negative, Field 9.357 Local Quality Issues (LQI) can be used to define the specific tonally reversed areas.[12] Note that in some cases, the tonal reversal is so mixed that only portions of individual ridges are reversed, making it impractical or impossible to define the tonally reversed areas.[13]

Note that when this field is set, the image in the Type-13 record should be left as it was originally received (i.e., tonally reversed): setting this field and reversing the image when saving will result in inconsistent data. When this field is set, a software user interface may display the tonally corrected image, but save the image as originally received with this field set.

Table 18: Tonal reversal codes

Code	Description
N	Negative – ridges are light and valleys are dark throughout the image.
P	Partial – ridges are light and valleys are dark only in portions of the image.

Field 9.315 Possible Lateral Reversal (PLR)

This field indicates if the original image is or may be laterally reversed (i.e., flipped left-right). In many cases, an examiner cannot tell the correct lateral direction of the image, such as latents on tape that has been closed on itself, or latents that may have been transferred to the substrate/surface.

[12] Example: very heavy pressure can leave matrix from valleys, whereas lighter pressure at the edges of the same impression would leave matrix from ridges.

[13] Example: if light powder is applied from a single direction, one edge of each ridge is light and the remainder dark.

If the image is or may be laterally reversed, this 1-character optional field is set to the appropriate value from Table 19; otherwise, this field is to be omitted.

Note that when this field is set to L (Image is known to be laterally reversed), the image in the type-13 record should be left as it was originally received (i.e., laterally reversed): setting this field and reversing the image when saving will result in inconsistent data. When this field is set a software user interface may display the laterally corrected image, but save the image as received with this field set.

Note that when this field is set to U (Image may be laterally reversed), it is incumbent on the recipient (software system or examiner) to search/compare the impression and features both as presented and flipped left-right.

Table 19: Lateral reversal codes

Code	Description
L	Image is known to be laterally reversed.
U	Image may be laterally reversed

Field 9.316 Friction Ridge Quality Metric (FQM)

This optional field is used to specify one or more different metrics of friction ridge quality for the friction ridge impression corresponding to this record, as delimited by the region of interest. 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 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 image for a particular function.

If the corresponding image is present in the file with this Type-9 record, this field corresponds to fields 13.024, 14.024, and 15.024, but differs in that the quality metric is limited to the area in the image delimited by the region of interest.

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 consists of three information items:

Quality metric value

The first information item shall be a quantitative expression of the quality of the biometric sample. This item contains the ASCII representation of the integer friction ridge quality score between 0 and 100 assigned to the 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.

Quality algorithm vendor code

The second 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.

Quality algorithm product code

The third 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.

Field 9.317 Possible growth or shrinkage (PGS)

This optional field is only used in the unusual circumstance that the friction ridge impression is believed to have changed size or scale from potential comparisons. This provides for handling of images from deceased subjects with desiccated skin, or with swollen skin due to water exposure. This also provides for handling of overall growth of subjects between capture, such as in comparing an adult's fingerprints with those taken as a child. In these cases the size of ridges and distances between ridges change to a greater extent than would ordinarily be assumed in comparisons; this field acts as a flag to indicate that greater than ordinary dimensional variation should be expected in performing subsequent comparisons.

This field is to be omitted unless there is reason to believe that growth or shrinkage may have occurred.

This field consists of two information items:

Type

The type of characteristic, selected from Table 20.

Comment

Optional text describing the rationale for believing that growth or shrinkage may have occurred.

Table 20: Growth or shrinkage codes

Code	Description
G	Growth: impression is believed to be dimensionally larger than exemplars or other prints from the same subject.
S	Shrinkage: impression is believed to be dimensionally smaller than exemplars or other prints from the same subject.
B	Both: impression may be dimensionally larger or smaller than exemplars or other prints from the same subject.

Fields 9.318-9.319: 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.

7.2.4 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 9 shows an example of how the core is placed. Note that the core is not on the innermost recurving ridgeline itself.

Figure 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 21.

- Cores may be marked on tented arches if an innermost recurving ridge is present above the delta, so that each side of the recurving ridge extends to either side of the delta.
- Plain or central pocket loop whorls will only have one core if the innermost recurving ridge is circular, or two cores if elliptical. A circular whorl only has one core and does not have a defined direction.
- Accidentals may have any number of cores.

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

Table 21: 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

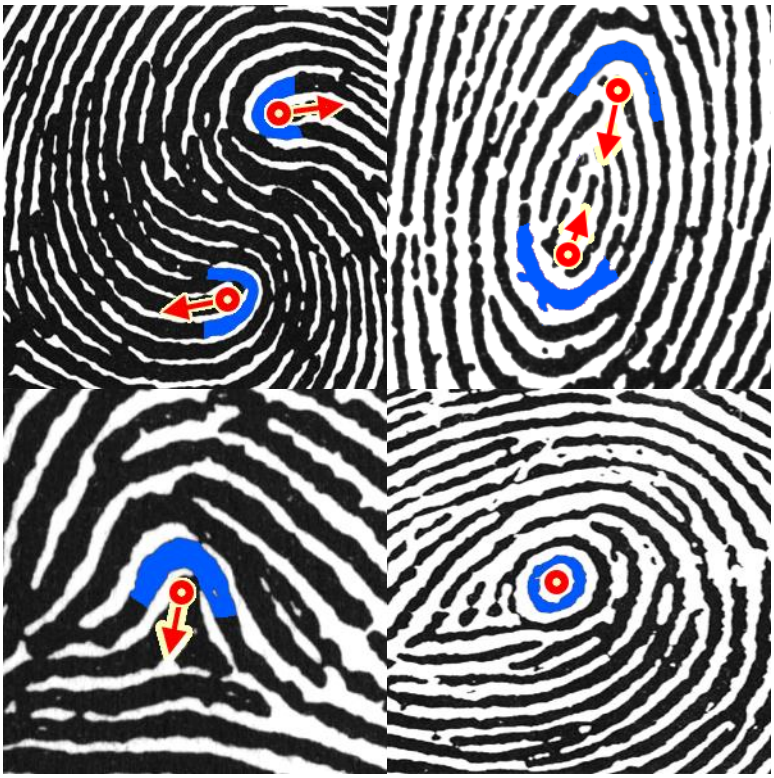

Figure 10: Examples of core locations for a double loop whorl, plain whorl, tented arch, and central pocket loop whorl

This field consists of the following information items:

X, Y

The location of the core, in units of 10 micrometers (0.01mm)

Direction

This optional information item is the direction of the core. This is 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.

Note that if one or more cores are present and the features set is from a fingerprint, Pattern Class (PAT) should be defined. 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)

For fingerprints, one or more deltas are defined for all pattern classifications other than plain arches, as shown in Table 21. Note that tented arches should have deltas marked if such a structure is present. Accidentals may have any number of deltas.

Most palmprints contain four interdigital deltas and one carpal delta.

Other delta-like patterns may be defined using this field if such structures are present in friction ridge images.

This field consists of the following 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 the type of delta, as defined in Table 22.

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.

Table 22: Types of deltas

Code	Applies to	Name	Description
L	Fingerprint	Left fingerprint delta	The delta to the left of the image for whorls or right loops. For accidentals with more than two deltas, this indicates the leftmost delta.
R	Fingerprint	Right fingerprint delta	The delta to the right of the image for whorls or left loops. For accidentals with more than two deltas, this indicates the rightmost delta.
I00 I02..I05 I07..I10	Palm	Interdigital delta (with finger number)	The deltas at the base of the fingers in the interdigital areas. The finger number shall be noted if known, else set to “00”. Note that thumbs do not have interdigital deltas.
C	Palm	Carpal delta	The delta at the base of the palm where the thenar and hypothenar meet.
<empty>	Fingerprint, Palm, or Foot	Other delta	Any other delta or delta-like structure in a friction ridge impression.

Note that if one or more deltas are present and the features set is from a fingerprint, Pattern Class (PAT) should be defined. 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.

Figure 11: Palm with carpal delta and interdigital deltas 7-10 marked

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. If the relevant core is not defined, this shall be set to “U” to indicate an upper core or “L” to indicate a lower core (whorls only), permitting minimum ridge counts when cores are not in the region of interest.

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. If the relevant delta is not defined, this shall be set to “L” to indicate a left delta or “R” to indicate a right delta, permitting minimum ridge counts when deltas are not in the region of interest.

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 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 is defined for fingerprints or toeprints, not for other types of friction ridge images.

This field consists of the following information items:

Method

The method of determining the X,Y location, selected from Table 23.

X, Y

The location of the center point of reference, as defined in Method, in units of 10 micrometers

(0.01mm)

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.

Table 23: Methods of determining center point of reference locations

Code	Name	Description
L	Lateral center only	The center location is defined laterally (across the finger) but is not meaningful in the other dimension (longitudinally, or along the finger). Lateral center is most frequently used for defining the center line of arches, tips, and lower joints. Lateral center is only meaningful if the orientation (Field 9.301) is known; the point marked is the center with respect to the orientation angle.
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 13. 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 14. The point of convergence is determined in terms of least squares (see, e.g., Novikov and Kot (1998)[14])

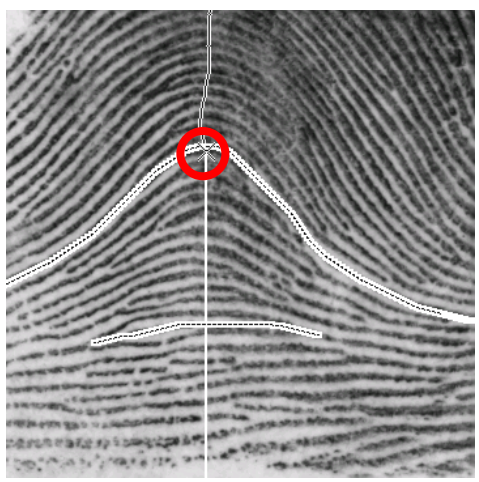

Figure 12: Lateral center example

[14] 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

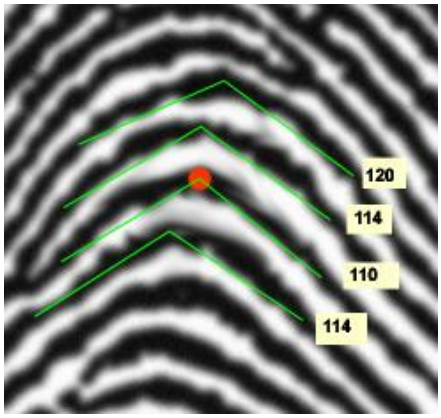

Figure 13: Uppermost point of the ridge with greatest curvature. Measurements are angles (degrees)

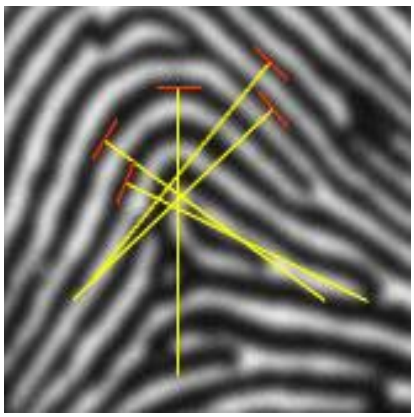

Figure 14: Overall fingerprint focal point

Field 9.324 Distinctive Features (DIS)

This field is used to define one or more areas containing unusually discriminating features that are not fully defined using other Extended Friction Ridge Features. The characteristics noted in this field are specific to the friction skin itself, as opposed to issues specific to the impression (such as smudging) which are noted in Field 9.357 Local Quality Issues (LQI).

This field consists of three information items:

Type

The type of characteristic, selected from Table 24.

Polygon

A polygon (closed path) outlining the area of the distinctive feature, defined as stated in Section 7.1.4.

Comment

Optional text describing the feature.

Table 24: Types of distinctive features

Code	Description
SCAR	Scar
WART	Wart or blister
MINGROUP	Unusual group or cluster of minutiae
CORE	Unusually distinctive core area
DELTA	Unusually distinctive delta area
MINUTIA	Unusually shaped minutia
CREASE	Unusually distinctive crease
CLEAR	Large clear field of ridges; large clear area with no minutiae
DYSPLASIA	Dissociated ridges/ Dysplasia
OTHERFEAT	Other unusual features not characterized elsewhere; details should be noted in Comments

Field 9.325 No Cores Present (NCR)

This optional field is used to indicate whether the analysis process has determined that no cores (Field 9.320 Cores (COR) could be discerned in the image:

- If the analysis process has determined that no cores could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

See Section 7.1.6, No features present fields for further explanation of this field.

Field 9.326 No Deltas Present (NDL)

This optional field is used to indicate whether the analysis process has determined that no deltas (Field 9.321 Deltas (DEL)) could be discerned in the image:

- If the analysis process has determined that no deltas could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

See Section 7.1.6, No features present fields for further explanation of this field.

Field 9.327 No Distinctive Features Present (NDF)

This optional field is used to indicate whether the analysis process has determined that no distinctive characteristics (Field 9.324 Distinctive Features (DIS))) could be discerned in the image:

- If the analysis process has determined that no distinctive characteristics could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

See Section 7.1.6, No features present fields for further explanation of this field.

Fields 9.328-9.330: 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.

7.2.5 Minutiae

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

The type of minutiae shall be marked if clearly identifiable as a ridge ending or bifurcation; otherwise, it shall be marked as unknown type. The location for a bifurcation shall be at the “Y” of the ridge, with the direction running down the valley (see Figure 15). The location for a ridge ending or unknown type shall be at the “Y” of the valley, with the direction running up the ridge (see Figure 16). Note that the ridge ending location corresponds with that used for the FBI’s EFTS and INCITS 378, and differs from some vendor-specific approaches. If the precise location for a ridge ending cannot be ascertained, a radius of uncertainty shall be marked to include the area of possible locations. If the type is unknown, the radius of uncertainty must be indicated (see Figure 17).

Note the relationship between Field 9.308 Ridge Quality/Confidence Map (RQM) and minutiae: in areas of Ridge Quality/Confidence that are green, blue, or aqua, the presence and absence of minutiae is definitive, and can be used for exclusion in future comparisons — otherwise the region should be marked yellow.

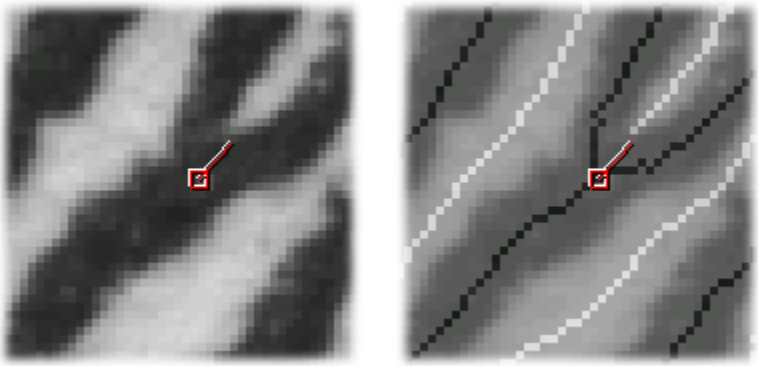

Figure 15: Minutia placement for a bifurcation. The center of the bifurcation should be at the "Y" of the ridge. The theta angle should run down the valley.

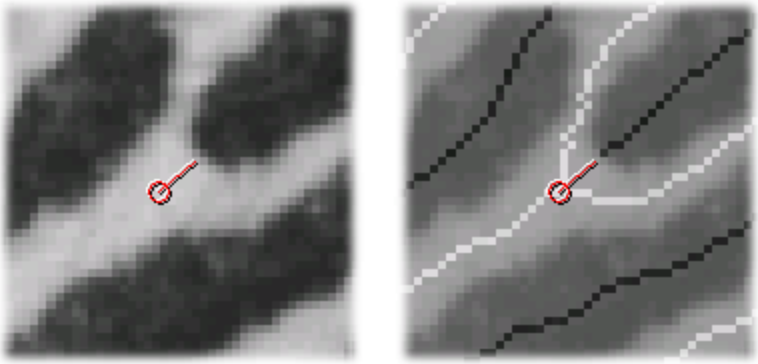

Figure 16: Minutia placement for a ridge ending. The center of the ridge ending should be at the "Y" of the valley. The theta angle should run up the ridge.

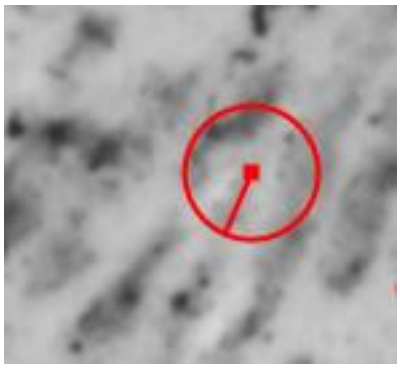

Figure 17: Minutia placement when type is unknown. The minutia is placed as for a ridge ending, type is set to unknown, and the radius of uncertainty is defined to include possible points of intersection with neighboring ridges.

Field 9.331 Minutiae (MIN)

This field is used to define the characteristics of all minutiae in the region of interest.

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 six 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 midpoint of the valley (see Figure 16), and bifurcations are at the fork of the midpoint of the ridge (Figure 15). Unknown types are marked as for ridge endings, but with the radius of uncertainty also defined (Figure 17).

Theta

The direction of the minutia, in degrees. The angle of the minutia is determined by constructing three virtual rays originating at the minutia and extending 1.93mm (0.064” – about three ridge

widths) 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 25. The type of minutia shall be set if the examiner/encoding process is confident as to type: the "either" type shall be used for all minutiae that are not clearly identifiable as a ridge ending or a bifurcation. Because of the frequency with which minutiae appear to be ridge endings in one impression and bifurcation in another, even in clear images, it is recommended that the minutiae type be used as supporting evidence rather than as a basis for exclusion.

All complex minutiae types (crossovers/trifurcations etc) should be marked as combinations of bifurcation/endings. Unusually distinctive types/combinations of minutiae should be marked as unusual minutiae/groups of minutiae in Field 9.324 Distinctive Features (DIS).

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 Region of Interest.

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. The resulting direction is Theta±Uncertainty°. 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 25: Minutia types

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

Field 9.332 Minutiae Ridge Count Algorithm (MRA)

This optional 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 26.

Table 26: Minutiae ridge count algorithms

Code	Description
OCTANT	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. Ridge count values are set to number of intervening ridges. (Default)

EFTS7	Identical to OCTANT algorithm, except that ridge count values are one more than the number of intervening ridges. See [EFTS7][15] for further details.

Field 9.333 Minutiae Ridge Counts (MRC)

This field contains the counts of intervening ridges between specified minutiae. Field 9.332 Minutiae Ridge Count Algorithm (MRA) governs how the minutiae are selected for ridge counts, and the details of how the ridges are counted.

Note that if Field 9.372: Skeletonized image (SIM) is used, ridge counts can be derived from that field rather than included explicitly.

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 minutiae 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 the OCTANT and EFTS7 ridge count algorithms, this information item specifies the octant.

Residual

An optional information item specific to the OCTANT and EFTS7 ridge count algorithms, specifying the half of the octant in which the neighboring minutia lies. The residual is 0 if the neighboring minutia lies in the clockwise half of the octant, or 1 if the minutia lies in the counterclockwise half of the octant.

Field 9.334 No Minutiae Present (NMP)

This optional field is used to indicate whether the analysis process has determined that no minutiae (Field 9.331 Minutiae (MIN)) could be discerned in the image:

- If the analysis process has determined that no minutiae could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

See Section 7.1.6, No features present fields for further explanation of this field.

[15] Federal Bureau of Investigation, “Electronic Fingerprint Transmission Standard”, Version 7.1.

Field 9.335 Ridge Count Confidence (RCC)

This optional field is used to indicate confidence in intervening ridge counts between any two points. While primarily used to indicate ridge count confidence between minutiae, this confidence measure can also apply to other features such as Core/Delta ridge counts.

If this field not used, the default assumption is that the ridge counts were manually determined. This field provides a means to save state when only a portion of ridge counts have been manually checked.

This field consists of six information items:

AX, AY

The coordinates for Point A, in units of 10 micrometers (0.01mm).

BX, BY

The coordinates for Point B, in units of 10 micrometers (0.01mm).

Method of Ridge Counting

Method by which ridge counts were determined and/or validated selected from Table 27

Confidence Value

The confidence value for a ridge count from 0 to 99, with 0 indicating no confidence.

Table 27: Method of Ridge Counting

Value	Definition	Description
A	Auto	The ridge count was automatically performed without human review
T	Manual Tracing	The ridge count was automatically determined, based on a skeletonized image created by a human examiner.
M	Manual Ridge Count	The ridge Count was determined or validated manually by a human examiner.

Fields 9.336-9.339 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.

7.2.6 Additional 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 local ridge width. 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).

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, 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)

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.

Linear discontinuities are creases, cracks, cuts, and thin or non-permanent scars. They are often called “white lines”. 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.

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 28 (illustrated in Figure 18). For fingerprints, the only permanent flexion crease is the DIP (the distal interphalangeal crease separating the distal and medial segments of the finger, or 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 28: Permanent flexion creases

Code	Name	Location
DIP	Distal interphalangeal crease	Finger between medial and distal segments, or Thumb between proximal and distal segments
PIP	Proximal interphalangeal crease	Finger between proximal and medial segments
PDC##	Proximal digital crease	Finger/Thumb at Palm. The 2-digit fingerprint position code is appended (e.g. PDC01-PDC10)[16] The fingerprint position code is 00 if the finger position cannot be determined.
RLC	Radial longitudinal crease (also known as bottom crease)	Palm around base of thumb (thenar)
PTC	Proximal Transverse crease (also known as middle crease)	Diagonal across palm
DTC	Distal Transverse crease (also known as top crease)	Palm at base of interdigital area
WC	Wrist crease	Wrist

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

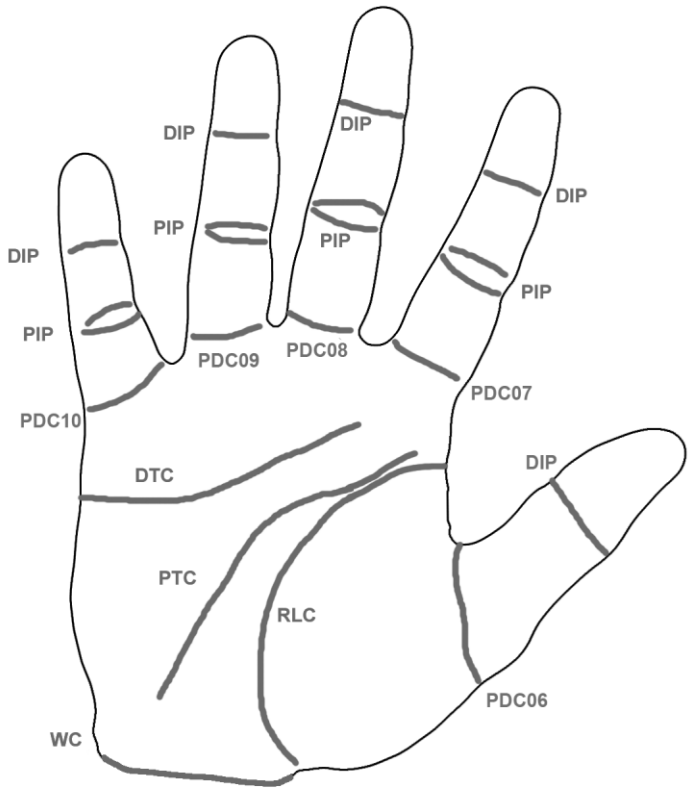

Figure 18: Locations of major flexion creases

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 (or spur) is an abrupt increase in ridge width that is not long enough to be called a bifurcation. An event on a ridge longer than local ridge width shall be marked as a standard bifurcation with a ridge ending; a shorter event shall be marked as a protrusion. Protrusions are marked at the center of the protruding area.
- An indentation is an abrupt decrease in ridge width. Indentations are marked at the center of the gap in the ridge.
- A discontinuity is a point where the ridge stops briefly 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 No Pores Present (NPP)

This optional field is used to indicate whether the analysis process has determined that no pores (Field 9.345 Pores (POR)) could be discerned in the image:

- If the analysis process has determined that no dots could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

See Section 7.1.6, No features present fields for further explanation of this field.

Field 9.345 Pores (POR)

Each pore is marked by its center point.

This field consists of two information items:

X, Y

The center of the pore.

Field 9.346 No Dots Present (NDT)

This optional field is used to indicate whether the analysis process has determined that no dots (Field 9.340 Dots (DOT)) could be discerned in the image:

- If the analysis process has determined that no dots could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

Field 9.347 No Incipient Ridges Present (NIR)

This optional field is used to indicate whether the analysis process has determined that no incipient ridges (Field 9.341 Incipient Ridges (INR)) could be discerned in the image:

- If the analysis process has determined that no incipient ridges could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

See Section 7.1.6, No features present fields for further explanation of this field.

Field 9.348 No Creases Present (NCR)

This optional field is used to indicate whether the analysis process has determined that no creases (Field 9.342 Creases and Linear Discontinuities (CLD)) could be discerned in the image:

- If the analysis process has determined that no creases could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

See Section 7.1.6, No features present fields for further explanation of this field.

Field 9.349 No Ridge Edge Features Present (NRE)

This optional field is used to indicate whether the analysis process has determined that no ridge edge features (Field 9.343 Ridge Edge Features (REF)) could be discerned in the image:

- If the analysis process has determined that no ridge edge features could be discerned in the image, this field shall be set to Y.
- Otherwise, this field will be omitted.

See Section 7.1.6, No features present fields for further explanation of this field.

7.2.7 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 nine 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 29.

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[17], 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.

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.

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

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.

Examiner Affiliation

For methods other than “AUTO”, this information item shall contain the employer or organizational affiliation of the examiner.

Date and time

The date and time that the determination was made, in terms of universal Greenwich Mean Time (GMT) units. See Section 0 for details.

Notes

This optional information item shall contain free text with additional information regarding the detection or modification of features.

Table 29: 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 location, background information, or descriptive information. If comments need to be made about specific portions of the impression, use Field 9.324 Distinctive Features (DIS) or Field 9.357 Local Quality Issues (LQI).

Field 9.352 Latent Processing Method (LPM)

This text field contains a three-letter code from Table 30 indicating the technique(s) used to process the latent fingerprint. This field is only used for latent images.

Note that unprocessed impressions (patent images visible to the naked eye) are labeled VIS. Multiple methods can be marked if appropriate. Methods should only be marked if they contributed substantively to the visualization of the image, and are not a list of all methods attempted.

Table 30: Methods of latent processing

Code	Processing method		Code	Processing method
ADX	Ardrox		MBD	7-p-methoxybenzylanimo-4-nitrobenz-2-oxa-1, 3-diazole
ALS	Alternate light source		MBP	Magnetic black powder
AMB	Amido black		MGP	Magnetic grey powder
BLE	Bleach (sodium hypochlorite)		MPD	Modified physical developer
BLP	Black powder		MRM	Maxillon flavine 10gff, Rhodamine 6g, and MBD
BPA	Black powder alternative (for tape)		NIN	Ninhydrin
CBB	Coomassie brilliant blue		OTH	Other
CDS	Crowle's double stain		PDV	Physical developer
COG	Colloidal gold		R6G	Rhodamine 6G
DAB	Diaminobenzidine		RAM	Cyanoacrylate fluorescent dye (Rhodamine 6G, Ardrox, MBD)
DFO	1,8-diazafluoren-9-one		SAO	Safranin O
FLP	Fluorescent powder		SDB	Sudan black
GRP	Gray powder		SGF	Superglue fuming (cyanoacrylate)
GTV	Gentian violet		SSP	Stickyside powder
IOD	Iodine fuming		SVN	Silver nitrate
ISR	Iodine spray reagent		TEC	Theonyl Europiom Chelate
LAS	Laser		VIS	Visual (patent image, not processed by other means)
LCV	Leucocrystal violet		WHP	White powder
LQD	Liquid-drox		ZIC	Zinc chloride

Field 9.353 Examiner Analysis Assessment (EAA)

This text field indicates an examiner's assessment of the value of the single impression delineated by Field 9.300 Region of Interest (ROI). See also Field 9.362 Examiner Comparison Determination (ECD) for comparison determinations.

This field consists of six information items:

Value

This information item indicates the value of the impression, from Table 31.

Examiner last name

The surname (last name) of the fingerprint examiner.

Examiner first name

The first name (or first and middle names) of the fingerprint examiner.

Examiner affiliation

The employer or organizational affiliation of the examiner.

Date and time

The date and time that the determination was made, in terms of universal Greenwich Mean Time (GMT) units. See Section 0 for details.

Comment

Text that provides additional clarifying information for the examiner analysis assessment.

Table 31: Value Assessments

Code	Usage
VALUE	The impression is of value and is appropriate for further analysis and potential comparison. Sufficient details exist to render an individualization and/or exclusion decision.
LIMITED	The impression is of limited, marginal, value. It is not of value for individualization, but may be appropriate for exclusion.
NOVALUE	The impression is of no value, is not appropriate for further analysis, and has no use for potential comparison.
NONPRINT	The image is not a friction ridge impression.

Field 9.354 Evidence of Fraud (EOF)

This text field indicates that there is basis for determination that the image may be fraudulent.

This field consists of two information items:

Type of Fraud

This information item indicates the potential type of fraud attempted as determined from the impression, from Table 32.

Comment

Text that provides clarifying information regarding the assessment of potential evidence of fraud.

Table 32: Fraud Type Assessments

Code	Name	Usage
EVA	Evidence of evasion	Evasion includes actions that prevent/lessen the likelihood of matching such as by degrading or obscuring physical characteristics or mutilating fingers.
SPO	Evidence of spoofing	Spoofing includes purposefully attempting to match a different person; techniques include modifying biological characteristics and using fabricated characteristics.
FOR	Evidence of forged evidence	Forged evidence is forensic evidence that was fraudulently placed on the surface from which it was collected.
FAB	Evidence of fabricated evidence	Fabricated evidence is forensic evidence that never existed on the surface from which it was supposedly collected.

Field 9.355 Latent Substrate (LSB)

This field is used to define the substrate, or surface on which the friction ridge impression was deposited.

This field consists of the following information items:

Code

This information item indicates the type of substrate, from the Code column of Table 33.

Comment

Optional text that provides clarifying information regarding the substrate.

Table 33: Types of latent substrates

Category	Code	Description
Porous Substrate		
	1A	Paper
	1B	Cardboard
	1C	Unfinished/raw wood
	1D	Other/unknown porous substrate
Nonporous Substrate		
	2A	Plastic
	2B	Glass
	2C	Metal, painted
	2D	Metal, unpainted
	2E	Glossy painted surface
	2F	Tape, adhesive side
	2G	Tape, nonadhesive side
	2H	Aluminum foil
	2I	Other/unknown nonporous substrate
Semiporous Substrate		
	3A	Rubber or latex
	3B	Leather
	3C	Photograph, Emulsion side
	3D	Photograph, Paper side
	3E	Glossy or semi-glossy paper or cardboard
	3F	Satin or flat finish painted surface
	3G	Other/unknown semiporous substrate
Other / Unknown Substrate		
	4A	Other substrate (Specify)
	4B	Unknown substrate

Field 9.356 Latent Matrix (LMT)

This field is used to define the matrix, or substance deposited by the finger that forms the impression.

This field consists of three information items:

Code

This information item indicates the type of matrix, from the Code column of Table 34. Note that all visible contaminants are apparent rather than necessarily known to certainty: for example, the substrate may be marked as blood if it appears to be blood; if known for certain that should be indicated as a comment.

Comment

Optional text that provides clarifying information regarding the matrix.

Table 34: Types of latent matrices

Code	Description
1	Natural perspiration and/or body oils (eccrine and/or sebaceous)
	Visible contaminants:
2	Blood
3	Paint
4	Ink
5	Oil or Grease
6	Dirt or soil
7	Other visible contaminants
8	Impression in pliable material
9	Contaminant removal via touch
10	Other/Unknown matrix

Field 9.357 Local Quality Issues (LQI)

This field is used to define one or more areas containing localized quality or transfer issues that are not fully defined using other Extended Friction Ridge Features. The problems noted in this field apply to the specific impression under consideration; issues that are specific to the friction skin itself (such as scars) are noted in Field 9.324 Distinctive Features (DIS).

This field consists of three information items:

Type

The type of characteristic, selected from Table 35.

Polygon

A polygon (closed path) outlining the area of the distinctive feature, defined as stated in Section 7.1.4.

Comment

Optional text describing the quality issue.

Table 35: Types of quality issues

Code	Description
ARTIFACT	Digital artifacts, such as occasionally caused by compression or livescan devices.
BACKGROUND	Interference with background makes following ridges difficult (e.g. check patterns)
COMPRESSED	Distorted area in which ridges are compressed together
DISTORT	Miscellaneous distortion (See also Compressed and Stretched)
NEGATIVE	Used if only a portion of the friction ridge image is tonally reversed (has ridges and valleys inverted so that ridges appear white and valleys appear black). Note that Field 9.314 Tonal Reversal (TRV) is used if the entire image is tonally reversed.
OVERDEV	Overdeveloped area: excessive processing medium such as ink, powder, etc.
OVERLAP	Area in which another friction ridge impression is superimposed over the impression of interest
SMEAR	Smeared or smudged area
STRETCHED	Distorted area in which ridges are stretched apart from each other
TAPE	Lifting tape artifacts (crease, bubble, etc.)
OTHER	Other quality issues not characterized elsewhere; details should be noted in Comments

Fields 9.358-9.359: Reserved for future definition (RSV)

These fields are reserved for definition of additional fields, 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.

7.2.8 Corresponding Features

These fields are used to define the areas or points that correspond or do not correspond between two or more of the images contained in the current ANSI/NIST file: when images are compared as candidates for individualization (potential mates), the corresponding areas and points can be retained in these fields. Points of Correspondence may be marked using any type of feature, and are explicitly not limited to minutiae.

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 19 for an example. Note that the latent has two different areas of correspondence, one for each of the exemplars.

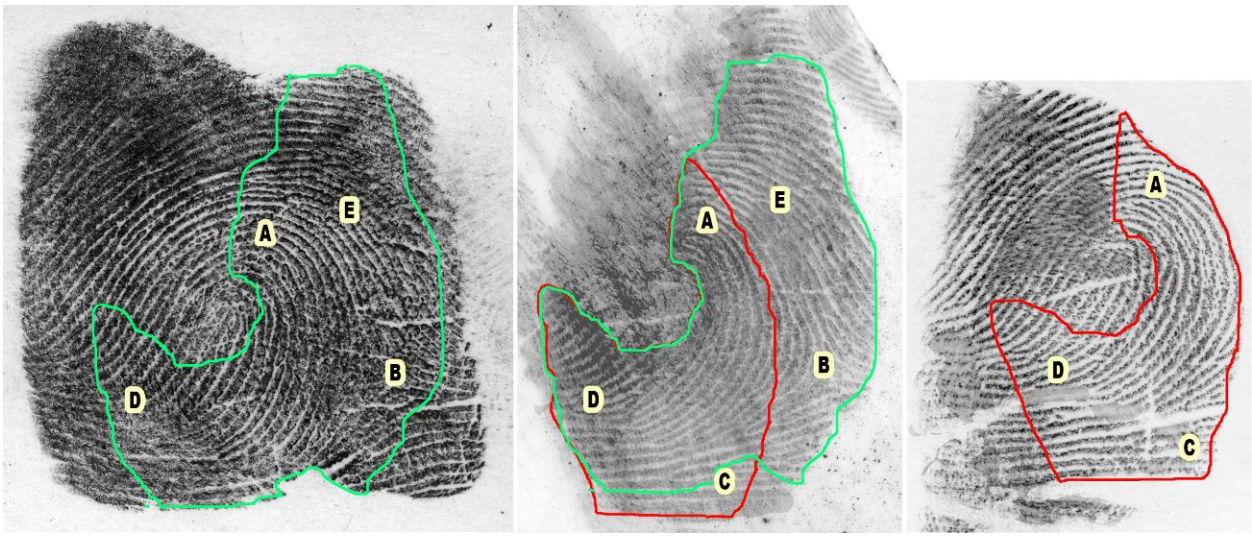

Figure 19: Examples of areas and points of correspondence in rolled exemplar, latent, and plain exemplar images

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). 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 20. 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.

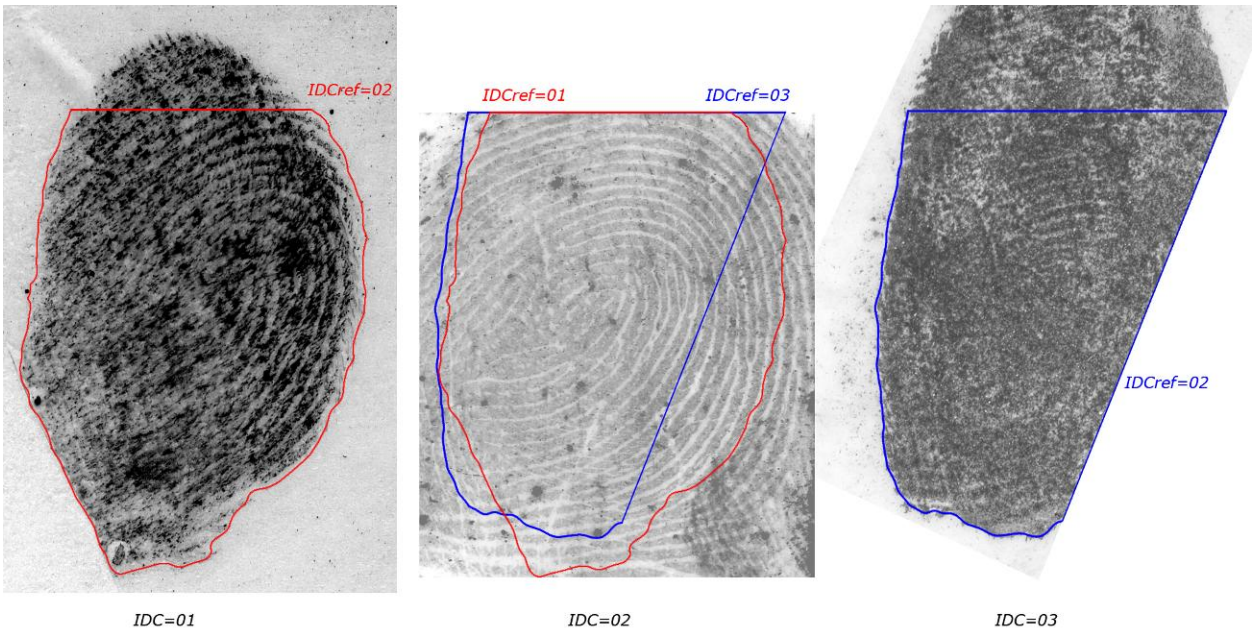

Figure 20: Examples of the use of IDC references in Areas of Correspondence for more than 2 images

This field consists of 3 information items:

IDC Reference

The IDC Reference information item indicates the target image for a given AOC. Figure 20 shows examples of the use of IDC references in Corresponding Regions of Interest. 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 (Closed Path) information item defines the outline of the corresponding area. The format of polygons is described in 7.1.4 Paths.

Comment

The optional Comment information item allows a free text comment or description related to the AOC.

Field 9.361 Corresponding Points or Features (CPF)

This field is used to label points or features for comparison of the current feature set with other Type-9 feature sets in this ANSI/NIST file, as was shown in Figure 19. 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). 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 label. Labels within a single Type-9 record shall be unique.

For example, if an ANSI/NIST file contains one latent and multiple candidate exemplars, a feature labeled “A” in the latent’s Type-9 feature set corresponds with the feature labeled “A” (if present) in all of the exemplar Type-9 feature sets.

Table 36: Types of corresponding points and features

Category	Code	Type	Description
Definite correspondence	F	Feature	The labeled feature definitely corresponds to the feature defined by the Field Number and Field Occurrence information items. (X and Y information items are unused) *Informally: It definitely exists & it corresponds to this specific minutia (or dot, pore, core, etc).*
	P	Point	The labeled feature definitely corresponds to the location with the coordinates defined in the X,Y information items. (Field Number and Field Occurrence information items are unused) *Informally: It definitely exists & it corresponds to this specific point (allows quick definition of points, rather than having to define each feature)*
Possible or debatable correspondence	DF	Debatable Feature	The labeled feature may debatably correspond to the feature defined by the Field Number and Field Occurrence information items. (X and Y information items are unused) *Informally: It appears to correspond to this specific minutia (or dot, pore, core, etc), but it isn't clear enough to be certain.*
	DP	Debatable Point	The labeled feature may debatably correspond to the location with the coordinates defined in the X,Y information items. (Field Number and Field Occurrence information items are unused) *Informally: It appears to correspond to this specific point, but it isn't clear enough to be certain.*
Definite lack of correspondence	X	Does not eXist	The labeled feature definitely does not exist in the impression, and the clarity of the potentially corresponding region is sufficient to make a definite determination. (X, Y, Field Number, and Field Occurrence information items are unused) *Informally: The feature isn't there, and the regions correspond enough that I would be able to see it if it were there – this is presumably a justification for an exclusion.*
Inconclusive	R	Out of Region	The labeled feature is not visible in the impression because it lies outside of the area of correspondence for this image: the feature may or may not be present, but the impression does not include the relevant area (X, Y, Field Number, and Field Occurrence information items are unused) *Informally: It isn't in the area of overlap, so I can't say anything.*
	U	Unclear area	The labeled feature is not visible in the impression because the potentially corresponding region is not sufficiently clear: the feature may or may not be present, but local quality issues prevent a definite determination. (X, Y, Field Number, and Field Occurrence information items are unused) *Informally: I can't tell if the feature is there because the area where it would be is smudged or otherwise unclear.*

Corresponding Points or Features may refer to arbitrary points, or may refer to predefined features (as noted in Table 36 and Table 38). Note that the features include point features (such as minutiae, dots, or pores), but also may refer to areas (such as distinctive characteristics), lines (incipients or creases), or paths (ridge path segments). Arbitrary points may be used to indicate characteristics that were not noted during analysis, or to indicate points in an exemplar that was not previously marked up.

For example, see Table 37; assume that a latent and exemplar are both present in an ANSI/NIST file, and that the latent and exemplar columns in these tables are examples from field 9.361 from different type-9 records in that file. The label “M1” indicates that the latent minutia (field 9.331) #5 corresponds to corresponds to location (1024,765) within the exemplar’s ROI. The label “X1” indicates that the dot (field 9.340) #1 does not exist within the exemplar image.

Table 37: Examples of corresponding points and features

	Latent	Exemplar	Latent	Exemplar
Label	M1	M1	X1	X1
Type	F	P	F	X
Field Number	331		340	
Field Occurrence	5		1	
X		1024		
Y		765		

This field consists of the following information items:

Label

This 1-3 character alphanumeric label is used to indicate correspondence between CPFs in different type-9 records. Labels within a single Type-9 record shall be unique. Note that the use of a given label in one type-9 record means that that point or feature corresponds with any or all other features with the same label in other type-9 records in the ANSI/NIST file.

Type of correspondence

This 1-2 character information item is set to the appropriate value from Table 36.

Field Number

(used only if Point or Feature = F) The Field Number information item indicates the type of field being compared, from Table 38. Note that these are simply the Type-9 field numbers of the fields that can be used for comparisons.

Field Occurrence

(used only if Point or Feature = F) The Field Occurrence information item indicates which data entry (occurrence) of the specified field the label is applied to. Note that this is a 1-based index, not a 0-based index: occurrences are numbered (1…count), not (0…count-1).

X,Y

(used only if Point or Feature = P) These two optional information items define the location of the CPF, in units of 10 micrometers (0.01mm).

Comment

This optional information item allows a free text comment or description related to the CPF.

Table 38: Field numbers used for corresponding features

Field number	Type
320	Cores
321	Deltas
324	Distinctive Characteristics
331	Minutiae
340	Dots
341	Incipient Ridges
342	Creases and Linear Discontinuities
343	Ridge Edge Features
345	Pores
373	Ridge Path Segments

Field 9.362 Examiner Comparison Determination (ECD)

This text field indicates an examiner's determination based on analysis and comparison of two specified friction ridge images. Note that the determinations labeled "potential" are included to mark preliminary determinations for work in progress, and are not final determinations.

This field consists of eight information items:

IDC Reference

The IDC Reference information item indicates the target image for a given determination, and is used in the same way as the IDC subfield in Field 9.360

Determination

This information item indicates a comparison conclusion, from Table 39.

Work in progress

This information item is set to "PRELIMINARY" (default) or "FINAL". For a determination to be accepted for further processing, the status must be set to "FINAL". The purpose of this is to allow saving work in progress, and requiring a doublecheck to verify that determinations are in fact final.[18]

Examiner last name

The surname (last name) of the fingerprint examiner.

Examiner first name

The first name (or first and middle names) of the fingerprint examiner.

[18] The Work in progress flag is included so that e.g. someone going to lunch or home for the night, or screening out a long list of candidates, can flag cases requiring further evaluation. A classic human factors design error is not allowing people to save work in progress, resulting either in losing work or rushing determinations.

Examiner affiliation

The employer or organizational affiliation of the examiner.

Date and time

The date and time that the determination was made, in terms of universal Greenwich Mean Time (GMT) units. See Section 7.1.8 for details.

Comment

Text that provides clarifying or qualifying information regarding the comparison determination.

Table 39: Comparison Determinations

Code	Name	Usage
INDIV	Individualization	The two impressions originated from the same source.
INC_C	Inconclusive, but with corresponding features noted	No conclusive determination can be made. Corresponding features are present, and no substantive contradictory features are present. The correspondence of features is supportive of the conclusion that the two impressions originated from the same source, but not to the extent sufficient for individualization. This determination should be made if the examiner determines that the impressions are almost certainly from the same source, but cannot make an individualization determination. This is sometimes described as a qualified conclusion.
INC_D	Inconclusive, but with dissimilar features noted	No conclusive determination can be made. Non-corresponding features are present. The dissimilarity of features is supportive of the conclusion that the two impressions originated from different sources, but not to the extent sufficient for exclusion. This determination should be made if the examiner determines that the impressions are almost certainly not from the same source, but cannot make an exclusion determination. This is sometimes described as a qualified exclusion.
INC_N	Inconclusive due to no overlapping area	Individualization and exclusion are not possible because no corresponding or potentially corresponding areas of friction ridge detail are present. This determination should be made if there is sufficient information in the impressions to determine that there are no areas in the impressions to compare, such as when one print is of the left half of a finger and the other is of the right half.
INC_I	Inconclusive due to insufficient information	Individualization and exclusion are not possible because of insufficient corresponding or contradictory data. This determination should be used if the specific other types of inconclusive determinations do not apply.
EX_SRC	Exclusion of source	The two impressions originated from different sources of friction ridge skin, but the subject cannot be excluded.
EX_SUB	Exclusion of subject	The two impressions originated from different subjects.
NONE	No determination	No determination has been made. (default)

Fields 9.363-9.371: Reserved for future definition (RSV)

These fields are reserved for definition of additional fields, 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.

7.2.9 Ridge Path: Skeletonized Image and Ridge Path Segments

Ridge path describes the course of a friction ridge. This specification provides for image or vector representations of ridge path information: as a skeletonized image, or as a set of ridge path segments (open path vectors). Either representation is a simplified representation of the ridges in the image that provides a rich method of conveying information, including feature placement, interrelationships, ridge direction, and wavelength. Note that the ridge path representation is a means of annotating the image (rather than replacing the image): it is a clear way of defining and communicating the specific path of each ridge, both for a human examiner and an automated extractor.

Skeletonized image

The ridge path for the entire region of interest can be represented as a skeletonized image, also known as a ridge tracing, which reduces the friction ridge impression to an image with thinned representations of each ridge. The skeletonized image is a 2-tone image with a white background and a black single-pixel-wide thinned representation of each ridge and stored in Field 9.372: Skeletonized image data (SIM).

Ridge Path Segments

The ridge path can be decomposed of a number of ridge path segments. Each ridge path segment (if completely visible) is the portion of a ridge that connects two minutiae, so each ridge path segment starts and stops either where the ridge intersects another ridge path segment (a bifurcation) or ends (a ridge ending). In the infrequent case in which a ridge segment forms a complete loop back on itself without intersecting another ridge segment (such as near the core of some plain whorls or central pocket loops), the ridge path starts and stops at a single arbitrary point on the ridge. Each ridge path segment is saved as an open path (ordered set of vertices) in Field 9.373: Ridge Path Segments (RPS); see Section 7.1.4 Closed and Open Paths for information on path formats.

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

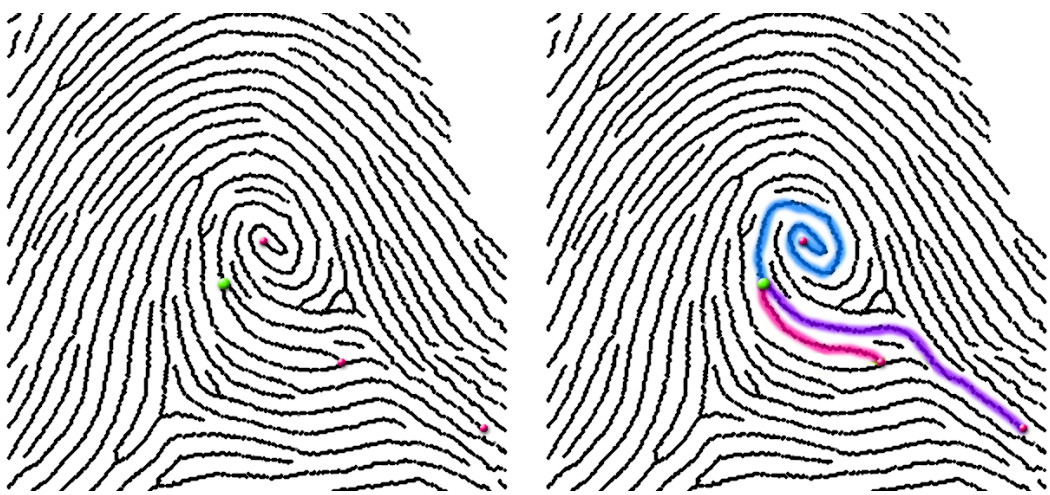

Figure 21: Example of interrelationships between minutiae, with connecting ridge path segments highlighted

Note that often ridge path segments are not visible over their entire length due to image clarity problems or due to being truncated by the edge of the impression, and therefore one or both ends of a ridge segment may not end at points defined as minutiae. Effective use of ridge path representations requires distinguishing between any areas in which the skeleton is debatable rather than definitive. Field 9.308

Ridge Quality/Confidence Map (RQM) is used for this purpose: Table 40 shows the relationship between the local quality values and the ridge path. Figure 22 shows an example of a skeletonized image with a quality map: black and red areas (quality 0-1) have no skeleton; the yellow areas are poor (quality 2) and the skeleton information is not definitive; in other areas the skeleton is definitive.

Table 40: Local ridge quality and tracing

Ridge path	Local Quality Code	Name	Display color
Ridge path is definitive	5	Definitive pores	
	4	Definitive ridge edges, debatable pores	
	3	Definitive minutiae, debatable ridge edges	
Ridge path is debatable	2	Definitive ridge flow, debatable minutiae	
No ridge path	1	Debatable ridge flow	
	0	Background	

Figure 22: Examples of fingerprint, skeletonized representation, and overlay of original / skeleton / quality map

A ridge skeleton can represent sophisticated interrelationships between features. For example, Figure 21 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.

Note that the PATH format permits the treatment of each ridge segment as a distinct feature, indexed by its data entry (occurrence) number. Each ridge segment can be associated with the minutiae at its ends and features such as pores and ridge edge features along its length. Dots and incipients can be associated with the ridge segments on either side. Each ridge ending is associated with one ridge segment; each bifurcation is associated with three ridge segments.

In the case that the type of minutia cannot be determined or its precise location cannot be ascertained, a minutia can be tentatively associated with any ridge segments that cross the minutia's radius of uncertainty, as shown in Figure 23.

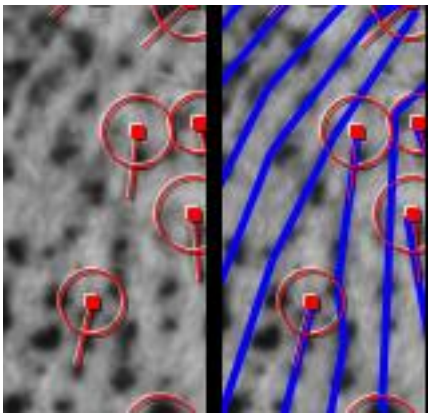

Figure 23: Examples of minutiae of uncertain type and radii of uncertainty, without and with ridge segments

Field 9.372: Skeletonized image (SIM)

The skeletonized image, also known as a ridge tracing, is stored as a 1-bit grayscale PNG compressed image, bit-packed 6 bits per character using base-64[19] representation. The entire PNG-formatted image file is included as a single data entry. Interlacing, alpha transparency, and color palettes shall not be used. The resolution of the skeletonized image must be the same as the original image.

Each black pixel can have 1, 2, or 3 neighboring black pixels (1,2,3-connexity); other values (0, 4-8) are errors. The skeletonized image's dimensions shall be identical to the Region of Interest (ROI) field.

The values in Field 9.308 Ridge Quality/Confidence Map (RQM) are used to distinguish between the areas in which the skeleton is debatable and those in which it is definitive: Table 40 shows the relationship between the local quality values and the tracing.

Field 9.373: Ridge Path Segments (RPS)

Each skeletonized ridge segment is stored as a separate data entry (occurrence), as an open path of consecutive vertices (see Section 7.1.4 Closed and Open Paths). Each endpoint of a ridge segment is either shared by 3 ridge segments (at a bifurcation) or is unique to a single ridge segment (at a ridge ending).

Fields 9.374-9.399: Reserved for future definition (RSV)

These fields are reserved for definition of additional fields, 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.

7.3 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.

[19] Base-64 is a method of representing binary data as text, as specified in IETF RFC 2045 (http://tools.ietf.org/html/rfc2045).

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 area delineated by its Field 9.300 Region of Interest (ROI), although these areas can overlap in the case of superimposed impressions. In this case, all of the Type-9 records would share the same IDC as the image.