# Performance Without Conformance? Value of Level 1, 2 and 3 Conformance

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IBPC 2012

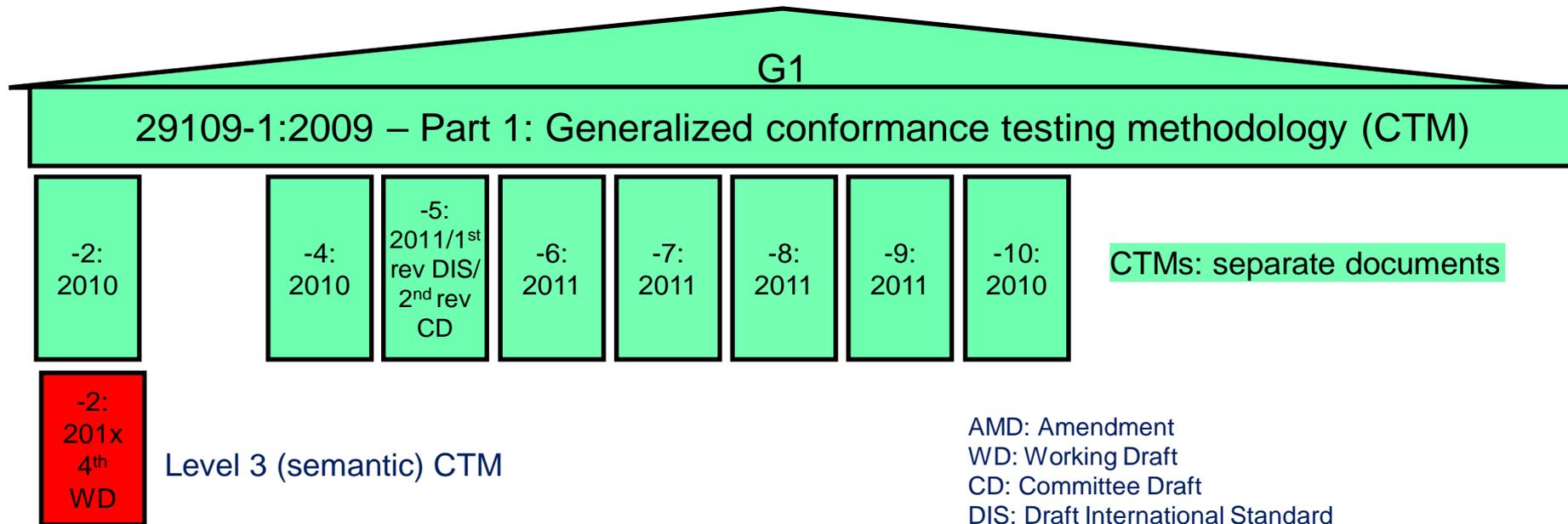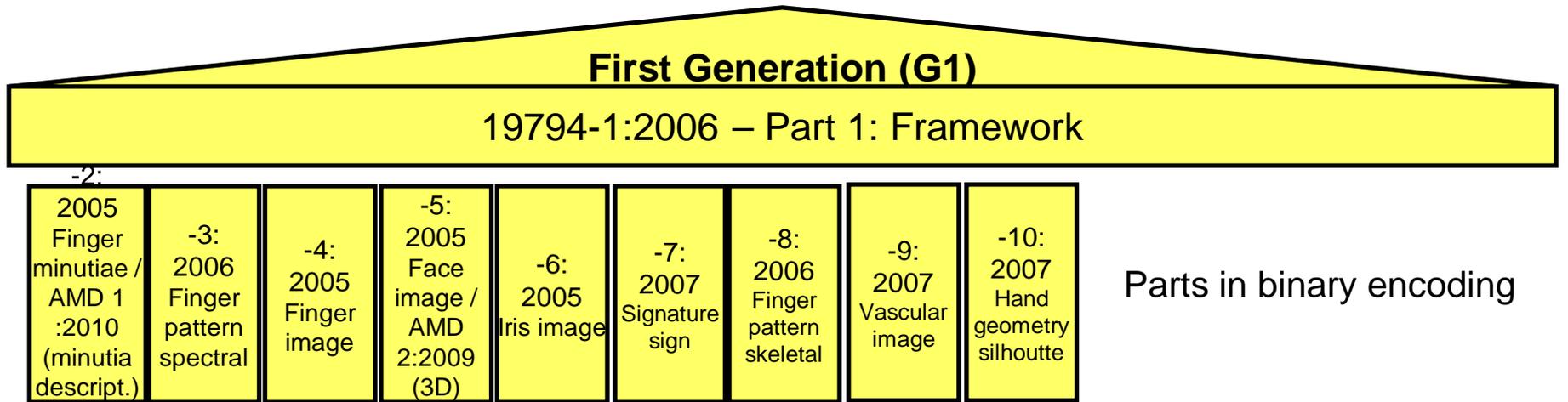# Conformance to Biometric Standards

- The existence of biometric standards alone is not enough to demonstrate that products meet the technical requirements specified in the standards.

- Conformance testing:

    - Captures the technical description of a specification and measures whether an implementation faithfully implements the specification.

    - Supports increasing levels of confidence in product quality and increases the probability of successful interoperability and data interchange.

# Conformance to Biometric Standards
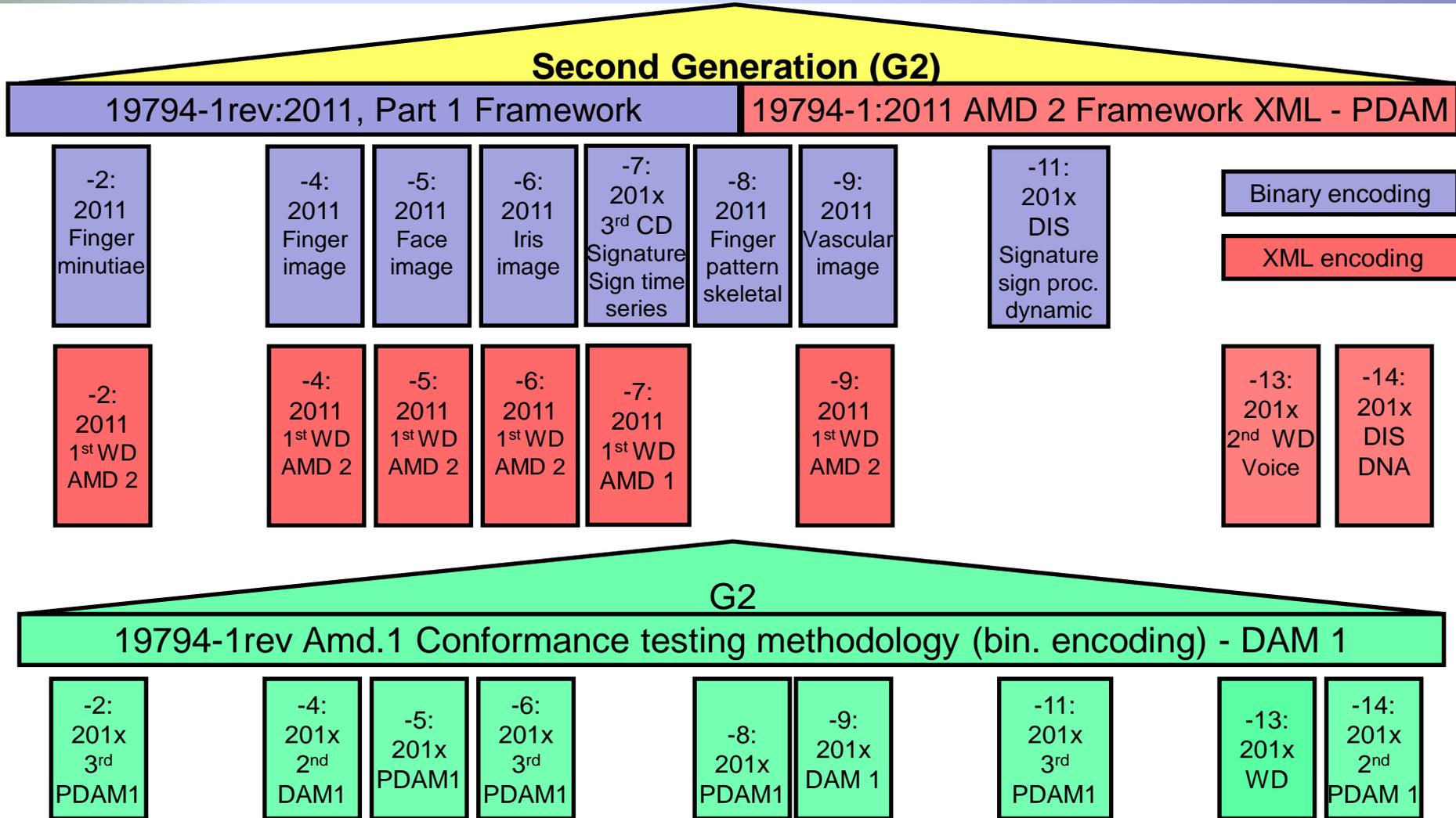
- Can the lack of conformance to biometric standards (data interchange formats in this discussion) also seriously influence operational <u>access</u> to the biometric data and/or <u>deter the system from achieving the expected performance</u>?

- Conformance testing plays the role of <u>the canary in the coal mine</u> warning on possible issues related with the expected level of performance.

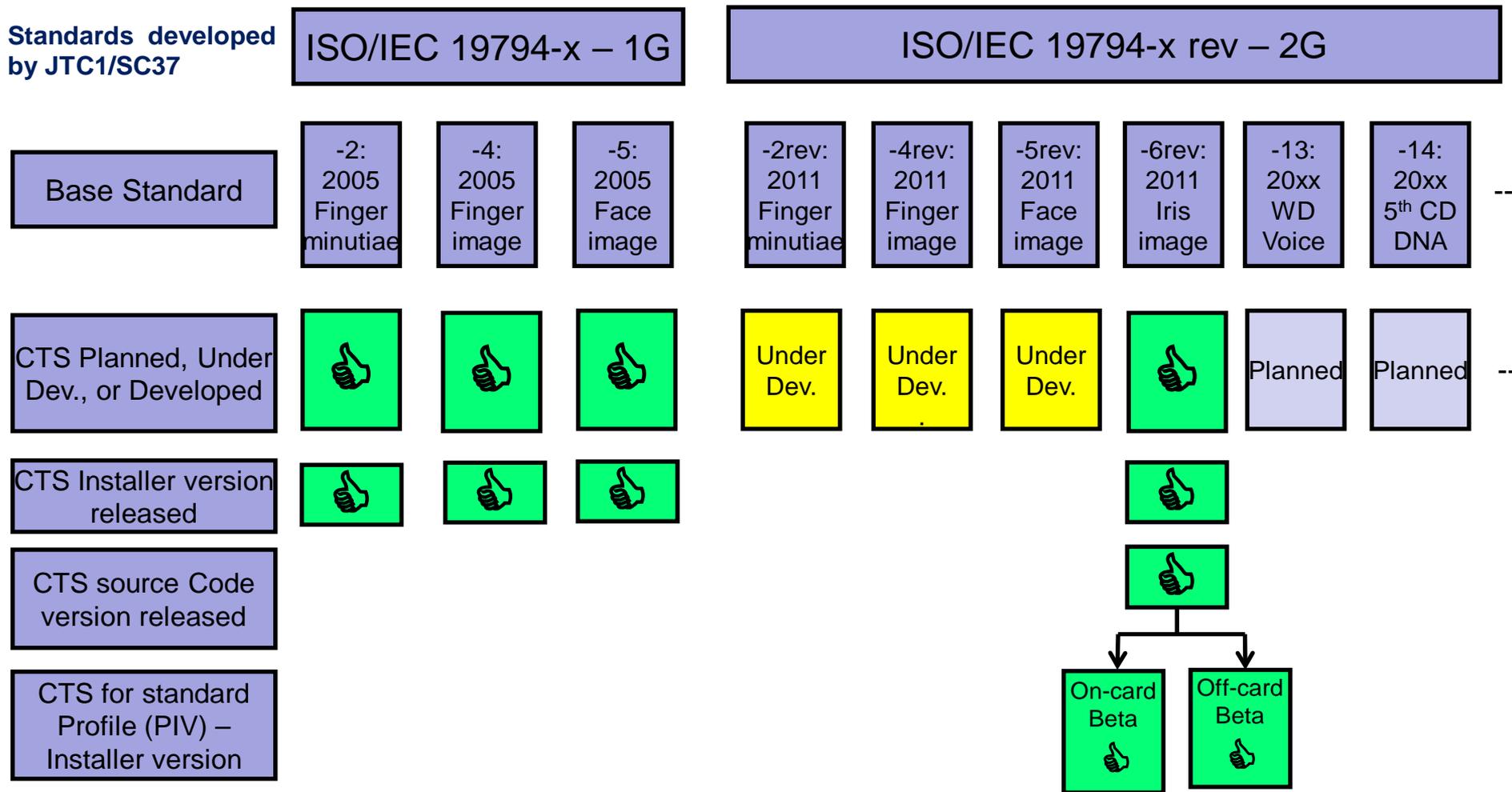# ISO/IEC JTC 1 SC 37 Biometric Data interchange Formats and Related Conformance Testing Methodology Standards

## First Generation (G1)

### 19794-1:2006 – Part 1: Framework

| -2: 2005 Finger minutiae / AMD 1 :2010 (minutia descript.) | -3: 2006 Finger pattern spectral | -4: 2005 Finger image | -5: 2005 Face image / AMD 2:2009 (3D) | -6: 2005 Iris image | -7: 2007 Signature sign | -8: 2006 Finger pattern skeletal | -9: 2007 Vascular image | -10: 2007 Hand geometry silhoutte |
|---|---|---|---|---|---|---|---|---|

Parts in binary encoding

## G1

### 29109-1:2009 – Part 1: Generalized conformance testing methodology (CTM)

| -2: 2010 | | -4: 2010 | -5: 2011/1st rev DIS/ 2nd rev CD | -6: 2011 | -7: 2011 | -8: 2011 | -9: 2011 | -10: 2010 |
|---|---|---|---|---|---|---|---|---|

CTMs: separate documents

-2: 201x 4th WD

Level 3 (semantic) CTM

AMD: Amendment
WD: Working Draft
CD: Committee Draft
DIS: Draft International Standard

From Dr. Busch's BCC 2010 Presentation: *"Status and Trends for Biometric Data Interchange Formats Standardization"* and *SC 37/WG 3 Roadmap*

# ISO/IEC JTC 1 SC 37 Biometric Data interchange Formats and Related Conformance Testing Methodology Standards

**Second Generation (G2)**

**19794-1rev:2011, Part 1 Framework** | **19794-1:2011 AMD 2 Framework XML - PDAM**

| -2: 2011 Finger minutiae | -4: 2011 Finger image | -5: 2011 Face image | -6: 2011 Iris image | -7: 201x 3rd CD Signature Sign time series | -8: 2011 Finger pattern skeletal | -9: 2011 Vascular image | -11: 201x DIS Signature sign proc. dynamic |

Binary encoding

XML encoding

| -2: 2011 1st WD AMD 2 | -4: 2011 1st WD AMD 2 | -5: 2011 1st WD AMD 2 | -6: 2011 1st WD AMD 2 | -7: 2011 1st WD AMD 1 | -9: 2011 1st WD AMD 2 | -13: 201x 2nd WD Voice | -14: 201x DIS DNA |

**G2**

**19794-1rev Amd.1 Conformance testing methodology (bin. encoding) - DAM 1**

| -2: 201x 3rd PDAM1 | -4: 201x 2nd DAM1 | -5: 201x PDAM1 | -6: 201x 3rd PDAM1 | -8: 201x PDAM1 | -9: 201x DAM 1 | -11: 201x 3rd PDAM1 | -13: 201x WD | -14: 201x 2nd PDAM 1 |

WD: Working Draft / CD: Committee Draft / DIS: Draft International Standard / FDIS: Final Draft International Standard
PDAM: Proposed Draft Amendment / DAM: Draft Amendment

Updated from Dr. Busch's BCC 2010 Presentation: *"Status and Trends for Biometric Data Interchange Formats Standardization" and SC 37/WG 3 Roadmap*

# Hierarchy of Conformance Tests for Biometric Data Interchange Formats

- Conformance Testing Methodology standards include:

  - Summary of the conformance test requirements in the data format standard that indicates what <u>level of conformance testing</u> is applicable to each requirement.

  - Three levels of conformance testing are defined:

    - *Level 1 conformance testing (L1)*

    - *Level 2 conformance testing (L2)*

    - *Level 3 conformance testing (L3)*

  - <u>Conformance test assertions</u> to be tested for the corresponding requirements.

# Conformance Test Suites (CTSs) Designed to Test Implementation of Biometric Data Interchange Format Standards

**Standards developed by JTC1/SC37**

| | ISO/IEC 19794-x – 1G | | | ISO/IEC 19794-x rev – 2G | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Base Standard** | -2: 2005 Finger minutiae | -4: 2005 Finger image | -5: 2005 Face image | -2rev: 2011 Finger minutiae | -4rev: 2011 Finger image | -5rev: 2011 Face image | -6rev: 2011 Iris image | -13: 20xx WD Voice | -14: 20xx 5th CD DNA |
| **CTS Planned, Under Dev., or Developed** | 👍 | 👍 | 👍 | Under Dev. | Under Dev. | Under Dev. | 👍 | Planned | Planned |
| **CTS Installer version released** | 👍 | 👍 | 👍 | | | | 👍 | | |
| **CTS source Code version released** | | | | | | | 👍 | | |
| **CTS for standard Profile (PIV) – Installer version** | | | | | | | On-card Beta 👍 / Off-card Beta 👍 | | |

# Level 1 (L1) Conformance Testing

- L1 testing checks field by field and byte by byte conformance with the standard, both in terms of ranges, values and, as required, cardinality.

- Most values are used to determine which L2/L3 tests to run.

- If no L1 processing is performed, L2 tests (and in some cases) L3 tests may not be performed.

# L1 Testing – 2G Finger Minutiae Data Format (19794-2:2011) - Error Example & Possible Impact

## General Header

- Format Identifier
- Version Number
- Length of Record
- Number of Finger Representations
- Device Certification Block Flag

- The standard defines a field for Finger Position (e.g., left index finger, right index and middle ring).

- Allowed values are: 0 - 10, 13 - 15, and 40 - 50.

- If the value in the field would be 51, a decision statement would have no L2 tests to perform for 51.

- Any use of the record / further tests based on finger position may be jeopardized by this error.

## Representation

- Representation Length
- Capture Date and Time
- Capture Device Technology Identifier, Capture Device Vendor Identifier, Capture Device Type Identifier
- Quality and Certification Blocks
- **Finger Position (51)**
- Representation Number
- Image Spatial Sample Rate (horiz and vert)
- Impression Type
- Size of Scanned Image in X-Dir and in Y-Dir
- Minutiae Field Length
- Ridge Ending Type
- Number of Minutiae
- Minutia Type
- Minutia X, Minutia Y and Angle Ø
- Minutia Quality
- Extended Data Block Length
- Extended Data Area Type Code
- Extended Data Area Length
- Extended data

# Level 2 (L2) Conformance Testing

- L2 conformance testing checks the internal consistency of a data format implementation under test (IUT), relating values from one part of the IUT to values from other parts of the IUT.

- L2 tests involve interactions between multiple values from different parts of the IUT and sometimes are derived from implicit assumptions that are not explicitly stated in a standard.

- L2 tests require more complex validation than L1 tests.

- Example: Length (e.g., Record, Representation, Extended Data Area). Length errors can create havoc in L1, L2 and L3 testing and record parsing/processing.

# L2 Testing – 2G Iris Data Format (19794-6:2011) Error Example & Possible Impact

## General Header

- Format Identifier
- Version Number
- Record Length
- Number of Representations
- Certification Flag
- **Number of Eyes Represented = 0 (laterality is unknown)**

- Inconsistency between the Number of Eyes Represented and the Eye Label field in the representation.

- The General Header specifies that the Number of Eyes Represented is 0; meaning the record should ONLY contains representations where the Eye Label = 0 (Undefined).

- A DB query to select a specific subset of records may disregard this record. Do you need it?

## Representation

- Representation Length
- Capture Date and Time
- Capture Device Technology Identifier
- Quality Block
- Representation Number
- **Eye Label = 1 (SUBJECT_EYE_LABEL_RIGHT = 1)**
- Image Type
- Image Format
- Iris Image Property Bit
- Image Width
- Image Height
- Bit Depth
- Range
- Roll Angle of Eye
- Roll Angle Uncertainty
- Iris Center Smallest X
- Iris Center Largest X
- Iris Center Smallest Y
- Iris Center Largest Y
- Iris Diameter Smallest
- Iris Diameter Largest
- Image Data Length
- **Iris Image Data (Right eye)**

# L2 Testing - 2G Finger Image Data Format (19794-4:2011) – Possible Impact Due to Unexpected Extended Data

## General Header

- Format Identifier
- Version Number
- Record Length
- Number of Finger/Palm Representations
- Certification Flag
- Number of Distinct Finger/Palm Positions

## Representation

- **Representation Length = 2000**
- Capture Date and Time
- Capture Device Technology Identifier
- Capture Device Vendor Identifier
- Capture Device Type Identifier
- Quality Block
- Certification Block
- Finger/Palm position
- Representation Number
- Scale Units
- Scan Spatial Sampling Rate (horiz)
- Scan Spatial Sampling Rate (vert)
- Image Spatial Sampling Rate (horiz)
- Image Spatial Sampling Rate (vert)
- Bit Depth
- Image Compression Algorithm
- Impression Type
- Horizontal Line Length
- Vertical Line Length
- **Image Data Length = 1500**
- Image **(compressed)**

Extended Data

- Example assumes that the system is designed to handle records that are not expected to have any representation with <u>extended data</u> so it assumes the **length of the image** to be: Representation Length – Length of **(Representation Header**)

- The "Length of the image" could be incorrect:
- How robust the record/image processing is?
- Is the image detected using "magic bytes"?
- Is the image processed correctly?
- Was L2 testing performed to detect possible errors/inconsistencies?

# L2 Testing – 2G Iris Data Format (19794-6:2011) Image Format Specified vs. Iris Image Data Format

## General Header

- Format Identifier
- Version Number
- Record Length
- Number of Representations
- Certification Flag
- Number of Eyes Represented

## Representation

- Representation Length
- Capture Date and Time
- Capture Device Technology Identifier
- Quality Block
- Representation Number
- Eye Label
- Image Type
- **Image Format = 0x0A$_{Hex}$ (JPEG2000)**
- Iris Image Property Bit
- Image Width
- Image Height
- Bit Depth
- Range
- Roll Angle of Eye
- Roll Angle Uncertainty
- Iris Center Smallest X
- Iris Center Largest X
- Iris Center Smallest Y
- Iris Center Largest Y
- Iris Diameter Smallest
- Iris Diameter Largest
- Image Data Length
- **Iris Image Data = PNG Image**

- The Image Format field was erroneously filled out as 0x0A$_{Hex}$, specifying that the image is a JPEG2000 format; however the image inserted is a PNG image (Image Format of 0x0E$_{Hex}$).

- If the system uses the Image Format field as directions on how to parse the Image Data, once attempting to parse the PNG as a JPEG2000, it finds it "incompatible" and may not use the record.

- Was L2 testing performed to detect this inconsistency?

# Level 3 (L3) Conformance Testing (Semantic )

- L3 conformance testing checks if the biometric data implementation is a faithful representation of the input biometric data record or "parent biometric data" and ensures requirements are satisfied that are not merely "L1 & L2" requirements.

- The input biometric data record may be (e.g.,):
  - An image
  - Raw sensor output such as a time series of data points from a digitization tablet.

- For some requirements in a standard, L3 testing might be significantly difficult or even impossible to test.

# "L3" Standard Requirements/Error – Examples

- 19794-4 :2011 (finger image data format):

  - "Each record shall pertain to a single subject."

  - Incorrectly labeled fingerprint (labeling a Right thumb as a Right index finger).

- 19794-5:2005 (face image data format):

  - Pose Angle: "The (3 multi-byte) Pose Angle field (BY, BP, BR) shall represent the estimate or measure pose of the subject in the image."

- 19794-2 (finger minutiae format)

  - See detailed discussion in: "*The Benefit of Ground Truth Data to Semantic Conformance Testing of Fingerprint Minutia Encoding",* Dr. Christoph BuschFraunhofer IGD / Hochschule Darmstadt, Germany

  *http://biometrics.nist.gov/cs_links/ibpc2010/pdfs/Busch_Christoph_IBPC2010-gtm-100224.pdf*

# L3 Testing – 2G Iris Data Format (19794-6:2011) Error Example & Possible Impact

## General Header

- Format Identifier
- Version Number
- Record Length
- Number of Representations
- Certification Flag
- **Number of Eyes Represented = 1**

**(left or right eye is known to be present)**

- Discrepancy between Eye Label indicating that the representation is on a right eye and the iris image data (which is of a left eye).

- Is there an impact on recognition performance?

## Representation

- Representation Length
- Capture Date and Time
- Capture Device Technology Identifier
- Quality Block
- Representation Number
- **Eye Label = 1 (SUBJECT_EYE_LABEL_RIGHT = 1)**
- Image Type
- **Image Format (Raw, JPEG2000,PNG)**
- Iris Image Property Bit
- Image Width
- Image Height
- Bit Depth
- Range
- Roll Angle of Eye
- Roll Angle Uncertainty
- Iris Center Smallest X
- Iris Center Largest X
- Iris Center Smallest Y
- Iris Center Largest Y
- Iris Diameter Smallest
- Iris Diameter Largest
- Image Data Length
- **Iris Image Data (Left eye)**

# Conclusions on Conformance Testing

- Conformance testing plays the role of the canary in the coal mine: lack of conformance to the required standard(s) can, in many cases, jeopardize the expected recognition performance or prevent access to the data (as well as impact the overall operational performance).

- Implementers may handle non-conformant records in different ways during processing.

- All levels of conformance testing are important and necessary. Whenever possible, in addition to L1 and L2 tests, L3 tests should be performed.

- More research on L3 testing procedures is necessary.

# Contact

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Background slides:

- Role of ISO/IEC SC 37 on biometric data formats

- Role of NIST/ITL in support of these standards

- ANSI/NIST-ITL 1-2011 Implementation Conformance Error Example and NIST/ITL Conformance Test Tools Roadmap
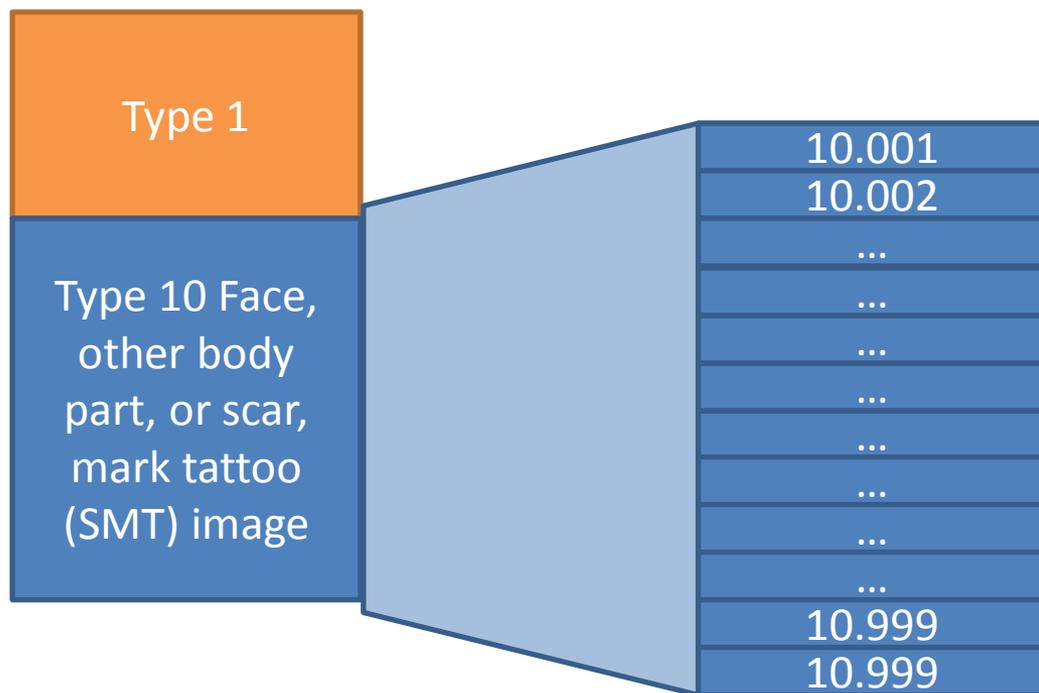
- Additional Conclusions

# ISO/IEC JTC 1/SC 37 (SC 37)

- Scope:

  - "*Standardization of generic biometric technologies pertaining to human beings to support interoperability and data interchange among applications and systems. Generic human biometric standards include: common file frameworks; biometric application programming interfaces; biometric data interchange formats; related biometric profiles; application of evaluation criteria to biometric technologies; methodologies for performance testing and reporting and cross jurisdictional and societal aspects.*

  - SC 37, in particular, is responsible for the development of biometric data interchange format standards and the associated conformance testing methodologies (CTMs) for these biometric data formats.

# NIST/ITL's Support for Conformance Testing

- NIST/ITL participates in the development of biometric (CTM) standards and other conformity assessment efforts.

- It also develops Conformance Test Architectures and Test Suites designed to test implementations of:

  - International (SC 37) biometric data interchange formats

  - ANSI/NIST-ITL Standards (developed with NIST/ITL's leadership), focus on Law  Enforcement, Military, Intelligence, Border Management and Homeland Security applications.

# Error Example - Multiple Tagged Image Fields in an ANSI/NIST-ITL 1-2011 Implementation

| Type 1 |
|---|

| Type 10 Face, other body part, or scar, mark tattoo (SMT) image |
|---|

| 10.001 |
|---|
| 10.002 |
| ... |
| ... |
| ... |
| ... |
| ... |
| ... |
| ... |
| ... |
| 10.999 |
| 10.999 |

10.999 contains the biometric data associated with the Record.

- There are two Fields 10.999 in the Type 10 Record.

- There should not be more than one field 10.999.

- To process the image:
  - Would you access the last field of the Record or
  - Would you scan the Records until you find a 999 Field and stop (since there is supposed to be only one)?

- Is the biometric data contains in the 10.999 the same?

- Which Field is supposed to be used in matching?

- The advantage of performing L2 / L3 tests before matching is apparent.

# Conformance Test Suites Designed to Test Implementations of ANSI/NIST-ITL (AN-20XX) Standards

| | ANSI/NIST-ITL 1-2007 | | ANSI/NIST-ITL 1-2011 |
|---|---|---|---|
| **Base Standard** | Target: CTA/CTS for selected Record Types: 1 (Transaction information), 4 (High-resolution grayscale fingerprint image), 10 (Facial and SMT image), 13 (Variable-resolution latent image), 14 (Variable-resolution fingerprint image), and 17 (Iris image) | | Target: CTA/CTS for Data Conventions, Information Associated with several Record Types, and selected Record Types: 1, 4, 10, 13, 14, 15 (Variable-resolution palm print image record), 17, and Traditional Encoding |
| **CTS Planned, Under Dev., or Developed** | V. 0.5 👍 | Other Record Types? | Required Conformance Test Architecture Changes From Previous Version Made |
| **CTS Installer version released** | V. 0.5 👍 | Evaluating need | Code under development |
| **CTS source Code version released** | 👍 | Evaluating need | Under consideration |
| **CTS for Profiles of the AN-20xx Standards** | Evaluating users' needs | | Evaluating users' needs |

# Additional Conclusions

- For many applications, suppliers declaration of conformance may be acceptable since other approaches to conformance testing (e.g. testing by third-party accredited labs) tend to be more expensive.

- However, the public availability of conformance test tools may <u>help end-users</u> interested in requiring conformance to biometric standards gain a higher level of confidence in products.

- These test tools, can also <u>support product developers</u> interested in using the same testing tools available to end-users and can also benefit <u>testing labs</u> interested in offering this type of service to developers and end-users.