BioCTS for ISO/IEC Binary and XML Encoded Records

User Guide

NIST/ITL CSD Biometric Conformance Test Software for ISO/IEC Biometric Data Interchange Format Standards and Selected PIV Profiles

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Contents

1. Disclaimer

NIST/ITL BioCTS

For ISO/IEC

Binary and XML Encoded Records

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2. Overview

This document describes the features of the Biometric Conformance Test Software (BioCTS) for selected ISO/IEC biometric data interchange format standards developed by JTC 1/SC 37 and PIV profiles (face image, iris image, finger minutiae, and finger image data interchange formats). BioCTS for ISO/IEC Binary and XML Encoded Records includes several Conformance Test Suites (CTSs) designed to test implementations of:

- Biometric Data interchange formats
- Full CBEFF[1] Biometric Information Records (BIR)
- Individual components of the CBEFF BIR

BioCTS for ISO/IEC Binary and XML Encoded Records is a desktop application which tests biometric Implementations (files). BioCTS for ISO/IEC Binary and XML Encoded Records can be used to test a significant number of files (1,000s+) in a single batch test; evaluate the results at a high level, and load files into the BioCTS Editor to drill down to errors found on specific Representations or Fields. Test Results from each file tested are logged and saved to a user-specified folder, with a time stamp. There are multiple CTSs developed for BioCTS for ISO/IEC Binary and XML Encoded Records which test Implementations of several national, and international biometric data format standards; these standards, and any additions/deviations from the standard requirements are listed in later sections within this document.

In this release, there is very early support for Conformance Test Suites that test the XML Encodings of ISO/IEC 19794 standards. An Alpha version of ISO/IEC 19794-4: 2011 XML Encoding is included; this Conformance Test Suite targets a draft version of the XML Encoding specification, and will be updated as the specification is finalized.

There are new features included in the BioCTS User Interface since the last release:

- **Graphical Statistic Display** – BioCTS provides multiple types of Graphical Charts to visualize the locations of errors within a file. The user can choose to save the chart as an image file to their computer.

There is a new CTS included since the last release:

- **ANSI/INCITS 385: 2004** Face Recognition Format for Data Interchange

[1] Common Biometric Exchange Formats Framework

2.1. Requirements

- Supported Microsoft® Operating Systems
    - Windows® XP ™ Service Pack 3
    - Windows® Vista ™ Service Pack 2
    - Windows® 7 ™ Service Pack 1
- Microsoft® .NET 4.0 Framework
    - Microsoft® .NET 4.0 Web Installer (http://www.microsoft.com/en-us/download/details.aspx?id=17851)
    - Microsoft® .NET 4.0 Stand Alone Installer (http://www.microsoft.com/en-us/download/details.aspx?id=17718)
    - Links working as of 7/22/2014

3. Conformance Test Suites and Relevant Standards

The following is a list of the available test tools and the relevant standards used in their development.

3.1. First Generation (1G) of ISO/IEC Data Interchange Formats

- **ISO/IEC 19794-2:2005**
  - ISO/IEC 19794-2:2005, Biometric data interchange formats – Part 2: Finger minutiae data
  - ISO/IEC 19794-2:2005 TECHNICAL CORRIGENDUM 1
  - ISO/IEC 29109-2:2010 Conformance testing methodology for biometric data interchange formats defined in ISO/IEC 19794 -- Part 2: Finger minutiae data
- **ISO/IEC 19794-4:2005**
  - ISO/IEC 19794-4:2005, Biometric data interchange formats -- Part 4: Finger image data
  - ISO/IEC 19794-4:2005 TECHNICAL CORRIGENDUM 1
  - ISO/IEC 29109-4:2010, Conformance testing methodology for biometric data interchange formats defined in ISO/IEC 19794 -- Part 4: Finger image data
  - ISO/IEC 29109-4:2010 TECHNICAL CORRIGENDUM 1
- **ISO/IEC 19794-5:2005**
  - ISO/IEC 19794-5:2005, Biometric data interchange formats -- Part 5: Face image data
  - ISO/IEC 19794-5:2005 TECHNICAL CORRIGENDUM 1
  - ISO/IEC 19794-5:2005 TECHNICAL CORRIGENDUM 2
  - ISO/IEC 29109-5:2012, Conformance testing methodology for biometric data interchange formats defined in ISO/IEC 19794 -- Part 5: Face image data

3.2. Second Generation (2G) of ISO/IEC Data Interchange Formats

- **ISO/IEC 19794-2:2011**
  - ISO/IEC 19794-2:2011, Biometric data interchange formats -- Part 2: Finger minutiae data
  - ISO/IEC 19794-2:2011 EDITORIAL CORRIGENDUM 1
  - ISO/IEC JTC 1/SC 37 N 5553 Text of 19794-2 FDAM 1, Biometric data interchange formats – Part 2: Finger minutia data – Amendment 1: Conformance testing methodology and clarification of defects
- **ISO/IEC 19794-4:2011**
  - ISO/IEC 19794-4:2011, Biometric data interchange formats -- Part 4: Finger image data
  - ISO/IEC 19794-4:2011 EDITORIAL CORRIGENDUM 1
  - ISO/IEC 19794-4:2011/AMD 1:2013, Biometric data interchange formats: Part4: Finger image data – Amendment 1: Conformance testing methodology and clarification of defects
- **ISO/IEC 19794-5:2011**
  - ISO/IEC 19794-5:2011, Biometric data interchange formats - Part 5: Face image data

- ISO/IEC JTC 1/SC 37 N5597, Text of ISO/IEC 19794-5:2011 FDAM 1, Biometric data interchange formats - Part 5: Face image data - Amendment 1: Conformance testing methodology and clarification of defects

- **ISO/IEC 19794-6: 2011**
  - ISO/IEC 19794-6:2011, Biometric data interchange formats -- Part 6: Iris image data
  - ISO/IEC 19794-6:2011 EDITORIAL CORRIGENDUM 1
  - ISO/IEC JTC 1/SC 37 N 4881 Text of 19794-6 3rd PDAM 1, Biometric date interchange formats - Part 6: Iris image data - Amendment 1: Conformance testing methodology

3.3. PIV Profiles (specified in NIST SP 800-76-2)[2]

- **CBEFF Header of the PIV Profile**
  - As defined in NIST SP 800-76-2 Table 14 "Patron format PIV specification"
- **PIV Profile of ISO/IEC 19794-6: 2011 On-Card**
  - In addition to the ISO/IEC 19794-6:2011 standard this CTS implements requirements specified in NIST SP 800-76-2 "Table 9 – ISO/IEC 19794-6 profile for iris images stored on PIV Cards"
- **PIV Profile of ISO/IEC 19794-6: 2011 Off-Card**
  - In addition to the ISO/IEC 19794-6:2011 standard this CTS implements requirements specified in NIST SP 800-76-2 "Table 11 – ISO/IEC 19794-6 profile for iris images stored outside PIV Cards"
- **PIV Profile of INCITS 378: 2004**
  - INCITS 378:2004, Finger Minutiae Format for Data Interchange
  - INCITS 423.2: 2008, Conformance Testing Methodology Standard for Biometric Data Interchange Format Standards – Part 2: Conformance Testing Methodology for ANSI INCITS 378-2004, Finger Minutiae Format for Data Interchange
  - Requirements specified in NIST SP 800-76-2 "Table 6 – INCITS 378 profile for PIV Card templates"
- **PIV Profile of INCITS 381: 2004**
  - INCITS 381:2004, Finger Image-Based Data Interchange Format
  - INCITS 423.4: 2009, Conformance Testing Methodology Standard for Biometric Data Interchange Format Standards – Part 4: Conformance Testing Methodology for INCITS 381-2004, Finger Image-Based Data Interchange Format
  - Requirements specified in NIST SP 800-76-2 "Table 4 – INCITS 381 profile for agency retention of fingerprint images"
- **PIV Profile of INCITS 385: 2004**
  - INCITS 385: 2004, Face Recognition Format for Data Interchange
  - Requirements specified in NIST SP 800-76-2 "Table 12 – INCITS 385 profile for PIV facial images"

[2] NIST Special Publication 800-76-2, Grother, P., Salamon. W., Chandramouli, R., Information Technology Laboratory, NIST, July 2013

- **CBEFF Opaque Security Block**
    - The Opaque SB CTS accepts any data passed to it. No standard was used to implement this. No testing is performed.

3.4. Test Limitations and/or Additions from the Standards

The following section lists any limitations/additions or discrepancies from the above listed standards and provide the rationale for these additions/discrepancies.

3.4.1. Common Parsing Discrepancy

A common discrepancy from the standards is that BioCTS parses data byte-by-byte; sometimes a data format will specify a field with less-than a byte length. In all cases an additional field is adjacent to it that is also missing several bits from a byte. These fields are combined in the CTSs and are listed in each section under "Fields Combined to meet Byte Boundaries".
(For example: Field 1 is *2 bits* long, Field 2 is *14 bits* long. Together Field_1_Field_2 is *2 bytes* long.)

3.4.2. Common Image Assertion Additions

For CTSs that process images there are standard image based assertions that they all implement – some of which are documented within the corresponding testing methodology; some of which are not yet documented.

- Image Header Tests
- Image Footer Tests
- Correct Encoding Tests
    - Has Corresponding Metadata
- Image Specified Dimensions vs. Representation Specified Dimensions

3.4.3. Discrepancies

- **ISO/IEC 19794-2:2005**
    - **Fields Combined to meet Byte Boundaries**
        - Capture Equipment Certification and Capture Device Type ID
        - View Number and Impression Type
        - Minutia Type and Minutia X Position
        - Reserved and Minutia Y Position
        - Core Information Type and Core X Location
        - Reserved and Core Y Location
        - Delta Information and Delta X Location
        - Reserved and Delta Y Location
    - This Conformance Test Suite does not specifically implement tests found in Table 4 to Table 11 – formats for On-Card Minutia.
    - **Additional Assertions**
        - Extended Data Block Length
            - ISO/IEC 29109-2:2010 specifies valid values as 0 to 65535

        - Extended data block is either not present (value 0) or has a length of 4 and greater.
        - Added L1 test for values 0 or 4 to 65545.
- **ISO/IEC 19794-4: 2005**
    - **Additional Assertions**
        - Finger or Palm Image Quality
            - ISO/IEC 19794-4:2005 Technical Corrigendum 1 added values 254 and 255
    - **Modified Assertions**
        - Image Compression Ratio LTE 15
            - ISO/IEC 29109-4:2010 Conformance testing methodology for biometric interchange records format – Part 4: Finger image data specifies the following formula for calculating the Image compression ratio in Test Note 9:
                - $\frac{\{\text{Horizontal line length}\} * \{\text{Vertical line length}\} * \{\text{pixel depth}\}}{\text{sizeof}\{\text{Image data}\}}$
                - This formula calculates size of the uncompressed image (in bits) divided by the size of the compressed image (in bytes)
            - The ISO/IEC 19794-4:2005 CTS implements the following formula:
                - $\frac{(\{\text{Horizontal line length}\} * \{\text{Vertical line length}\} * \{\text{pixel depth}\})/8}{\text{sizeof}\{\text{Image data}\}}$
                - This formula calculates the size of the uncompressed image (in bits), divides it by 8 to get the size of the uncompressed image (in bytes) and then divides that by the size of the compressed image (in bytes)
- **ISO/IEC 19794-5:2005**
    - No Discrepancies.
- **ISO/IEC 19794-2:2011**
    - **Fields Combined to meet Byte Boundaries**
        - Minutia Field Length and Ridge Ending Type
        - Minutia Type and Minutia X Position
        - Reserved and Minutia Y Position
        - Reserved and Number of Cores
        - Core Information Type and Core X Position
        - Reserved and Core Y Position
        - Reserved and Number of Deltas
        - Delta Information Type and Delta X Position
        - Reserved and Delta Y Position
    - The Conformance Test Suite does not specifically implement tests found in Table A.3 for On-Card Minutia.
    - **Additional Assertions**

        - Format Identifier NEQ 0x00524D46 (Little Endian Version of valid format)
        - Version Number NEQ 0x00303330 (Little Endian Version of valid format)
        - Expected Record Length EQ Counted Record Length
        - Minutia X Position LTE Image Width
        - Minutia Y Position LTE Image Height
        - Cell Width LTE Image Width
        - Cell Height LTE Image Height
- **ISO/IEC 19794-4:2011**
    - **Fields Split to Enable Easier Representation**
        - Segmentation Owner and Algorithm ID (4 bytes) was split into 2 fields:
            - Segmentation Owner (2 bytes)
            - Segmentation Algorithm ID (2 bytes)
        - Finger Image Quality Algorithm and Owner ID (4 bytes) was split into 2 fields:
            - Finger Image Quality Algorithm (2 bytes)
            - Finger Image Quality Owner ID (2 bytes)
    - **Modified Assertions**
        - Image Compression Ratio LTE 15
            - ISO/IEC 19794-4 Biometric data interchange formats: Part 4: Finger image data -Amendment 1: Conformance testing methodology specifies the following formula for calculating the Image compression ratio:
                - $\frac{\{\text{Horizontal line length}\} * \{\text{Vertical line length}\} * \{\text{pixel depth}\}}{\text{sizeof}\{\text{Image data}\}}$
                - This formula calculates size of the uncompressed image (in bits) divided by the size of the compressed image (in bytes)
            - The ISO/IEC 19794-4:2011 CTS implements the following formula:
                - $\frac{(\{\text{Horizontal line length}\} * \{\text{Vertical line length}\} * \{\text{pixel depth}\})/8}{\text{sizeof}\{\text{Image data}\}}$
                - This formula calculates the size of the uncompressed image (in bits), divides it by 8 to get the size of the uncompressed image (in bytes) and then divides that by the size of the compressed image (in bytes)
        -
- **ISO/IEC 19794-5:2011**
    - No Discrepancies
- **ISO/IEC 19794-6:2011**
    - No Discrepancies
- **PIV Profile**
    - **PIV Profile of ISO/IEC 19794-6:2011 On-Card**
        - No Discrepancies
    - **PIV Profile of ISO/IEC 19794-6:2011 Off-Card**
        - No Discrepancies

- **PIV Profile of INCITS 378:2004**
  - No Discrepancies
- **PIV Profile of INCITS 381:2004**
  - No Discrepancies
- **PIV Profile of INCITS 385:2004**
  - No Discrepancies

4. XML Conformance Test Suites Testing Phases

The design of BioCTS for XML Encoded Records CTS was a result of careful analysis of the base requirements in the ISO/IEC standards, the XML Encoding specific requirements, and the XML Schema definitions. The schemas are able to verify that the Data Interchange Package data is formatted and ordered correctly, but it does not ensure conformance to all of the base requirements. As shown in Fig. 1, BioCTS for XML Encoded Records' approach is to validate the implementation under test against the schema, report the validation as a single result, and continue testing all of the required test assertions that were not covered by the XML Schema.

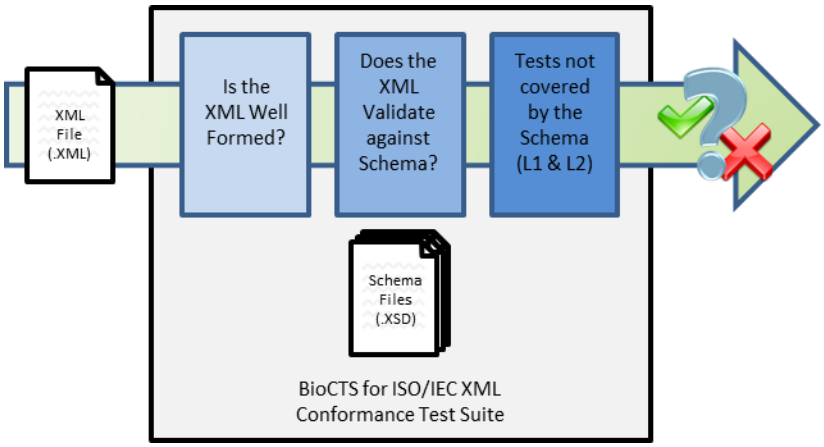

Figure 1 - High Level CTS Program Flow

The CTS has three test phases:

1. **Determination of whether the XML file is Well-Formed.**
   An XML file is Well-Formed when it is syntactically correct, and follows the rules of XML documents [1] [2]. Without a Well-Formed XML file, further testing would yield potentially unusable results.
   *If the XML file fails this phase of testing, the CTS **will not continue** to the next phase.*
2. **Validating the XML file against the specified schema file.**
   The CTS will attempt to validate the XML file against the specified schema file for the specified Data Interchange Format and will report as many errors as possible.
   *The CTS, regardless of whether the XML file passes or fails this phase of testing, **will continue** to the next phase.*
3. **Assertion testing for ISO/IEC base requirements.**

The final phase is testing against the base requirements of the Data Interchange Format that are not covered by the XML Schema file validation. These tests include, but are not limited to:

a. Valid Value tests
b. Relationship tests between XML elements
c. Basic Image Validation

After all three phases of testing is complete for the XML file, the test results are aggregated and an overall result (Pass or Fail) is determined. For the overall result of an XML file to be reported as "*Pass"* there must be no result of "*Error"* or "*Critical"* in any of the XML file's results.

5. Guide

5.1. Download and Installation

Download the installer from the website http://www.nist.gov/itl/csd/biometrics/biocta_download.cfm .

After the download completes, run the install program and follow the on screen instructions presented in the dialog boxes.

Eventually the following screen will appear; this is where a selection of CTSs can be made.

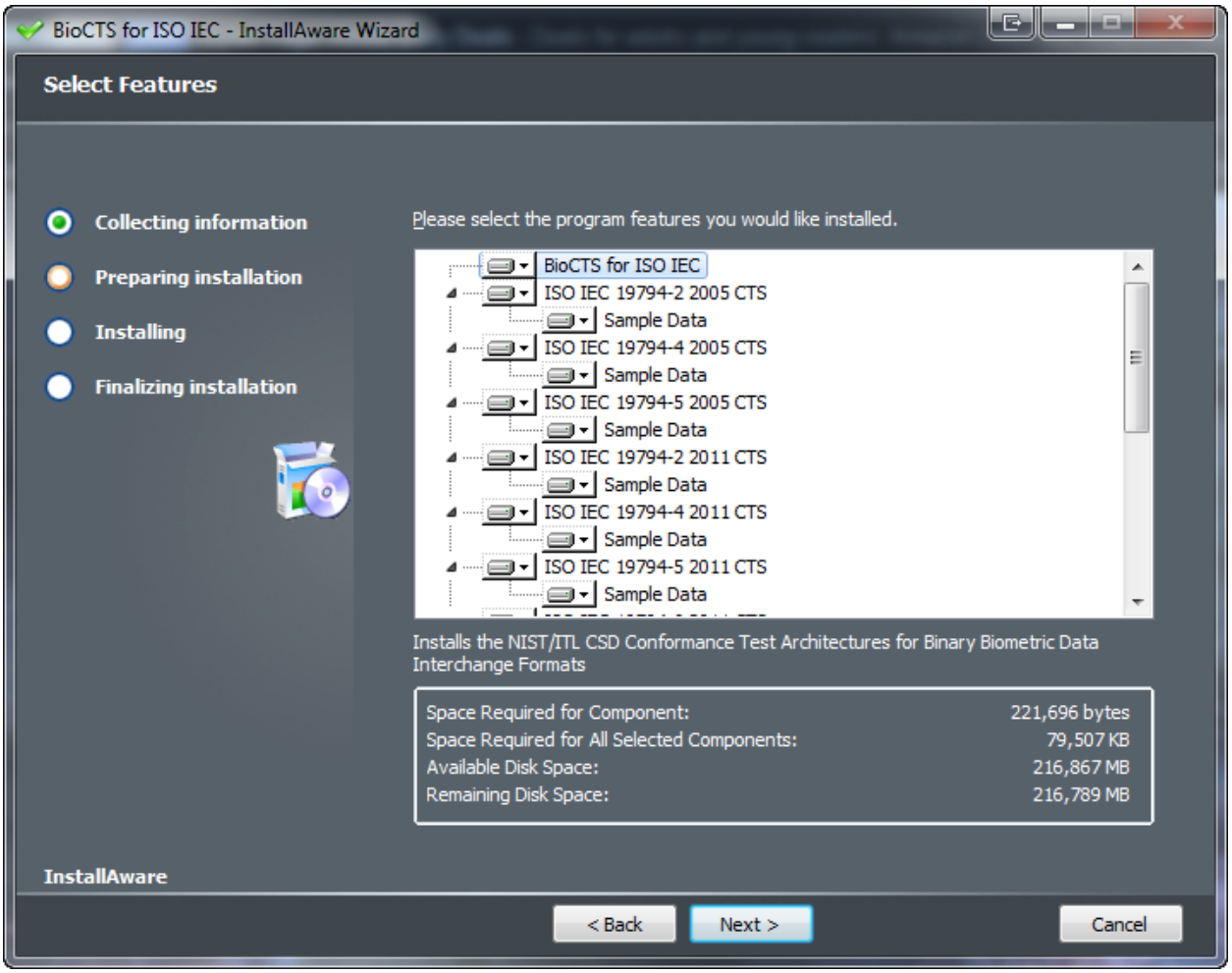

Figure 2 - BioCTS Installer

5.2. Running the Conformance Test Architecture

To run the CTA software from the Start menu:
Select **All Programs** then select **NIST BioCTS** then select **ISO IEC** and click on **BioCTS_ISO_IEC.**

After starting the BioCTS for ISO/IEC Binary and XML Encoded Records Conformance Test Architecture, a specific CTSs may be selected from the Options Tab (see Section 4.3.2 for the Options Tab). Several

Conformance Test Suites may be selected at once, but only one from each category: Standard Biometric Header, Biometric Data Block and Security Block, may be selected at any one time.

5.3. Conformance Test Architecture Features

Since the last official release of BioCTS for ISO/IEC Binary and XML Encoded Records a new feature has been added: Visual Analysis of Errors – which gives the user the ability to view statistics charts of the test results.

5.3.1.1. Visual Analysis

Previously, BioCTS for ISO/IEC Binary and XML Encoded Records provided a numeric statistical breakdown of the test results performed. This release of BioCTS adds a Visual Representation of those statistics. These charts are displayed within BioCTS itself, but can be saved to an external file for use in documents (as shown below).

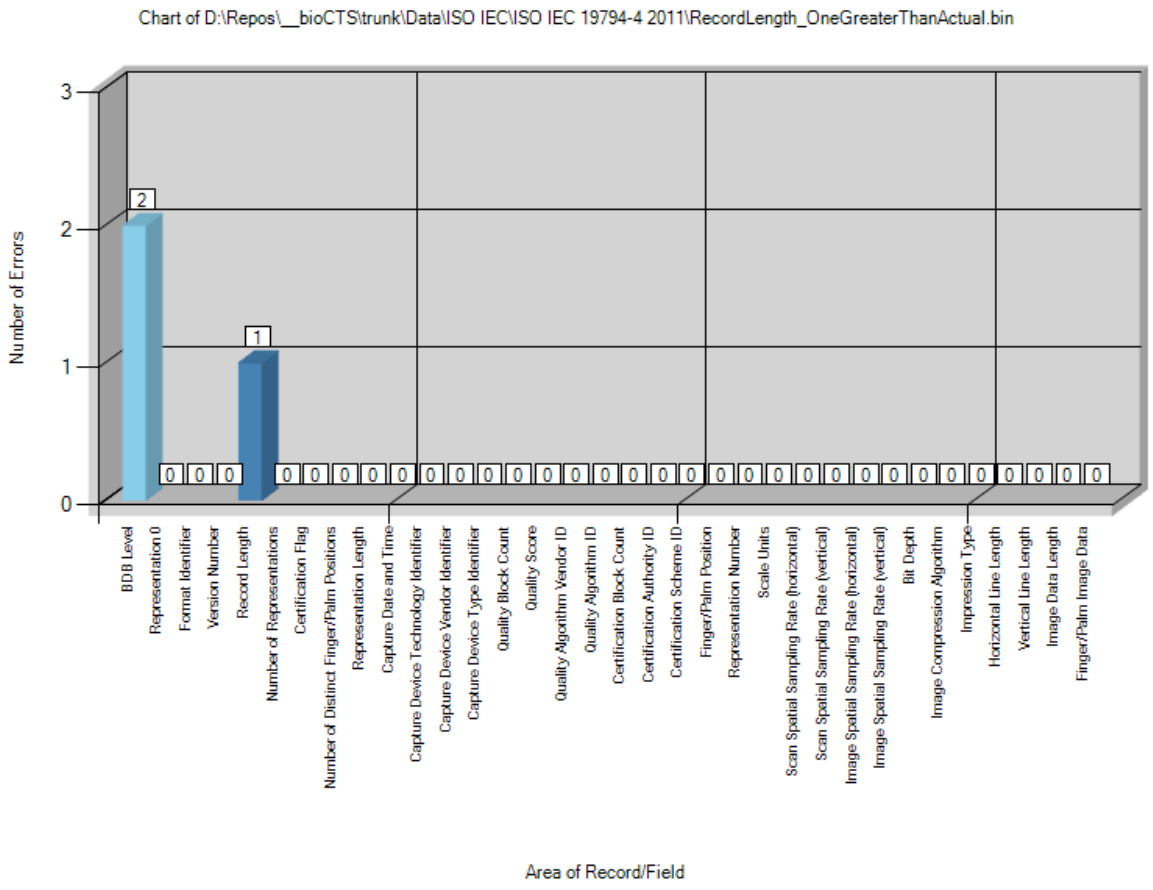

Figure 3 - BioCTS Visual Representation

5.3.2. Options

The Options Tab provides output file type and save location options, as well as drop down menus to select which CTS(s) to run.

The Time Stamped Folder Format:

- yyyy – 4 digit year (e.g. 2012)
- MM – 2 digit month (e.g. 10)
- dd – 2 digit day (e.g. 31)
- HH – 2 digit hour in 24-hour scale (e.g. 13)
- mm – 2 digit minutes (e.g. 59)
- ss – 2 digit seconds (e.g. 22)

In the example provided below:

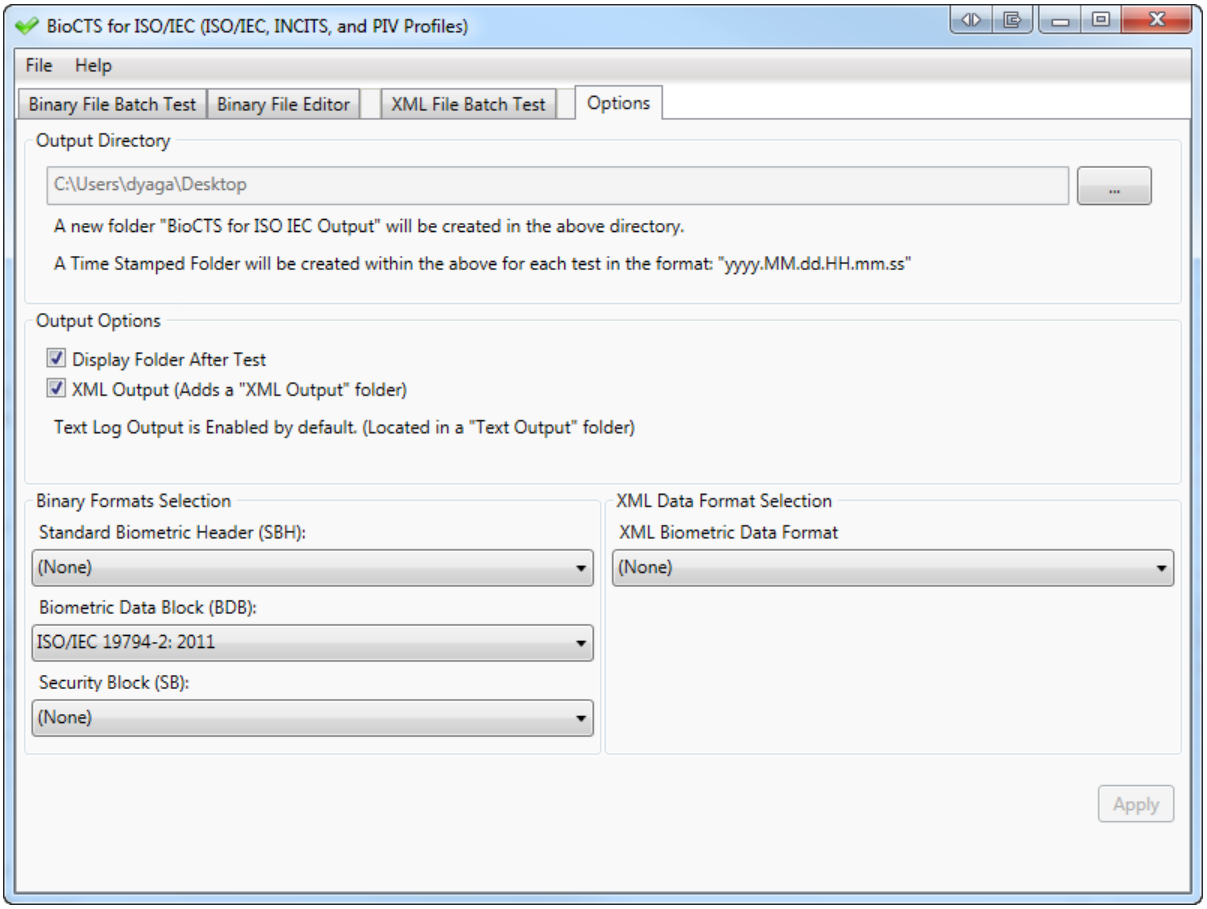

Figure 4 - BioCTS Options Tab

- Text Output will be generated in the directory:
C:\Users\mcginnis\Desktop\BioCTS For ISO IEC Output\2012.10.31.13.59.22\Text Output
- XML Output will be generated in the directory:
C:\Users\mcginnis\Desktop\BioCTS For ISO IEC Output\2012.10.31.13.59.22\XML Output

- The only CTS selected is the one designed to test implementations of the ISO/IEC 19794-2:2011 standard.

5.3.3. Binary File Batch Testing / XML File Batch Testing

The Binary File Batch Test tab allows multiple binary encoded transactions (files) to be tested in a group, and displays the overall results for each transaction in the Files Under Test pane. The design of the XML File Batch Tab is similar, and allows for XML encoded files to be tested in a group, and displays the overall results for each transaction in the Files Under Test Pane within the XML File Batch Test Tab.

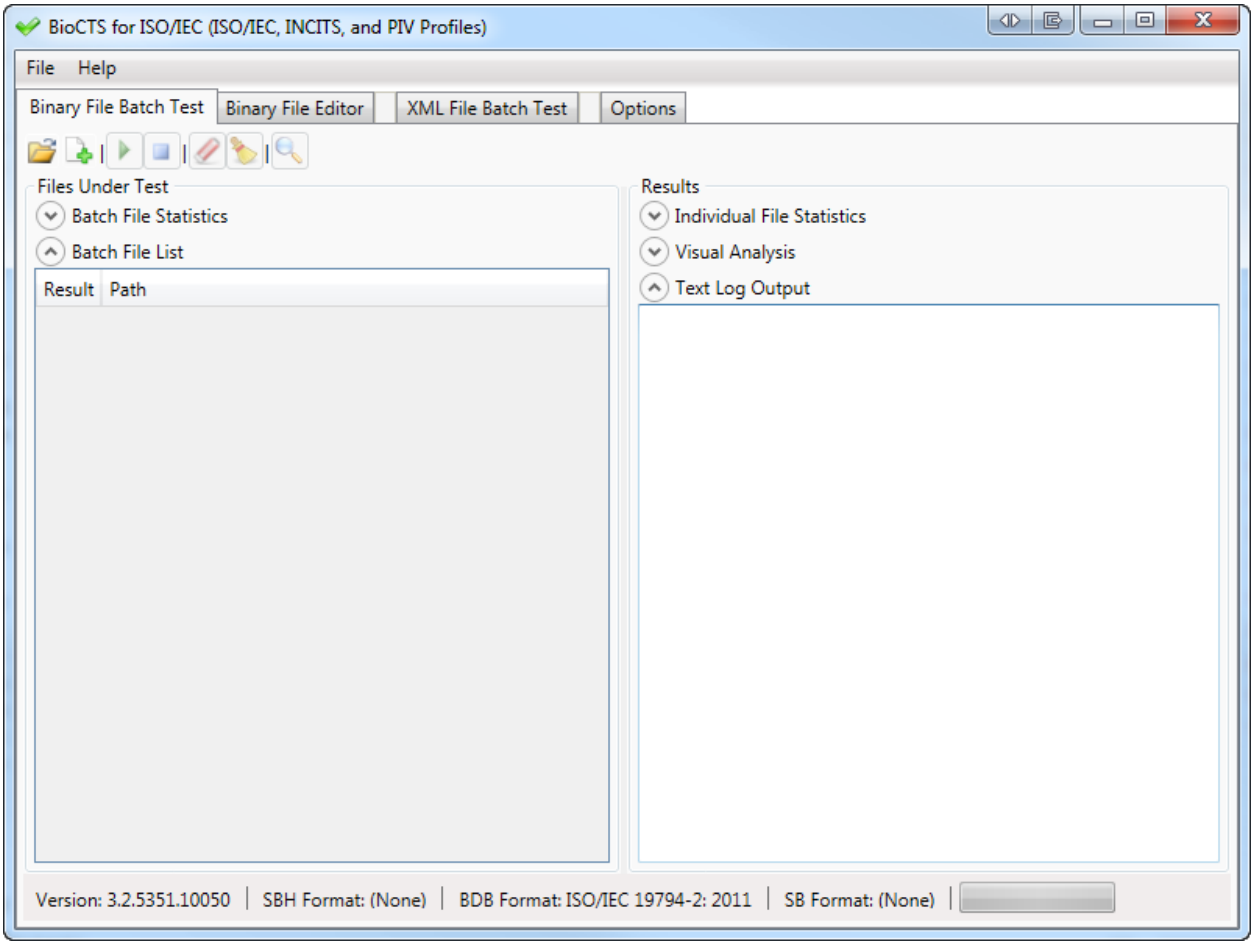

Figure 5 - BioCTS Binary File Batch Test Tab with No Files Loaded

Several files can be loaded at once.

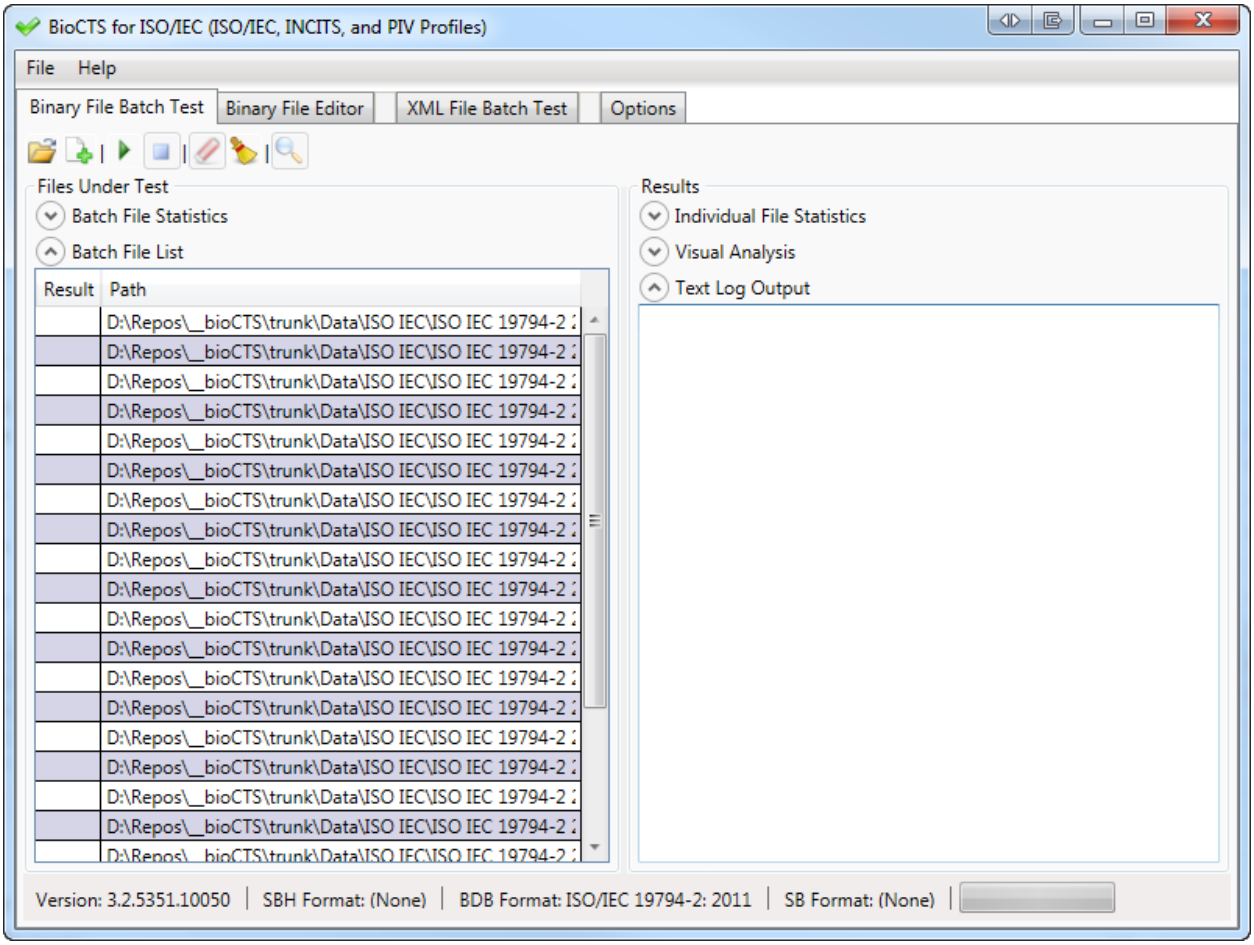

Figure 6 - BioCTS Files Loaded Binary File Batch Test Tab

The Binary File Batch Test Tab will display the Transaction's Overall Result with either:

- ✗ - Overall Result of Fail
- ✓ - Overall Result of Pass

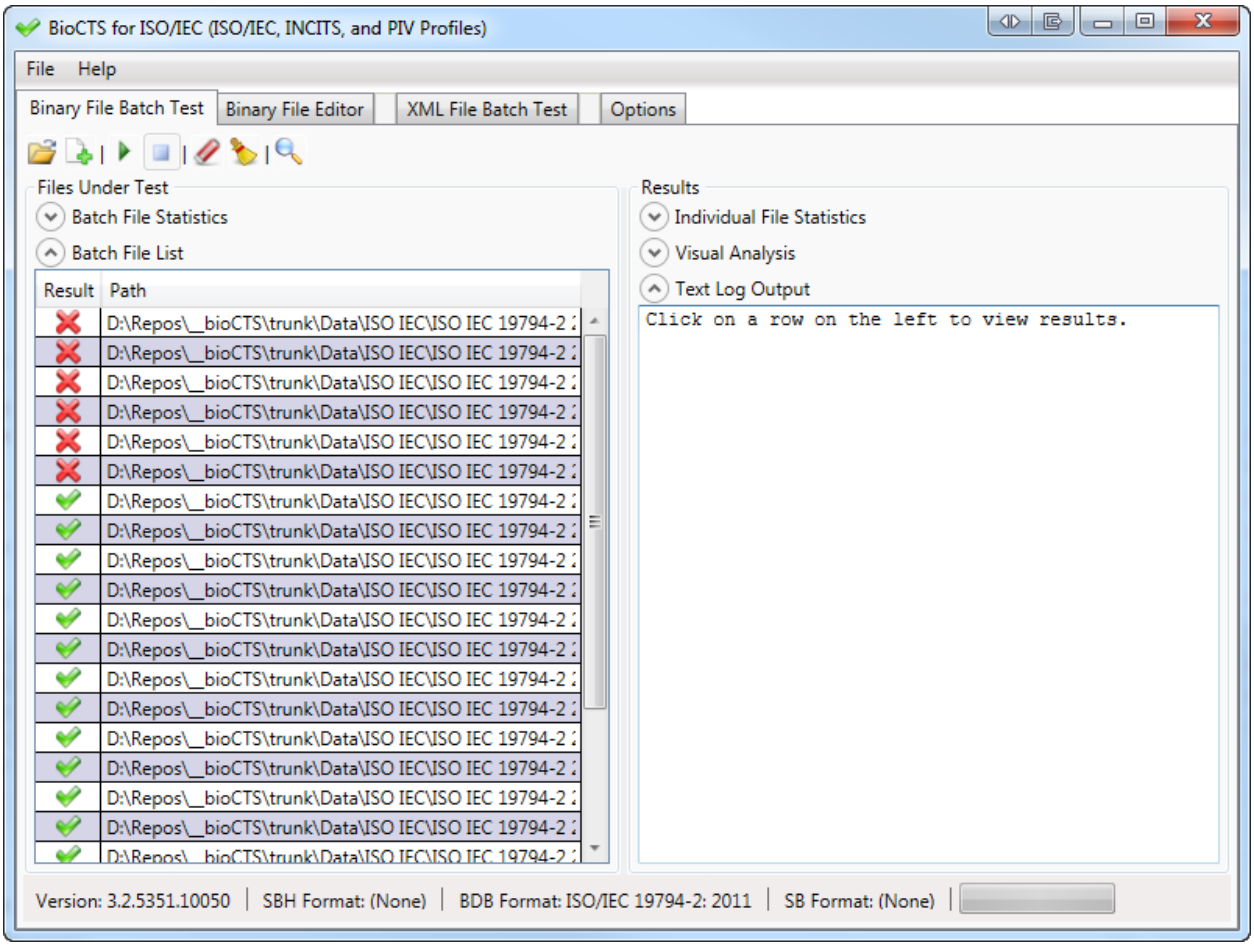

Figure 7 - BioCTS Tested Binary File Batch Test Tab

Textual output results for each Transaction can be viewed by clicking on the desired filename in the File Under Test pane. The complete textual results are displayed in the pane to the right. This feature is present for both Binary File Batch Testing and XML File Batch Testing.

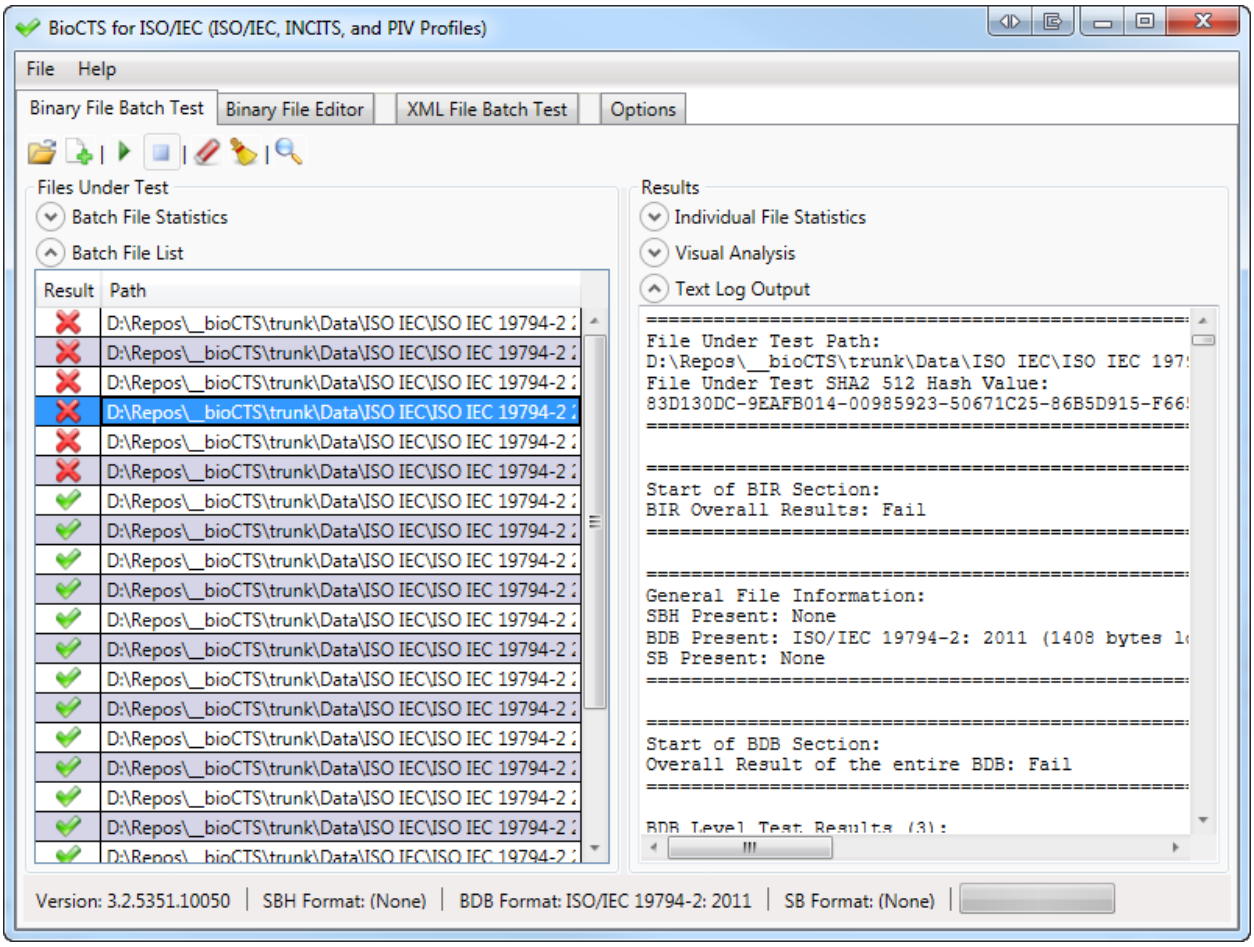

Figure 8 - BioCTS Tested Binary File Batch Test Tab with Results Showing

5.3.4. Binary File Editor

The Binary File Editor is designed to display as much information as possible upon demand; the editor makes use of Expander Sections, which can be expanded to display more information by pressing the  button within sections.

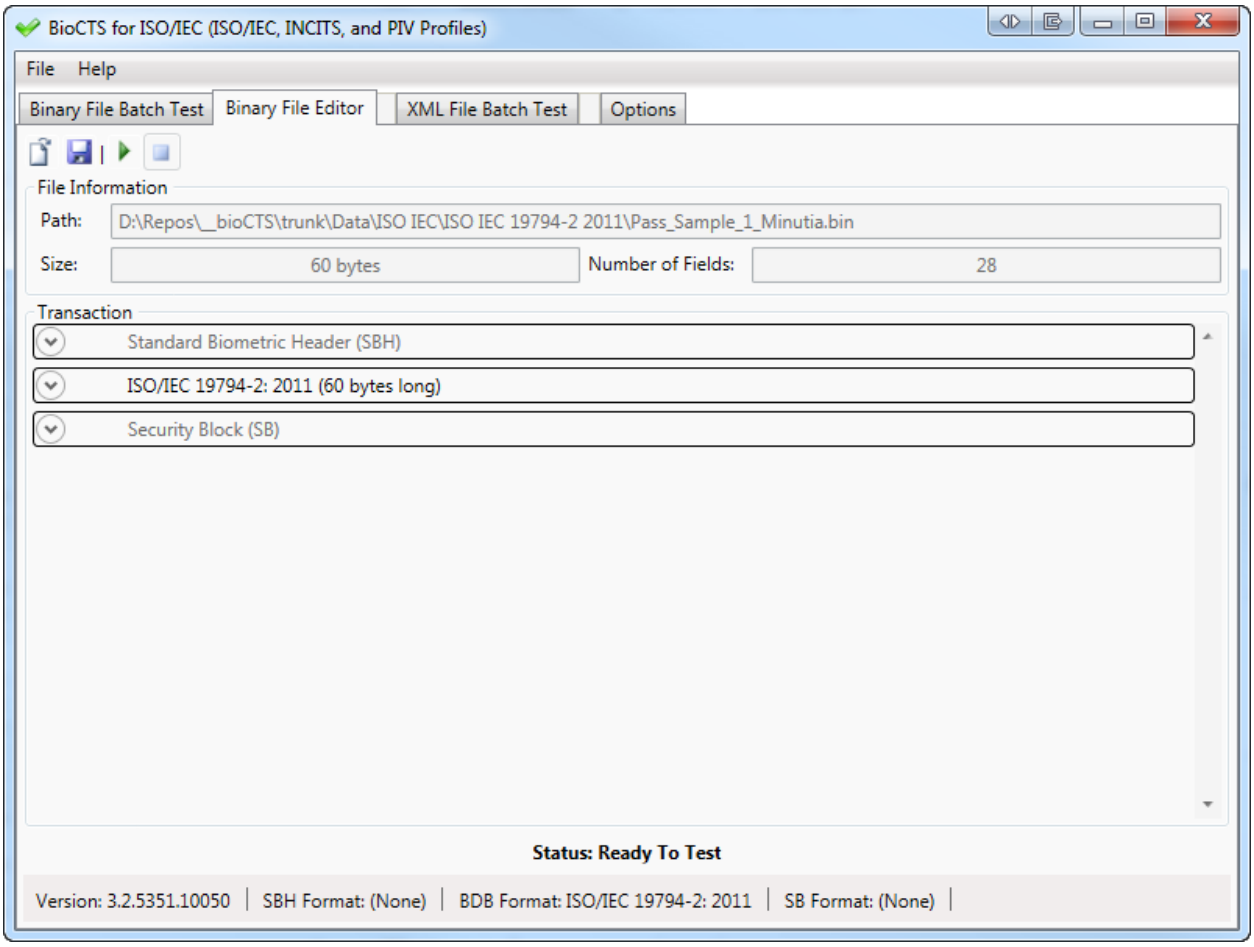

Figure 9 - BioCTS Binary File Editor Tab

The Binary File Editor displays the data and associated results in an expandable, hierarchical format, and allows editing of existing data using text fields.

When a component of the BIR is not being used (described as (None)) then those components are disabled, and greyed-out within the Binary File Editor.

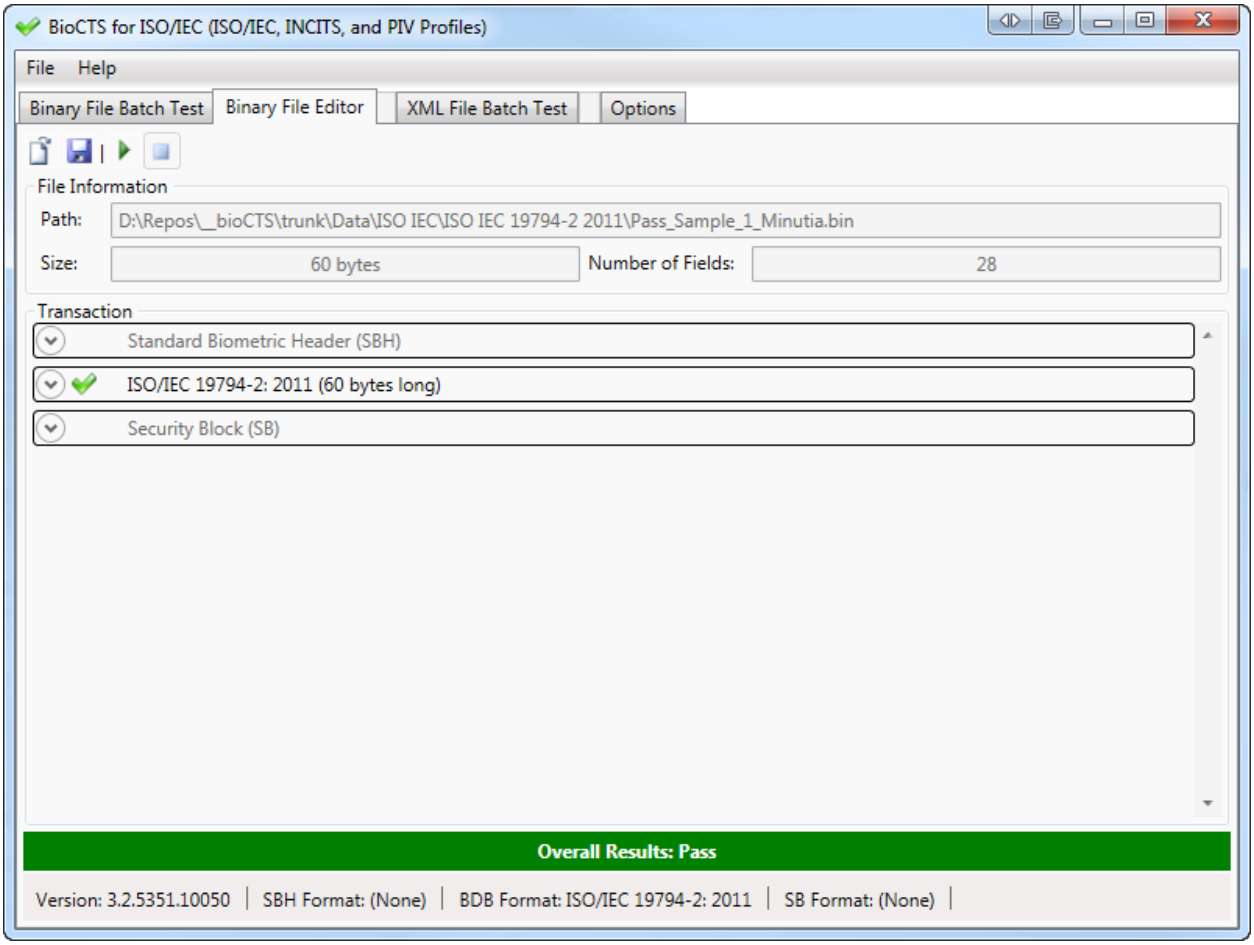

Figure 10 - BioCTS Binary File Editor Tab displaying a Tested File

When a Header or Representation is expanded the Binary File Editor displays a list of the Fields contained in it. Each Field may also be expanded to reveal the Data contained within and the associated Results.

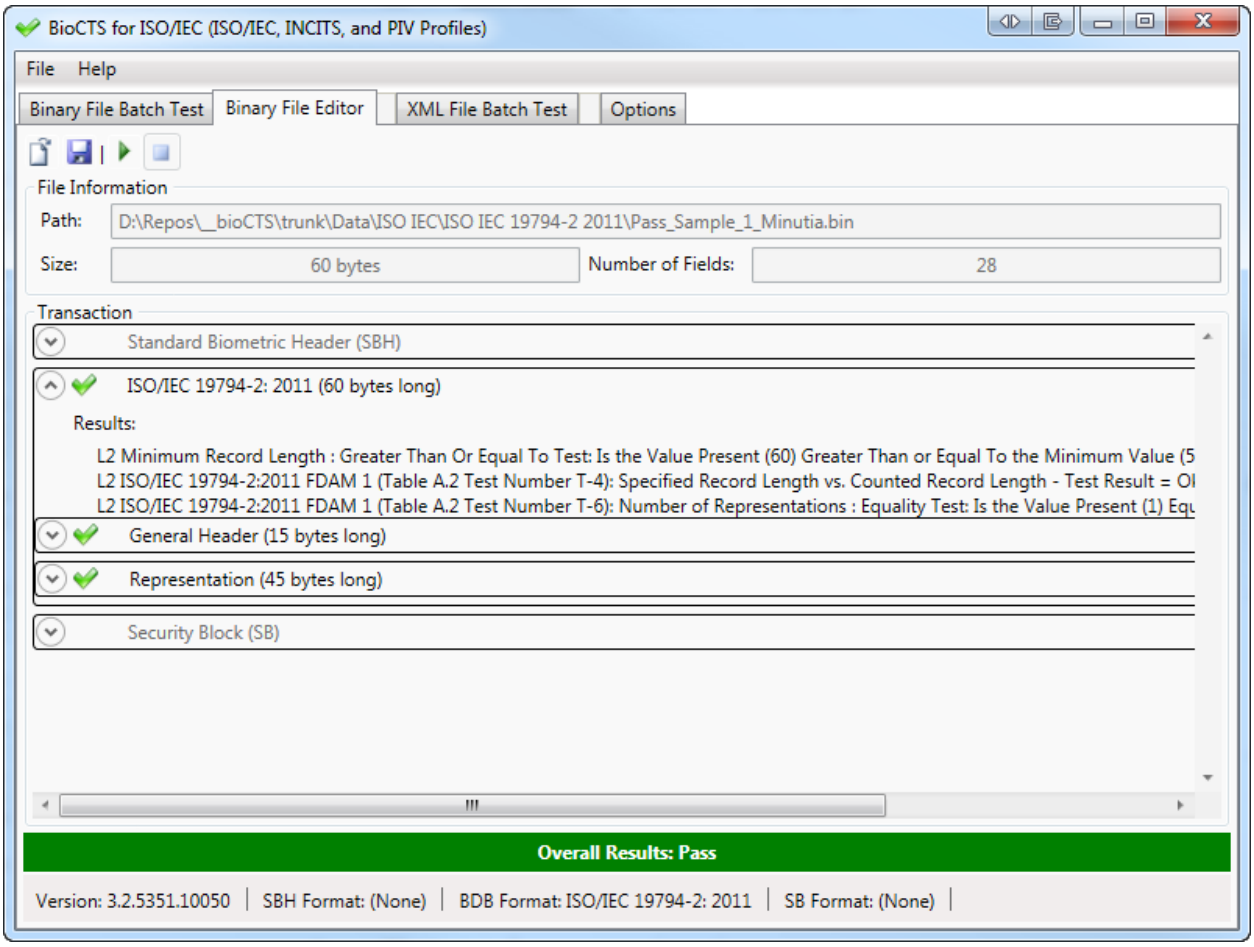

Figure 11 - BioCTS Binary File Editor Tab Showing General Header Results

When expanded, a Field displays expanders for the Field Level Results and the data that is held within the Field.

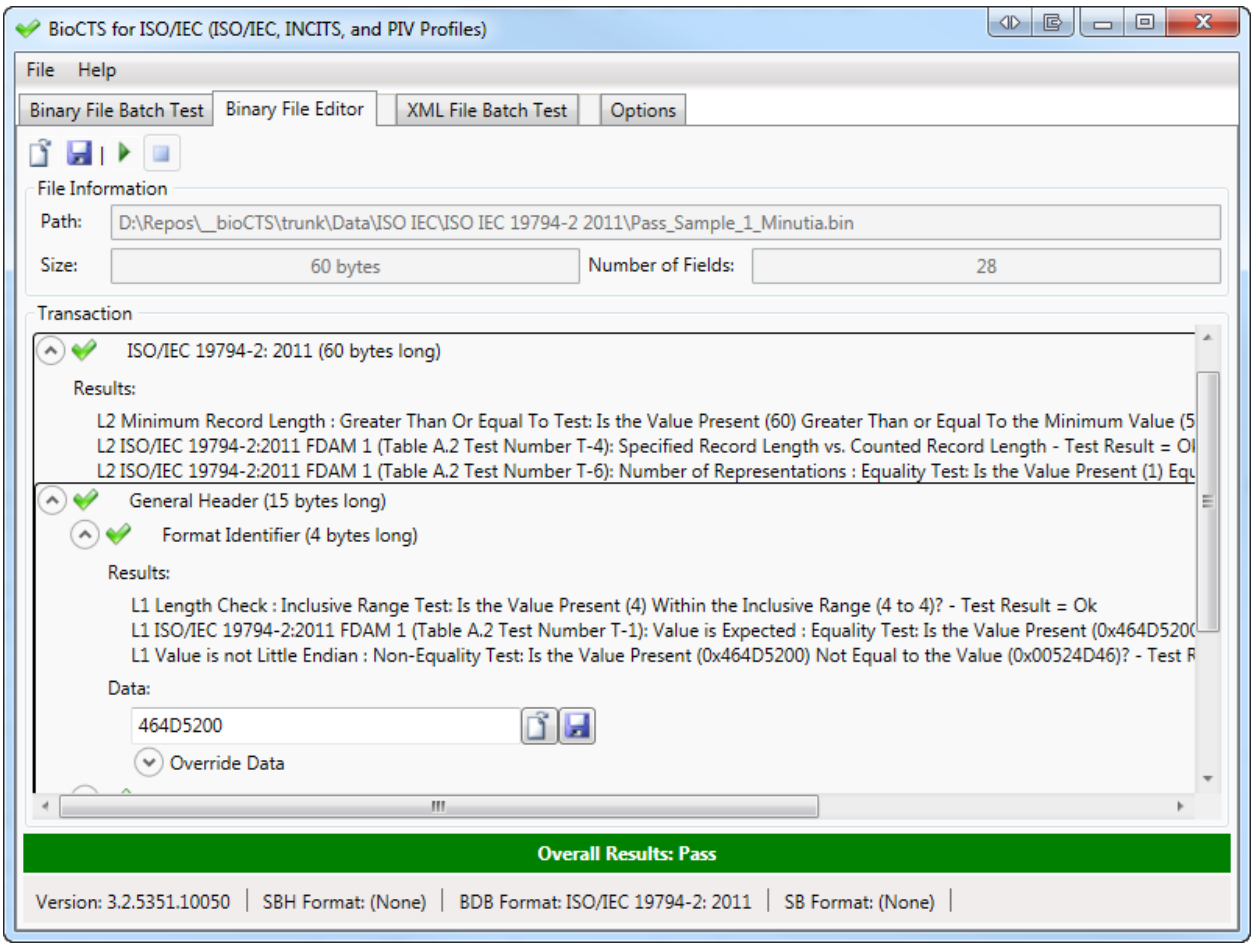

Figure 12 - BioCTS Binary File Editor Showing Field and Field Results

The values in the Data text fields can be edited. Two buttons are provided to assist when a large amount of data is being manipulated (such as in an image Field):

- Loads data into the contents of a field
- Saves the contents of a field

6. References

1. "Well-formed document" *Wikipedia: The Free Encyclopedia.* Wikimedia Foundation, Inc., 23 April 2013. Web. 30 May 2013. <http://en.wikipedia.org/wiki/Well-formed_document>
2. "Extensible Markup Language (XML) 1.0" World Wide Web Consortium (W3C), 10 February 1998. Web. 30 May 2013 <http://www.w3.org/TR/1998/REC-xml-19980210#dt-wellformed>

Appendix A

A.1 Description of a BioCTS Test Result

Every test performed in BioCTS for ISO/IEC Binary and XML Encoded Records CTSs generate a Result – passing or failing. In an effort to enhance the readability and clarity of the Results, the textual output formatting has been modified since the initial release of BioCTS for ISO/IEC.

The Text Log Output Result formatting is:

```
-------------------------------------------------------------------------------------------------------
 2.|    Test Name| Value
-------------------------------------------------------------------------------------------------------
   |        Level| L1
    ------------------------------------------------------------------------------------------------
   |       Result| Ok
    ------------------------------------------------------------------------------------------------
   | Test Message| Equality Test: Is the Value Present (0x464D5200) Equal to the Expected Value
   |             | (0x464D5200)?
-------------------------------------------------------------------------------------------------------
```

Figure 13 - BioCTS for ISO/IEC Binary and XML Encoded Records Text Log Output

The XML Log Output Result format:

```
<Result>
  <Level>L1</Level>
  <Message>Equality Test: Is the Value Present (0x464D5200) Equal to the Expected Value (0x464D5200)?</Message>
  <Results>Ok</Results>
  <Test>Value</Test>
</Result>
```

Figure 14 - BioCTS for ISO/IEC Binary and XML Encoded Records XML Log Output

A Result consists of, and clearly identifies:

- Test Name – The name of the test being performed.
- Test Level
    - Parse – A parse level test deals with any test that relates to parsing of the information; tests with this level happen before the data is inspected during L1, L2 and L3 testing.
    - L1 – A Level 1 test, which tests for values, lengths, and character counts of the data.
    - L2 – A Level 2 test, which tests for relationships between Fields, Subfields, Information Items and Records.
    - L3 – A Level 3 test, which tests to see if the data specified is consistent with the biometric sample presented.
- Test Result
    - Ok – The test was unable to find an error. This does not necessarily mean that this portion of data was without error; just that the tests could not find error.
    - Message – The test was unable to find an error; however the test found it necessary to convey an additional message.
    - Warning – The test was unable to find an error; however there may be an aspect that warrants further investigation.

- Error – The test was able to find an error.
- Critical – The test was able to find an error; this error was critical enough that it may impede further testing.
- Test Message – The message can contain any additional information to clarify the test.