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IREX
An Evaluation-based Program for the Development of Exchangeable Iris Imagery
and Support for Compact Interoperable ISO/IEC 19794-6 Records

Iris Exchange (IREX) Evaluation 2008

Concept, Evaluation Plan and API

Patrick Grother

NIST

November 19, 2007

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Commenting on this Draft

Nov 17, 2007: NIST welcomes comments on this draft. These should be submitted to patrick.grother@nist.gov by December 8, 2007. Proprietary information should not be sent to NIST, and any commentary marked with phrases such as "commercial in confidence" will be ignored.

As a first draft, the entire content of this document is open. Interested parties should feel free to address everything from motivation and scope, through the test structure, the data structures and the API, to typographical errors.

NIST directs readers attention to the questions formatted in red in the body of the text.

We anticipate producing at least one more draft before a definitive evaluation plan can be finalized. Given sufficient demand NIST would hold a workshop to discuss this project.

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NIST Request I

NIST is eager to identify organizations in possession of iris images who might share them with NIST, and who might benefit from their use in this effort. A number of issues would need to be addressed before such collaboration could proceed: We'd be happy to discuss these as soon as practicable.

Please email patrick.grother@nist.gov or phone 301 975 4157.

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NIST Request II

To help NIST plan, we would be very grateful if likely participants could send us an informal non-binding indication of such.

Please email patrick.grother@nist.gov or phone 301 975 4157.

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Project History

Nov 19, 2007 (18:10 EST)

- Fixed erroneous byte lengths of ISO records, Table 7+8.

Nov 19, 2007 (14:00 EST).

- Typos and cut-and-paste errors fixed.

Nov 18, 2007

- Announcement: NIST indicates it will conduct the Iris Exchange evaluation, IREX 08, to test the capabilities of industry and academia to segment irides, prepare compact rectilinear and polar standard records, and accurately match compressed images in a cross-vendor interoperable environment.
- Posting of this initial evaluation plan, for public comment.
- Establishment of IREX homepage: <http://iris.nist.gov/irex>

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Provisional Timeline

March 17, 2008	Completion of final validated operable SDKs to NIST
March 1, 2008	Delivery of beta SDKs to NIST, commencement of validation process
January 23, 2008	Conclusion of second comment period
January 7-12, 2008	SC 37 Working Group 3 meeting in Tel Aviv, Israel
January 15, 2008	Release of second draft evaluation plan, for comment. This date is contingent on the breadth, depth, and quantity of comments received.

IREX 2008

December 8, 2007	Conclusion of Initial comment period
November, 18, 2007	Release of initial evaluation plan for comment.

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29 **Acknowledgements**

30 The authors are grateful to the following contributors, and other anonymous individuals, without whose input this
31 document would not have been concluded.

32 A

33 B ...

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1. IREX Overview

The NIST Interoperable Iris Program is being initiated at NIST in support of an expanded marketplace of iris-based applications based on standardized interoperable iris imagery. The work is primarily conducted in support of the ISO/IEC 19794-6 standard, now under revision. It secondarily supports the recently completed ANSI/NIST ITL 1-2007 Type 17 standard, as derived from the ISO/IEC 19794-6:2005 parent [STD05], and future revision thereof.

The IREX is distinct from NIST's prior Iris Challenge Evaluations (ICE). Table 1 gives the context for IREX amongst the various iris activities at NIST.

Table 1 – NIST's iris evaluations

IREX 08	IREX 08 is intended to measure interoperable performance of compressed ISO/IEC 19794-6:2005 rectilinear and polar formatted records, and of a variant proposed for the forthcoming revision of ISO/IEC 19794-6.
ICE 06	Coordinated by Jonathon Phillips at NIST, the Iris Challenge Evaluation 2006 was a comparative assessment of commercial iris verification implementations on a common sequestered test corpus.
ICE 05	Coordinated by Jonathon Phillips at NIST, the ICE 05 activity was a cooperative research and development effort centered on the ICE 05 image corpus collected by University of Notre Dame.

2. Motivation and background

2.1. Toward compact forms

NIST's motivation in executing IREX 08 is the establishment of a standardized accurate, interoperable and compact iris image format suitable for large scale identity management applications.

While IREX 08 is structured only as an application-independent assessment of the core algorithmic performance of the segmentation and recognition components, NIST is particularly interested in establishing a set of specifications for an iris data element suitable for storage on an ISO/IEC 7816 crypto-token¹, and for efficient transmission across a network. Such specifications are

- segmentation parameters (e.g. inner and outer radii multipliers, see section X),
- compression settings (e.g. bits per pixel, see section Y), and
- geometric representation (e.g. polar or rectilinear, see section Z).

Toward similar ends, iris compression studies have been conducted [USNA,CAM07,BATH06,BATH07]. While the studies report promising results, they explored only the single-vendor case in which enrolment and verification data are processed by a lone supplier's segmentation and matching algorithms. The exception here is [BATH07] which showed similar compression sensitivities for two different matching algorithms.

The ISO/IEC 19794-6 standard was published in 2005 [STD05]. It is almost identical to its precursor, the INCITS 379:2004 standard published in the United States [I379]. As application-independent standards, neither document establishes normative requirements on compression. Instead the ISO standard's clause A.1.6 gives the following informative guidance "... a compression factor of 6:1 or less is recommended". This is rather conservative compared to the order of magnitude larger compression ratios cited in recent studies.

¹ For example, the U. S. Government's PIV Card, which currently uses fingerprint minutia. As the de facto leading data element for 7816 identity credentials, single-finger minutia templates, encoded as INCITS 378:2004 records, contain 38 minutiae (the MINEX 04 median value [MINEX]) and occupy 260 bytes including header information. ISO/IEC 19794-2:2005 compact card templates are less than half the size yet offer similar accuracy [MOC].

1 2.2. Support for the ISO standard

2 A second key motivation is to support the production of a more robust, interoperable, useful and implementable ISO/IEC
3 19794-6 standard. Thus, IREX 08 should be viewed as unofficial augmentation of the ISO development process. This
4 contrasts with the default practice of the responsible standards bodies, SC 37 Working Group 3 and M1.3, which is to not
5 embed conformance, performance and interoperability tests as part of the standards' development process. For [STD05]
6 the result of this structure was that the ultimate viability of the final standard rested on the considerable expertise of the
7 editor and the committee, and on any (unpublished) intra-supplier tests.

8 The ISO standard was adopted by at least the Registered Traveler (RT) program in the United States which sought to use
9 compact iris imagery on an identity credential. This was achieved by specifying a no-inner-boundary polar format² to
10 mitigate possible interoperability problems with the full polar format. Such problems have recently been asserted by
11 noting that the interoperability of the polar format is critically sensitive to the consistency of the segmentation [N2059,
12 N2124], and subject to sampling problems [PROC]. The solution advocated in the German proposal to SC 37 [N2059] is
13 complete removal of the polar format, and the revised text of the standard [N2226] identifies which text is to be removed.
14 A UK contribution [N2124] also advocates removal, and suggests the polar format's size can be achieved via cropping and
15 compression of the rectilinear format. The UK contribution [CAM07] indicates that compressed sizes of about 2KB are
16 achievable. The proposal to remove has been opposed by US [DHS,NIST,LG] with observations that the polar format can
17 be interoperable (viz. RT), that removal would undermine standards adoption, and that some testing is needed.

18 While NIST understands the assertions that the interoperability of the polar format is innately fragile, we note

- 19 — the polar format was developed and approved by SC 37 and M1, and,
- 20 — neither cross-vendor interoperability, nor segmentation consistency, have ever been reported³.

21 This test is therefore intended to assess the interoperability of the various polar formats, and independently measure the
22 dependence of verification error rates on compression.

23 NIST supports the current U.S. position to not remove the polar formats from the standard. NIST will support removal of
24 one or more of those formats if

- 25 — quantitative interoperability targets are met with compressed rectilinear formats, and
- 26 — quantitative interoperability targets are not met when data formatted according to the polar formats in ISO/IEC
27 19794-6 are matched.

28 3. Scope

29 IREX 08 is intended to support ISO/IEC 19794-6 by requiring participants to produce conformant instances of the
30 standard, and by contributing quantitative experimental measurements to SC 37 Working Group 3 for the development
31 of the ISO/IEC 19794-6 revision project.

32 Specifically the test aims to

- 33 — quantify the performance and interoperability of
 - 34 — rectilinear images,
 - 35 — no-inner boundary polar images,
 - 36 — fully segmented polar images, and
 - 37 — unsegmented polar images
- 38 — measure the effect of JPEG and JPEG 2000 compression on accuracy,

² Clause 6.3.2.3 of ISO/IEC 19794-6:2005 allows the pupil center to be used as the inner boundary, i.e. the pupil-iris boundary is not detected and the pupil radius is set to zero.

³ The International Biometric Group's ITIRT study [ITIRT] evaluated sensor interoperability with a common matching subsystem. The three sensors yielded either uncompressed or compressed JPEG rectilinear images.

- 1 — quantify the performance and interoperability of iris segmentation algorithms
 - 2 — time the various operations,
 - 3 — formulate content and comments toward possible revision of the relevant standards, and
 - 4 — check that suppliers can produce records conformant to the ISO/IEC 19794-6 standard.
- 5 The primary outputs of the test will be statements of performance including
- 6 — measurements of false non-match and false match error rates for various compression levels and operating
 - 7 thresholds,
 - 8 — rectilinear to polar conversion times,
 - 9 — feature extraction times, and
 - 10 — matching times.

11 In so doing, the IREX evaluation requires

- 12 — conversion of raw raster images into ISO/IEC 19794-6 rectilinear images, and
- 13 — conversion of ISO/IEC 19794-6 rectilinear images into ISO/IEC 19794-6 polar images.

14 The following are specifically not within the current scope of this evaluation:

- 15 — sensor evaluation (this study will be conducted with offline imagery),
- 16 — off-angle imagery (other than that incidentally present in the test corpora),
- 17 — conformance to INCITS 379:2004, and
- 18 — identification performance.

19 4. Normative References

20 The following referenced documents are indispensable for the application of this document. For dated references, only
 21 the edition cited applies. For undated references, the latest edition of the referenced document (including any
 22 amendments) applies.

- 23 — ISO/IEC 19794-6:2005 — Information technology — Biometric data interchange formats — Part 6: Iris image data
- 24 — ISO/IEC FDIS 19795-4 — Biometric Performance Testing and Reporting — Part 4: Interoperability Performance
- 25 Testing.

26 5. Abbreviations

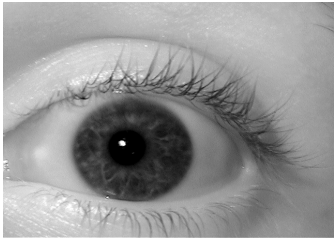
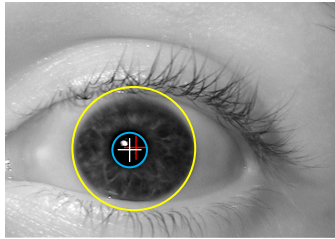
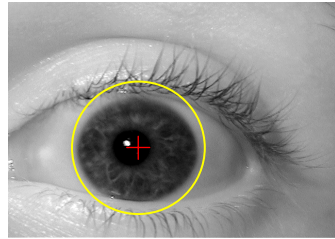
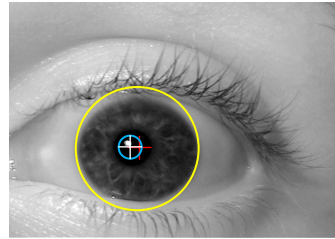
27 The abbreviations and acronyms of Table 2 are used in many parts of this document.

28 **Table 2 – Abbreviations**

DET	Detection error tradeoff characteristic – a plot of FNMR vs. FMR (sometimes as normal deviates, sometimes on log-scales)
FMR	False match rate
FNMR	False non-match rate
INCITS	InterNational Committee on Information Technology Standards
ISO/IEC 19794	Multipart standard of "Biometric data interchange formats"
I379	INCITS 379:2004
IREX	Generic name for the series of NIST's Iris Interoperability Program
NIST	National Institute of Standards and Technology
PIV	Personal Identity Verification
SC 37	Subcommittee 37 of Joint Technical Committee 1 – developer of biometric standards
SDK	The term Software Development Kit refers to any library software submitted to NIST

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Table 3 – IREX 08 image variants

	Rectilinear	Polar	No-inner-boundary Polar	Unsegmented Polar
Standards compliance	ISO/IEC 19794-6 rectilinear format Clause 6.3.1	ISO/IEC 19794-6:2005 polar format, clause 6.3.2	ISO/IEC 19794-6 polar format, clause 6.3.2.3	Proposed content for ISO/IEC 19794-6:200X, X > 7.
Notes	Essentially unprocessed.	Standard does not require circular boundaries, but if they are circular there are tight constraints on placement.	Outer boundary must be circular. Detection thereof is about as complex as a rectangular bounding box.	Inclusion of centers and radii supports reconstruction. The inner circle can be placed arbitrarily.
Region of Interest				
Remarks about the example image	An image from the ICE 05 corpus.	Both circles closely approximate the boundaries, in this case not very well because the iris is oblate. Iris and pupil centres are clearly distinct.	Yellow circle is larger than the standard prescribes. i.e. "over-segmentation".	The inner circle is shown smaller and not centered on the pupil, per the claim that this is not necessary.
Encoding	Raster, left top origin and row major.	As in ISO/IEC 19794-6:2005 6.3.2.7 and figure 1 therein	As in 6.3.2.7 and figure 1. This is clarified in Figure 1b of the draft of the revised standard [N2226].	As in ISO/IEC 19794-6:2005 6.3.2.7 and figure 1 therein
Pros	Simplicity, interoperability	Compact	No requirement to find inner boundary.	Rectilinear data can be reconstructed because centers and radii are encoded.
Cons	Size, the largest of the formats here.	Questionable interoperability due to segmentation in consistencies [N2124].	Elevated size due to inclusion of pupil	Requires alterations to standard – see Table 8.
API	See section 8.2.3	See section 8.2.4	See section 8.2.5	See section 8.2.6

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Q	Can the use of three polar formats be avoided, e.g. by consolidation?
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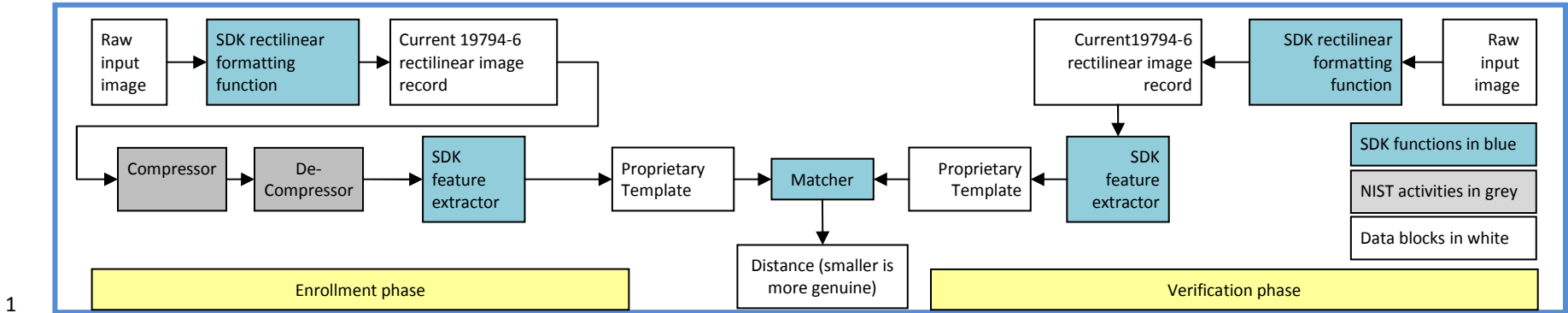


Figure 1 - Steps for verification of rectilinear images

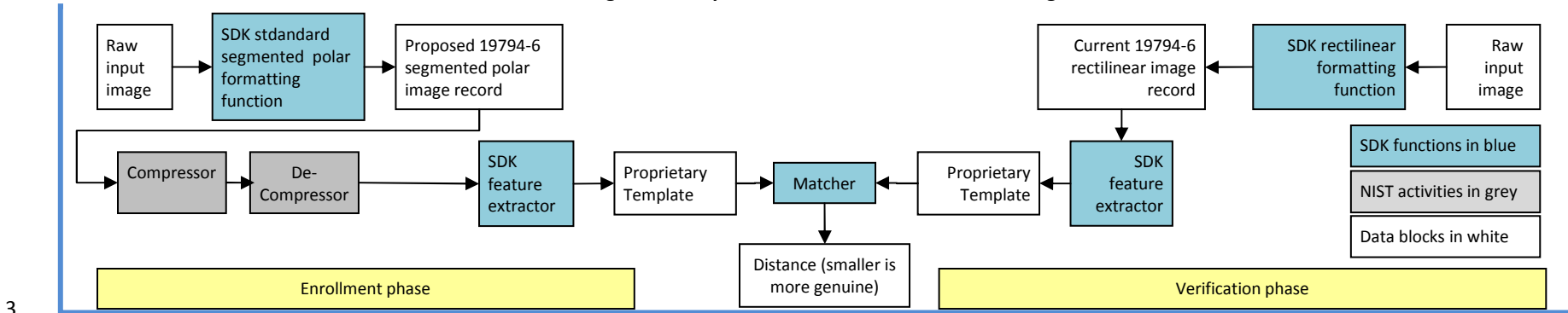


Figure 2 - Steps for verification of standard polar images

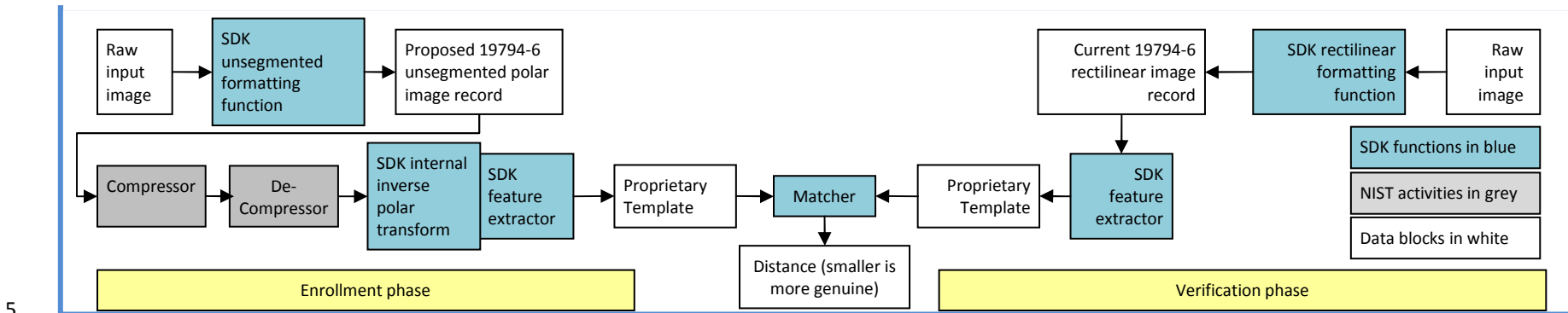


Figure 3 - Steps for verification of unsegmented polar images

1 **6. Aspects of the test**

2 **6.1. Fundamental concept of the test**

3 The IREX 08 is an interoperability test and is structured around three core operations:

4 In stage 1, functions within the supplier's SDK are called to prepare the four encodings of Table 3, specifically to convert

5 – In stage 1, archival rectilinear raster images to

6 – Rectilinear images conformant to ISO/IEC 19794-6:2005,

7 – Two polar instances conformant to ISO/IEC 19794-6:2005, and

8 – Unsegmented polar images conformant to the specifications herein.

9 – In stage 2, functions within a supplier's SDK are called to convert the processed images into an opaque proprietary
10 template.

11 – In stage 3, functions within a supplier's SDK are called to compare two proprietary templates and produce a distance
12 measure.

13 This procedural decomposition is depicted in Figure 1, Figure 2 and Figure 3. The left side of those diagrams shows the
14 enrollment process, and the right side shows the verification phase.

15 **6.2. Interoperability space**

16 The targeted interoperability scenario is a one-to-one verification application in which compressed enrollment imagery is
17 retrieved for storage to be compared with an uncompressed and unsegmented verification sample. This is reflected in
18 Figure 1, Figure 2 and Figure 3 which show the verification sample as always being a rectilinear image.

19 NIST will mimic this operation in an offline evaluation by comparing enrollment instances in the various compressed
20 formats against unprocessed and uncompressed verification images. This differs, for example, with [CAM07] in which
21 both images were compressed before any segmentation and feature extraction.

22 **6.3. Offline evaluation using archival imagery**

23 NIST intends to execute the test in an entirely offline fashion and to use images from the sequestered ICE 06 corpus of LG
24 2200 images, and a larger corpus collected using the LG 3000. NIST is likely to extend this data arbitrarily to include other
25 sources. IREX 2008 is unlikely to embed a dedicated scenario test or data collection.

26 NIST will identify the specific cameras in all published reports.

27 **6.4. Uniform software interface**

28 As in many prior NIST tests, we intend to evaluate algorithms by requiring them to be implemented behind a simple "C"
29 API. Note that this is a departure from the ICE protocol.

30 **6.5. Audience and options for participation**

31 Universities and commercial concerns with capabilities in following areas are invited to participate in the IREX 08 test.

32 – Production of conformant ISO/IEC 19794-6 records

33 – Segmentation of iris imagery, including production of polar formats

34 – Verification of standardized image records.

35 Prospective participants should read this document then complete the application form, Annex B. Participants must
36 submit an SDK that provides all of the components identified in one of the rows of Table 4. All components in a row shall
37 be supplied.

38 **Table 4 – IREX classes of participation**

Class of Participation	Annex B Participation agreement	Ability to convert a raw raster into a conformant instance of the ISO/IEC 19794-6:2005 rectilinear image format	Ability to convert a ISO/IEC 19794-6:2005 rectilinear image into a outer-boundary-only ISO/IEC 19794-6:2005 polar image	Ability to convert a ISO/IEC 19794-6:2005 rectilinear image into a full ISO/IEC 19794-6:2005 polar image	Ability to convert a rectilinear image into an unsegmented polar image [UNSEG]	Ability to extract features from and match conformant instances of the ISO/IEC 19794-6 rectilinear format.	Ability to extract features from and match conformance instances of all rectilinear and polar formats.
Class A	+	+					
Class B	+	+	+				
Class C	+	+	+	+	+		
Class D	+	+				+	
Class E	+	+	+	+	+	+	+

1 The inclusion of these classes is motivated as follows:

- 2 — Class A exists to allow organizations to demonstrate the capability to produce conformant records (e.g. for a card
3 issuance system)
- 4 — Class B exists to allow organizations to demonstrate the capability to find the bounding circle / bounding box in an
5 image, i.e. to do primary segmentation.
- 6 — Class C exists to allow organizations to demonstrate the capability to generate all variants of the ISO/IEC 19794-6
7 standard.
- 8 — Class D exists to allow organizations to demonstrate capability to match only rectilinear images.
- 9 — Class E exists to allow organizations to demonstrate segmentation and matching capability on all images.

10 **Q** These classes of participation are likely to be revised in subsequent drafts. How?

Q Should NIST allow a supplier to submit entirely separate SDK's, one for class X and one for class Y?

11 6.6. Segmentation on uncompressed data

12 All polar segmentation steps will be performed on uncompressed data. This mimics the scenario in which the image
13 processing steps need to instantiate the standard records are conducted at time of enrollment either in the sensor, or on
14 a local computer, before transmission or commitment to an identity credential.

15 6.7. Decompressed data passed to the SDK

16 NIST will not pass JPEG or JPEG 2000 encoded data to the SDK functions. Instead, we will apply compression and then
17 decompress the data before passing the record to the function. This avoids the need for the SDK to call decompression
18 routines.

19 **Q** Does the SDK need any information about the compressed imagery? Would, for example, a segmentation algorithm vary its function on, say, the basis of input file size?

20 6.8. Feature extraction on compressed data

21 Template generation will usually be performed on previously compressed data. This mimics the operational scenario in
22 which compressed imagery is exchanged (on a smartcard, or over a network) and features are extracted by the recipient.

23 Compression ratios from 1:1 (uncompressed) to perhaps 1:200 will be applied.

1 6.9. Compression metrics

2 JPEG implementations accept a quality parameter that controls the quantization of the DCT coefficients specified in
3 ISO/IEC 10918. The quantitative effect of this parameter is not standardized, and may vary between implementations.

4 ISO/IEC 15444 JPEG 2000 implementations are parameterized by a target value, such as the number of bits per pixel.

5 Some input images are more compressible than others. For example, a motion-blurred image will compress well, as will
6 images with large areas of smooth skin content.

7 NIST intends to establish operational guidance on the application of compression. NIST intends to quantify compression
8 damage in terms of, at least, PSNR as the independent variable. However, compression software does not take this an
9 input parameter and thus practical implementation would require iterative schemes to achieve a desired entropy or PSNR
10 value. This may be tenable if computational expense is not prohibitive. NIST intends to measure and report compression
11 times.

12 6.10. Provision of sensor information to SDKs

13 NIST will provide the manufacturer and model information to the image processing functions provided in the SDK. This
14 allows the implementation to tailor its algorithms to known properties of the sensor (e.g. spectral properties of the
15 illuminant).

16 NIST is not currently in possession of detailed sensor specifications, and it is therefore incumbent on participants to
17 acquire such information and to use it as they see fit.

Q	Does this provision favor some (e.g. experienced) vendors, and should therefore all sensors be identified simply as "unknown"?
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18 6.11. Repetition of the ICE 06 evaluation

19 IREX 2008 may include, as one slice of its scope, a repetition of the ICE 06 trial⁴. This arises because matching of
20 rectilinear ICE 06 images, compressed at an initial ratio of 1:1, is logically an approximate repetition of the ICE 06 trial.
21 This is approximate because the SDK protocol here differs from that used in ICE.

22 6.12. Verification performance

23 The test will embed pure 1:1 template comparisons. It will not enroll a population and thus will not support

- 24 – verification systems that run in an identification mode,
- 25 – cohort normalization techniques⁵, and
- 26 – 1:N testing, which is not needed to study the format and compression effects targeted by this study.

27 6.13. Phased testing

28 In an attempt to support SC37 timelines, NIST will depart from its usual practice (e.g. MINEX II, ELFT I) and conduct this
29 test in just a single phase. This means the results of testing will be published sometime after the implementations are
30 received, without any interim disclosure of results to the supplier, and without any resubmission of SDKs to NIST. We will
31 nevertheless communicate aberrant behavior to suppliers - for example, if generated records are non-conformant to the
32 ISO standard, or if the SDK is not conformant to our API.

Q	Should NIST adopt a two-phase approach? This would support an improvement loop: interim feedback from NIST – supplier development – SDK resubmission.
---	-------------------------------------------------------------------------------------------------------------------------------------------------------

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⁴ The ICE homepage is <http://iris.nist.gov/ice>

⁵ Such normalization methods may still be implemented within the matcher, by, for example, storing a supplier-owned internal background set of templates into the SDK.

Q	Should interim results be provided to the supplier? Or, instead, should an report be written with results that does not identify vendors?
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1 6.14. Open-source code for ISO/IEC 19794-6

2 As part of NIST's Biometric Data Interchange (BIOMDI) software distribution⁶, NIST has exposed its open-source "C" code
3 project for the reading, writing and validation of ISO/IEC 19794-6 records. The software is freely distributable. It is under
4 formal version control and subscribers to the server are automatically informed of development activities.

5 6.15. Standards-based evaluation

6 The IREX evaluation is an interoperability test. As such, NIST intends to conduct it in conformance to the ISO/IEC FDIS
7 19795-4 — *Biometric Performance Testing and Reporting — Part 4: Interoperability Performance Testing* standard. This
8 standard establishes requirements for the execution of multi-supplier biometric interoperability tests, primarily those
9 evaluating standardized interchange formats such as ISO/IEC 19794-x.

Q	Should NIST release a reference rectilinear to polar interpolation routine?
---	-----------------------------------------------------------------------------

10 7. Data structures

11 7.1. Overview

12 Much of IREX 08 will involve the generation or use of the data structures defined in the following two subsections. The
13 first is the ISO/IEC 19794-6:2005 record. The second is the proposed unsegmented polar augmentation of that record. In
14 both cases, the values in certain fields have been constrained to specific values. For example, the number of images is
15 always 1, and all image data is in uncompressed form.

16 7.2. Identifying the records of the standard

17 The ISO/IEC 19794-6 standard [STD05] required all iris biometric data blocks (BDBs) to be wrapped in CBEFF headers.
18 CBEFF, published as ISO/IEC 19785-1, advances abstract fields and values for encapsulating, signing and encrypting BDBs.

19 For IREX 08, CBEFF headers shall be absent.

20 In ISO/IEC 19794-6:2005, the only means of differentiating rectilinear records from polar records is via the CBEFF format
21 type, as shown in Table 5. However, CBEFF encapsulation is now optional in the draft revision [N2226] and there is no
22 normative mechanism for determining the encoding. This presents a bug worthy of WG3 attention.

23 **Table 5 – Identifying variants via CBEFF format type**

Geometric Encoding	CBEFF_BDB_format_type
Rectilinear	0x0009
Polar	0x000B

24
25 For IREX 08, in order to differentiate the various forms, NIST will deviate from the standard and require the Version
26 Number field to be populated and respected as per Table 6.

27 **Table 6 – Identifying variants using Version Number**

Geometric Encoding	Version Number	
All encodings in ISO/IEC 19794-6:2005	'nnn'	The 2005 standard was published with the undefined entry 'nnn'. This differs from all other parts 19794-x which stated definitive hex values.

⁶ The BIOMDI repository currently includes code for handling standardized iris, face, finger and minutiae records. Instructions for access are described here: <http://www.itl.nist.gov/iad/894.03/nigos/biomdi.html>

All encodings in ISO/IEC 19794-6:200X, X > 7	0x30333000	'030\0' - the draft revision [N2226] value.
Rectilinear	0x30313000	'010\0'
No-inner-boundary Polar	0x30313100	'011\0'
Full Polar	0x30313200	'012\0'
Proposed unsegmented Polar	0x30313300	'013\0'

1
2

3 7.3. Rectilinear image record structure

4 Rectilinear image generators shall produce records conformant to Table 7. This is identically the structure of the ISO/IEC
5 19794-6:2005 standard.

6 **Table 7 – Structure of the ISO/IEC 19794-6:2005 standard**

	Section title and/or field name	L	IREX actual or required values	Remarks	
Iris Record Header (Table 2 of ISO/IEC 19794-6:2005)					
1.	Format Identifier	4 B	0x49495200	i.e. ASCII "IIR\0"	
2.	Version Number	4 B	0x30313000 0x30313100 0x30313200	See Table 6	
3.	Record Length	4 B	$45 \leq L \leq 2^{32} - 1$	Total length	
4.	Capture Device ID	2 B	0	Value will be provided to SDK	
5.	Number of eyes imaged	1 B	1		
6.	Record header length	2 B	45		
7.	Iris image properties	Horz. orientation	2 b	ORIENTATION_BASE	
8.		Vert. orientation	2 b	ORIENTATION_BASE	
9.		Scan type	2 b	SCAN_TYPE_PROGRESSIVE, SCAN_TYPE_INTERLACE_FRAME	Rectilinear format only
10.		Occlusions	1 b	0	Polar format only
11.		Occlusion filling	1 b	0	Polar format only
12.	Boundary extraction	1 b	0	Polar format only	
13.	Iris diameter (rect)	2 B	> 0	Rectilinear format only	
14.	Image format	2 B	IMAGEFORMAT_MONO_RAW	IREX SDKs are neither permitted nor required to compress or decompress image data. Thus this field shall not be IMAGEFORMAT_MONO_JPEG, or IMAGEFORMAT_MONO_JPEG2000.	
15.	Raw image width	2 B	> 0		
16.	Raw image height	2 B	> 0		
17.	Intensity depth	1 B	8		
18.	Image transformation (polar only)	1 B	1	TRANS_STD = 1 i.e. linear radial interpolation per [STD05, 6.5.4].	
19.	Device unique identifier	16 B	'0000000000000000'	16 character zeroes '0' = 0x30, not '\0' = 0x00..	
Iris Biometric Subtype Header (Table 3 of ISO/IEC 19794-6:2005)					
20.	Eye	1 B	EYE_RIGHT, EYE_LEFT		
21.	Number of iris images of this eye	2 B	1		
Iris Image Header (Table 4 of ISO/IEC 19794-6:2005)					
22.	Image number	2 B	1	This field is an index starting at 1	
23.	Quality	1 B			
24.	Rotation angle of eye	2 B	ROT_ANGLE_UNDEF > 0	For rectilinear For polar unless next line is set non-zero	
25.	Rotation uncertainty	2 B	ROT_UNCERTAIN_UNDEF > 0	For rectilinear and polar when rotation is not estimated. For polar when rotation is estimated.	

26.	Image length	4 B	LEN	
27.	Image data	LEN		

1

2 7.4. Standard polar image record structure

3 Polar image generators shall produce records conformant to Table 7. This is identically the structure of the ISO/IEC
4 19794-6:2005 standard. Note that the standard treats rotation estimates and uncertainties differently for rectilinear and
5 polar instances, and thus appropriate values shall be assigned. This specification does not limit implementations to
6 circular models.

7 7.5. Unsegmented Polar image record structure

8 The following structure is advanced as an implementation of the proposed unsegmented polar addition to the ISO
9 standard [UNSEG]. The fields in yellow do not appear in the existing 2005 standard.

Q The [UNSEG] proposal suggests that non-circular boundary information should also be encoded in the revised standard. Should NIST include fields for the storage of such? If so, how?

10

Table 8 – Structure for the proposed unsegmented polar format

	Section title and/or field name	L	IREX actual or required values	Remarks	
Iris Record Header (Table 2 of ISO/IEC 19794-6:2005)					
28.	Format Identifier	4 B	0x49495200	i.e. ASCII "IIR\0"	
29.	Version Number	4 B	0x30313300	i.e. ASCII "013\0". This value is non-standard, and instituted by NIST to differentiate it from the properly standardized record in Table 7.	
30.	Record Length	4 B	$57 \leq L \leq 2^{32} - 1$	Total length	
31.	Capture Device ID	2 B	0	Value will be provided to SDK	
32.	Number of eyes imaged	1 B	1		
33.	Record header length	2 B	45		
34.	Iris image properties	Horz. Orientation	2 b		ORIENTATION_BASE
35.		Vert. orientation	2 b	ORIENTATION_BASE	
36.		Scan type	2 b	SCAN_TYPE_PROGRESSIVE, SCAN_TYPE_INTERLACE_FRAME	Rectilinear format only
37.		Occlusions	1 b		Polar format only
38.		Occlusion filling	1 b		Polar format only
39.		Boundary extraction	1 b		Polar format only
40.	Iris diameter (rect)	2 B		Rectilinear format only	
41.	Image format	2 B	IMAGEFORMAT_MONO_RAW	IREX SDKs are neither permitted nor required to compress or decompress image data. Thus this field shall not be IMAGEFORMAT_MONO_JPEG, or IMAGEFORMAT_MONO_JPEG2000.	
42.	Raw image width	2 B	> 0		
43.	Raw image height	2 B	> 0		
44.	Intensity depth	1 B	8		
45.	Image transformation (polar only)	1 B	1	TRANS_STD = 1 i.e. linear radial interpolation per [STD05, 6.5.4].	
46.	Device unique identifier	16 B	'0000000000000000'	16 character zeroes '0' = 0x30, not '\0' = 0x00..	
Iris Biometric Subtype Header (Table 3 of ISO/IEC 19794-6:2005)					
47.	Eye	1 B	EYE_RIGHT, EYE_LEFT		
48.	Number of iris images of this eye	2 B	1		
Iris Image Header (Table 4 of ISO/IEC 19794-6:2005)					
49.	Image number	2 B	1	This field is an index starting at 1	
50.	Quality	1 B			
51.	Rotation angle of eye	2 B	ROT_ANGLE_UNDEF	Values will not be provided to SDK	

52.	Rotation uncertainty	2 B	ROT_UNCERTAIN_UNDEF	
53.	Inner circle X coordinate	2 B	$0 \leq x < W$	Coordinate system is zero oriented with (0,0) at the top left corner. The inner and outer circle centers are not necessarily the same.
54.	Inner circle Y coordinate	2 B	$0 \leq y < H$	
55.	Inner circle radius	2 B	$0 \leq r$	
56.	Outer circle X coordinate	2 B	$0 \leq x < W$	
57.	Outer circle Y coordinate	2 B	$0 \leq y < H$	
58.	Outer circle radius	2 B	$0 \leq r$	
59.	Image length	4 B	LEN	See Line 60
60.	Unsegmented polar-transformed image data	LEN		

1 8. PC-based API specification

2 8.1. Overview

3 This section describes the IREX API. All SDK's submitted to IREX 08 shall implement the functions below here as required
4 by the classes of participation listed in Table 4.

5 8.2. Testing interface

6 8.2.1. Requirement

7 IREX participants shall submit an SDK which presents the "C" prototyped interface given in the following subsections.

8 8.2.2. Sensor identifiers

9 The following sensors will be identified to the SDK using the two byte unsigned integer values in Table 9.

10 **Table 9 – Sensor identifiers**

#	Sensor Manufacturer and Model	Identifier
1	LG 2200	0x2A16
2	LG 3000	0x2A1E
3	Unknown	0x0000

11 Presence on this table indicates NIST's intention to use images captured by these devices. NIST may add to this table in
12 due course. **Also, please see NIST's call for images on Page 2.**

13 8.2.3. Conversion of raw imagery to standard rectilinear image

14 To support the standard all submissions to IREX 08 shall implement a function to execute the packaging operation of
15 Table 10. While this action is merely syntactic, prior interoperability tests conducted by NIST have revealed a not
16 uncommon inability to reliably instantiate conformant records.

17 The output instances are used as inputs to subsequent functions (polar processing, or feature extraction). NIST will apply
18 compression-decompression to the image data contained in these records.

19 **Table 10 – Preparation of standard rectilinear records**

Input	Action	Output
Raw raster, dimensions, and parameters needed to instantiate the standardized record	Package the input into a conformant record.	Conformant ISO/IEC 19794-6 rectilinear record. These records will be checked for conformance by NIST.

20 The function shall be implemented with the API call specified in Table 11.

21 **Table 11 – IREX API preparation of standard rectilinear record**

Prototype	INT32 convert_raster_to_rectilinear(
-----------	--------------------------------------

	BYTE *uncompressed_raster_data, const UINT16 image_width, const UINT16 image_height, const BYTE horz_orientation, const BYTE vert_orientation, const BYTE scan_type, const BYTE image_format, const BYTE intensity_depth, const UINT16 nist_encoded_device_id, BYTE *quality BYTE *ISO_19794_6_rectilinear_image);	
Description	This function takes a raw input image and outputs the corresponding ISO/IEC 19794-6 rectilinear record. This function executes only a syntactic repackaging of the input data. It shall not alter the image data.	
Input Parameters	uncompressed_raster_data	The uncompressed raw image used for template creation.
	image_width	The number of pixels indicating the width of the image.
	image_height	The number of pixels indicating the height of the image.
	horz_orientation	NIST anticipates setting these values to ORIENTATION_BASE, per [STD05, 6.5.4].
	vert_orientation	
	scan_type	Progressive or interlaced. Values per the standard.
	image_format	NIST anticipates using only unprocessed uncompressed 8 bit grayscale data, so the image format will be 0x0002, and the intensity depth will be 8, both per [STD05].
	intensity_depth	
nist_encoded_device_id	A two byte unsigned integer value from Table 9	
Output Parameters	Quality	A [0,100] quality value representing
	ISO_19794_6_rectilinear_image	The output rectilinear image, per Table 7
Return Value	This function returns zero on success or a documented non-zero error code otherwise.	

1 8.2.4. Conversion of rectilinear to standard polar

- 2 To assess viability of the standard's polar format, participating submissions to IREX 08 shall execute the conversion
 3 operation of Table 12. In addition to the required polar instance output, the function shall return center coordinates.
 4 This supports measurements of the pixel-level displacement between segmentation algorithms.

5 **Table 12 – Preparation of standard polar records**

Input	Action	Output
Conformant ISO/IEC 19794-6 rectilinear record, and desired circumferential and radial numbers of samples.	Find suitable inner and outer circles. Execute forward polar transform.	Segmented polar record, per Table 7. Coordinates of the centers of the inner and outer regions.

- 6 The function shall be implemented with the API call specified in Table 13.

7 **Table 13 – IREX API for creation of polar records**

Prototype	INT32 convert_rectilinear_to_segmented_polar(const BYTE *ISO_19794_6_rectilinear_image, const UNIT16 num_samples_radially, const UINT16 num_samples_circumferentially, UINT16 *x_iris_center, UINT16 *y_iris_center, UINT16 *x_pupil_center, UINT16 *y_pupil_center, BYTE *ISO_19794_6_seg_polar_image);	
Description	This function takes a conformant ISO/IEC 19794-6 rectilinear image and outputs the corresponding segmented polar image as a conformant ISO/IEC 19794-6 instance. The coordinates of the pupil and iris centers are returned also.	

	The memory for the output structure is allocated before the call i.e. the implementation shall not allocate memory for the result. The function returns either success (0) or failure (non-zero). Failure indicates a failure to convert the image. The result will nevertheless be a conformant instance with zero irides and zero images.	
Input Parameters	ISO_19794_6_rectilinear_image	The uncompressed raw image used for template creation.
	num_samples_radially	The requested number from inner to outer boundary
	num_samples_circumferentially	The requested number of samples around the limbus
Output Parameters	x_iris_center	Horizontal and vertical locations of the iris center.
	y_iris_center	
	x_pupil_center	Horizontal and vertical locations of the pupil center.
	y_pupil_center	
ISO_19794_6_seg_polar_image	The output polar image, per Table 7.	
Return Value	This function returns zero on success or a documented non-zero error code otherwise.	

1 An implementation may elect not to process the input image, or it may fail involuntarily. If this occurs, a documented
 2 non-zero error code will be returned and NIST will record this as a failure to segment.

3 **Q** Should NIST recommend or require that the grey level data is not processed? For example, eyelids are not removed, frequency domain filtering is not performed, or histogram equalization is not applied?

4 **Q** Should this function include an input over-segmentation parameter? The values for such a parameter would take on a limited number of values, say 100 for exact detection of the limbus, and 115 for a larger region [LG].

4 **8.2.5. Conversion of rectilinear to no-inner-boundary standard polar**

5 To assess viability of the standard's no-inner-boundary polar format, participating submissions to IREX 08 shall execute
 6 the conversion operation of Table 14. In addition to the required polar instance output, the function shall return center
 7 coordinates. This supports

- 8 – measurement of the pixel-level displacement between segmentation algorithms, and
- 9 – generation of a square bounding boxes to be used for generation and testing of cropped rectilinear iris records.

10 **Table 14 – Preparation of standard no-inner-boundary polar records**

Input	Action	Output
Conformant ISO/IEC 19794-6 rectilinear record, and desired circumferential and radial numbers of samples.	Find suitable inner and outer circles. Execute forward polar transform.	Standard no-inner-boundary polar record, per Table 7. Coordinates of the centers of the inner and outer regions.

11 The function shall be implemented with the API call specified in Table 15.

12 **Table 15 – IREX API for creation of no-inner-boundary polar records**

Prototype	INT32 convert_rectilinear_to_no_inner_boundary_polar(const BYTE *ISO_19794_6_rectilinear_image, const UNIT16 num_samples_radially, const UINT16 num_samples_circumferentially, UINT16 *x_iris_center, UINT16 *y_iris_center, UINT16 *x_pupil_center, UINT16 *y_pupil_center, BYTE *ISO_19794_6_seg_polar_image);
Description	This function takes a conformant ISO/IEC 19794-6 rectilinear image and outputs the corresponding no-inner-boundary segmented polar image as a conformant ISO/IEC 19794-6 instance. The coordinates of the pupil and iris centers are returned also. The memory for the output structure is allocated before the call i.e. the implementation shall not allocate memory for

	the result. The function returns either success (0) or failure (non-zero). Failure indicates a failure to convert the image. The result will nevertheless be a conformant instance with zero irides and zero images.	
Input Parameters	ISO_19794_6_rectilinear_image	The uncompressed raw image used for template creation.
	num_samples_radially	The requested number from inner to outer boundary
	num_samples_circumferentially	The requested number of samples around the limbus
Output Parameters	x_iris_center	Horizontal and vertical locations of the iris center.
	y_iris_center	
	x_pupil_center	Horizontal and vertical locations of the pupil center.
	y_pupil_center	
ISO_19794_6_seg_polar_image	The output no-inner-boundary polar image, per Table 7.	
Return Value	This function returns zero on success or a documented non-zero error code otherwise.	

1 An implementation may elect not to process the input image, or it may fail involuntarily. If this occurs, a documented
 2 non-zero error code will be returned and NIST will record this as a failure to segment.

3 **Q** Should NIST recommend or require that the grey level data is not processed? For example, eyelids are not removed, frequency domain filtering is not performed, or histogram equalization is not applied?

4 **Q** Should this function include an input over-segmentation parameter? The values for such a parameter would take on a limited number of values, say 100 for exact detection of the limbus, and 115 for a larger region [LG].

4 **8.2.6. Conversion of rectilinear to unsegmented polar**

5 To examine the viability of the proposed unsegmented polar format, participating submissions to IREX 08 shall execute
 6 the conversion of operation of Table 16. To allow surveys over the radial and circumferential sampling rates the function
 7 takes as input number-of-samples arguments.

8 **Table 16 – Preparation of unsegmented polar records**

Input	Action	Output
Conformant ISO/IEC 19794-6 rectilinear record, and desired circumferential and radial numbers of samples.	Find suitable inner and outer circles. Execute forward polar transform.	Proposed unsegmented polar record, per Table 8.

9 The function shall be implemented with the API call specified in Table 17.

10 **Table 17 – IREX API for creation of unsegmented polar records**

Prototype	INT32 convert_rectilinear_to_unsegmented_polar(const BYTE *ISO_19794_6_rectilinear_image, const UINT16 num_samples_radially, const UINT16 num_samples_circumferentially, BYTE *unseg_polar_image);	
Description	This function takes a conformant ISO/IEC 19794-6 rectilinear image and outputs the corresponding unsegmented polar image. The memory for the template is allocated before the call i.e. the implementation shall not allocate memory for the result. The function returns either success (0) or failure (non-zero). Failure indicates a failure to convert the image. The result will nevertheless be a conformant instance with zero irides and zero images.	
Input Parameters	ISO_19794_6_rectilinear_image	The uncompressed raw image as prepared by the function in Table 11.
	num_samples_radially	The number of sample along a spoke. The output polar data shall have this height.
	num_samples_circumferentially	The number of "spokes" around the iris. The output polar data shall have this width.
Output Parameters	ISO_19794_6_unseg_polar_image	The output template, per Table 8.
Return Value	This function returns zero on success or a documented non-zero error code otherwise.	

11

Q	Should NIST recommend or require that the grey level data is not processed? For example, eyelids are not masked, frequency domain filtering is not performed, or histogram equalization is not applied?
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1

Q	Should this function include an input over-segmentation parameter? The values for such a parameter would take on a limited number of values, say 100 for exact detection of the limbus, and 115 for a larger region [LG].
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2 An implementation may elect not to process the input image, or it may fail involuntarily. If this occurs, a documented
3 non-zero error code will be returned and NIST will record this as a failure to segment.

4 **8.2.7. Template creation**

5 This function converts any of the input data structures to an opaque proprietary template. The function will need to look
6 at the header of the input record to determine the content. This routine will need to heed the hexadecimal "Version
7 Number" values in the Table 7 and Table 8 records.

8

Table 18 – IREX API template creation

Prototype	INT32 convert_image_to_template(const BYTE *input_record, BYTE *proprietary_template);	
Description	<p>This function takes either</p> <ul style="list-style-type: none"> – a conformant ISO/IEC 19794-6 rectilinear image, or – a conformant ISO/IEC 19794-6 polar image, or – a proposed standard unsegmented polar image, <p>and outputs a proprietary template. The implementation should inspect the input header to determine which kind of imagery is being provided.</p> <p>The memory for the output template is allocated before the call i.e. the implementation shall not allocate memory for the result. The function returns either success (0) or failure (non-zero). Failure indicates a failure to convert the image. The result will nevertheless be a template record that may be passed to the match_templates function without error.</p>	
Input Parameters	input_record	An input image presented either as instance of Table 7 or Table 8..
Output Parameters	proprietary_template	The output template. The format is entirely unregulated, but it shall include its own length as this will not be provided to the subsequent matcher function.
Return Value	This function returns zero on success or a documented non-zero error code otherwise.	

9 An implementation may elect not to make a template, or it may fail involuntarily. If this occurs, a documented non-zero
10 error code will be returned, size then NIST will record this as a failure to acquire.

11 **8.2.8. Template comparison**

12 This function compares two proprietary templates and returns a real-valued distance score.

13

Table 19 – IREX API template matching

Prototype	INT32 match_templates(const BYTE *verification_template, const UINT16 verification_template_size, const BYTE *enrollment_template, const UINT16 enrollment_template_size, double *score);	
Description	<p>This function compares two opaque proprietary templates and outputs a non-negative match score.</p> <p>The returned score is a distance measure. It need not satisfy the metric properties. NIST will allocate memory for this parameter before the call. When the function is called with either or both templates containing zero data (see Error! Reference source not found.) the function shall assign the value -1 to the score.</p>	
Input Parameters	verification_template	A template from create_template().

	verification_template_size	The size, in bytes, of the input verification template $0 \leq N \leq 2^{16} - 1$
	enrollment_template	A template from create_template().
	enrollment_template_size	The size, in bytes, of the input enrollment template $0 \leq N \leq 2^{16} - 1$
Output Parameters	score	A similarity score resulting from comparison of the templates, on the range [0,DBL_MAX].
Return Value	This function returns zero on success (i.e. a valid score is produced) or a documented non-zero error code on failure.	

1

Q	Should NIST add a polarity flag to indicate smaller-is-more-genuine vs. larger-is-more-genuine, or are all suppliers content with smaller-is-more-genuine distance scores?
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2

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3 8.2.9. Implementation identifiers

4 The implementation shall support the self-identification function of Table 20. This function is required to support internal
5 NIST book-keeping. The version numbers should be distinct between any versions which offer different algorithmic
6 functionality.

7

Table 20 – IREX API get_pids function

Prototype	INT32 get_pid(UINT32 *nist_assigned_identifier);	
Description	This function retrieves an identifier that the provider must request from NIST, and compile into the source code. NIST will assign the identifier that will uniquely identify the supplier and the SDK version number.	
Output Parameters	nist_assigned_identifier	A PID which identifies the SDK under test. The memory for the identifier is allocated by NIST's calling application, and shall not be allocated by the SDK.
Return Value	This function returns zero on success or a documented non-zero error code on failure.	

8 8.3. Software and Documentation

9 8.3.1. SDK Library and Platform Requirements

10 Participants shall provide NIST with binary code only (i.e. no source code) – supporting files such as header (".h") files
11 notwithstanding. Such files shall not contain intellectual property of the company nor any material that is otherwise
12 proprietary. It is preferred that the SDK be submitted in the form of a single static library file (ie. ".LIB" for Windows or
13 ".a" for Linux). However, dynamic/shared library files are permitted.

14 If dynamic/shared library files are submitted, it is preferred that the API interface specified by this document be
15 implemented in a single "core" library file with the base filename 'libIREX' (for example, 'libIREX.dll' for Windows or
16 'libIREX.so' for Linux). Additional dynamic/shared library files may be submitted that support this "core" library file (i.e.
17 the "core" library file may have dependencies implemented in these other libraries).

18 8.3.2. Linking

19 NIST will link the provided library file(s) to a C language test driver application developed by NIST. The runtime
20 environment shall be either

- 21 – The cygwin⁷ layer running on a Windows Server 2003 OS.
- 22 – RedHat Linux Enterprise 4 or 5 platforms.

23 Both will use GNU's gcc compiler, version 3.3.3. These use libc. The link command might be:

- 24 – `gcc -o irextest irextest.c -L. -lIREX`

⁷ According to <http://www.cygwin.com/> is a Linux-like environment for Windows. It consists of two parts: A DLL (cygwin1.dll) which acts as a Linux API emulation layer providing substantial Linux API functionality; a collection of tools which provide Linux look and feel.

1 Participants are required to provide their library in a format that is linkable using GCC with the NIST test driver, which is
 2 compiled with GCC. All compilation and testing will be performed on x86 platforms. Thus, participants are strongly
 3 advised to verify library-level compatibility with GCC (on an equivalent platform) prior to submitting their software to
 4 NIST to avoid linkage problems later on (e.g. symbol name and calling convention mismatches, incorrect binary file
 5 formats, etc.).

6 Dependencies on external dynamic/shared libraries such as compiler-specific development environment libraries are
 7 discouraged. If absolutely necessary, external libraries must be provided to NIST upon prior approval by the Test Liaison.

8 **8.3.3. Installation and Usage**

9 The SDK must install easily (i.e. one installation step with no participant interaction required) to be tested, and shall be
 10 executable on any number of machines without requiring additional machine-specific license control procedures or
 11 activation.

12 The SDK's usage shall be unlimited. The SDK shall neither implement nor enforce any usage controls or limits based on
 13 licenses, execution date/time, number of executions, presence of temporary files, etc.

14 It is recommended that the SDK be installable using simple file copy methods, and not require the use of a separate
 15 installation program. Contact the Test Liaison for prior approval if an installation program is absolutely necessary.

16 **8.3.4. Documentation**

17 Participants shall provide complete documentation of the SDK and detail any additional functionality or behavior beyond
 18 that specified here. The documentation must define all error and warning codes (see 8.4.3).

19 **8.3.5. Modes of operation**

20 Individual SDKs provided shall not include multiple "modes" of operation, or algorithm variations. No switches or options
 21 will be tolerated within one library. For example, the use of two different "coders" by an iris feature extractor must be
 22 split across two separate SDK libraries, and two separate submissions.

23 **8.4. Runtime behavior**

24 **8.4.1. Speed**

25 The following limits are instituted to constrain NIST's total IREX computational workload.

- 26 – The mean template match operation shall not exceed 10 milliseconds.
- 27 – The mean template creation operation shall not exceed 1.2 seconds (using a 2GHz Pentium IV).
- 28 – The mean iris segmentation operation (e.g. polar) shall not exceed 1.2 seconds (using a 2GHz Pentium IV).

29

d	Should these times be lowered (for operational relevance) or raised (for improved algorithmic function)?
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30 **8.4.2. Interactive behavior**

31 The SDK will be tested in non-interactive "batch" mode (i.e. without terminal support). Thus, the submitted library shall
 32 not use any interactive functions such as graphical user interface (GUI) calls, or any other calls which require terminal
 33 interaction e.g. reads from "standard input".

34 **8.4.3. Error codes and status messages**

35 The SDK will be tested in non-interactive "batch" mode (i.e. without terminal support). Thus, the submitted library shall
 36 run quietly, i.e. it should not write messages to "standard error" and shall not write to "standard output". Instead, the
 37 SDK shall conform to the error notification procedures of Annex A.

1 8.4.4. External communication

2 Processes running on NIST hosts shall not side-effect the runtime environment in any manner, except for memory
3 allocation and release. Implementations shall not write any data to external resource (e.g. server, file, connection, or
4 other process), nor read from such. If detected, NIST will cease evaluation, inform the provider and document evidence of
5 such in published reports.

6 8.4.5. Stateful behavior

7 All components in this test shall be stateless. This applies to segmentation, feature extraction and matching. Thus the all
8 functions should give identical output, for a given input, independent of the runtime history. NIST will institute
9 appropriate tests to detect stateful behavior. If detected, NIST will

- 10 – cease evaluation of all implementations from the supplier,
- 11 – inform the supplier, and
- 12 – publicly report the behavior, with attribution and documentary evidence.

13 9. NIST conversion of Rectilinear to Polar Coordinates

Q	Rather than have suppliers execute the conversion of rectilinear to polar format, should NIST instead require the supplier to return the parameters of the transform with which NIST would then execute it.?
	NIST's transformation code would include neither boundary detection nor segmentation code.

14 10. References

AN27	NIST Special Publication 500-271: American National Standard for Information Systems — <i>Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information – Part 1</i> . (ANSI/NIST ITL 1-2007). Approved April 20, 2007.
DHS	J. Mayer-Splain for DHS, <i>DHS Technical Contribution in Support of Retaining the Iris Polar Image Format</i> . August 31, 2007. This document is a password protected contribution toward the US position on the revision of 19794-6:2005. http://www.incits.org/tc_home/m1htm/2007xdocs/m1070456.pdf
I379	American National Standard for Information Technology – <i>iris Image Format for Data Interchange</i> , ANSI/INCITS 379-2004, http://www.incits.org
MINEX	P. Grother et al., <i>Performance and Interoperability of the INCITS 378 Template</i> , NIST IR 7296 http://fingerprint.nist.gov/IREX04/IREX_report.pdf
MOC	P. Grother and W. Salamon, <i>MINEX II - An Assessment of ISO/IEC 7816 Card-Based Match-on-Card Capabilities</i> http://fingerprint.nist.gov/minex/minexII/NIST_MOC_ISO_CC_interop_test_plan_1102.pdf
N2059	JTC001-SC37-N-2059 — <i>German National Body contribution on the revision project on Iris Image Data standard ISO/IEC 19794-6</i> . April 20, 2007
N2124	JTC001-SC37-N-2124 — <i>UK Contribution on a defect in ISO/IEC 19794-6 polar iris image format</i> . May 29, 2007
CAM07	JTC001-SC37-N-2125 — <i>UK Contribution on the effect of severe image compression on iris recognition performance</i> . May 29, 2007. This document was submitted as a UK contribution to SC 37 Working Group 3. It is available as: John Daugman and Cathryn Downing, <i>Effect of severe image compression, on iris recognition performance</i> . Technical Report No. 685, University of Cambridge, Computer Laboratory, UCAM-CL-TR-685, ISSN 1476-2986, May 07.
N2226	JTC001-SC37-N-2226 — <i>Base document for revision of ISO/IEC 19794-6, Information technology: Biometric data interchange formats – Part 6: Iris image data</i>
NIST	P. Grother, <i>NIST comments toward US position on N2226, revision of ISO/IEC 19794-6</i> , September 7, 2007 http://www.incits.org/tc_home/m1htm/2007xdocs/m1070488.pdf

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UNSEG	D. Kim, <i>Introducing the Unsegmented Polar Format</i> , posted as m1070606 and m1070606rev to the M1 document register: http://m1.incits.org/m1htm/2007docs/m1docreg_2007.htm . These documents are password protected US contributions to the January 2008, SC37/WG3 meeting in Tel Aviv. Substantially the same information was presented to the Second NIST Quality Workshop on November 8, 2007 and is linked here: http://www.itl.nist.gov/iad/894.03/quality/workshop07/presentations.html as http://www.itl.nist.gov/iad/894.03/quality/workshop07/proc/Kim_Introducing_Unsegmented_Polar_Data_Format_for_NIST_Presentation_20071106_forPrinting.pdf
LG	S. Shah, <i>Comment on Iris Boundary Determination (Polar Representation) and Polar Format</i> , September 7, 2007. This document is a password protected US contribution to the January 2008, SC37/WG3 meeting in Tel Aviv. http://www.incits.org/tc_home/m1htm/2007xdocs/m1070486.pdf
STD05	ISO/IEC 19794-6:2005 — <i>Information technology — Biometric data interchange formats — Part 6: Iris image data</i> The standard was published in 2005, and can be purchased from ANSI at http://webstore.ansi.org/ or ISO.
PROC	Hugo Proença and Luís A. Alexandre, <i>Iris Recognition: An Analysis of the Aliasing Problem in the Iris Normalization Stage</i>
BATH07	Soumyadip Rakshit and Donald M. Monro, <i>An Evaluation of Image Sampling and Compression for Human Iris Recognition</i> , IEEE Transactions On Information Forensics And Security, Vol. 2, No. 3, September 2007
USNA	Robert W. Ives, Bradford L. Bonney, and Delores M. Etter, <i>Effect of Image Compression on Iris Recognition</i> , IMTC 2005 – Instrumentation and Measurement Technology Conference, Ottawa, Canada, 17-19 May, 2005.

Annex A Error Codes and Handling

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Each participant shall provide their SDK with text documentation of all (non-zero) error or warning return codes (see section 8.3.4, Documentation).

The application should include error/exception handling so that in the case of a fatal error, the return code is still provided to the calling application.

At minimum the bit masked return codes of Table 21 shall be set and returned.

Table 21 – IREX API return codes

Return code	Explanation
0	Success
1	Image size not supported
2	Failed to find iris
4	Failed to find pupil center
8	Failed to find iris center
16	Failed to match templates
32	Failed to match templates – unable to parse probe template
64	Failed to match templates – unable to parse gallery template
> 128	Supplier defined error codes in here.

9 All messages which convey errors, warnings or other information shall be suppressed.

Annex B

Application to participate in IREX

This participation agreement is an incomplete adaptation of the one used in MINEX II, a recent fingerprint interoperability test. It is very much a draft, and will be revised in subsequent drafts. It is included only to indicate the kind of content.

3 B.1 Who should participate

4 Providers of implementations using ISO/IEC 19794-6:2005 iris images are invited to participate in IREX. In addition,
5 companies, research organizations, or universities that have developed mature prototypes or who research iris
6 segmentation or matching are invited to participate.

7 The algorithms and software need not be “operational,” nor a production system, nor commercially available. However,
8 the system must, at a minimum, be a stable implementation capable of being “wrapped” (formatted) in the API
9 specification that NIST has specified in section 8 for this evaluation.

10 Anonymous participation will not be permitted. This means that signatories to this Agreement acknowledge that they
11 understand that the results (see sections 6.6 and Annex B.7) of the evaluation of the software and/or hardware will be
12 published with attribution to their organization(s).

13 B.2 How to participate

14 B.2.1 Application package

15 10.1. Submission

16 Those wishing to participate in IREX testing shall provide NIST with those components identified in the Participation
17 Classes given in section 6.1. Software shall be submitted as an SDK (Software Development Kit) library which complies
18 with the API (Application Programmer Interface) specified in this document.

19 In order to request participation in IREX, prospective participants must assemble ALL of the following items and send the
20 entire package to NIST at the address given in Annex C.

21 — A signed and fully completed copy of this entire Annex B, including the *Agreement Application to Participate in IREX*,
22 form below. This must identify, and include signatures from, the Responsible Parties as defined in section B.4.

23 The package may also include:

24 — Software for each submission (see section 6.1 and B.3.3).

25 B.3 NIST activity

26 B.3.1 Initiation

27 Upon receipt of the signed Annex B form by NIST, the organization shall be classified as a “Participant”. NIST must receive
28 the form during the submission period described in schedule on Page 2 of this document.

29 B.3.2 Supplier validation

30 Registered Participants will be provided with a small Validation Dataset available on the website <http://iris.nist.gov/irex>.
31 Prior to submission of their SDK, the Participant must to verify that their software executes on the validation data, and
32 produces correct similarity scores and templates.

1 **B.3.3 Submission of software to NIST**

2 After the Participant has executed his software on the validation imagery, the participants shall send the software and its
3 validation output to NIST. All submitted material shall be encrypted using GnuPG (gpg) by downloading the IREX Test
4 Liaison's public key: http://fingerprint.nist.gov/minex/minex_pk.asc whose fingerprint is 448F 3828 719D B6B0 FDC5
5 3DE6 715B 6C72 062A 520A.

- 6 — Importing it into your keyring using: `gpg --import minex_pk.asc`
- 7 — Using it to encrypt your SDK (with ASCII armor if submitting via email): `gpg -r minex -ae mysdk.zip`

8 The result shall be emailed to irex@nist.gov.

9 NIST accepts no responsibility for unencrypted materials sent to NIST.

10 **B.3.4 Acceptance testing**

11 Software submitted shall implement the IREX API Specification of section 8.

12 Upon receipt of the SDK and validation output, NIST will attempt to reproduce the output by executing the SDK on the
13 validation imagery, using a NIST computer. In the event of disagreement in the output, or other difficulties, the
14 Participant will be notified.

15 In the event cards or software is found to be non-functional or non-compliant with this document's specifications, or
16 where the validation dataset results cannot be replicated by NIST, Participants will be notified with a detailed description
17 of the problem(s) and given a reasonable opportunity to resubmit (as time allows) according to the discretion of the IREX
18 Liaison.

19 **B.3.5 Limits of testing**

20 NIST will use the Participant's cards and SDK software only for the testing described in this document. The provided
21 hardware and software will also be used to resolve any errors identified subsequent to the test or publication of results.

22 NIST agrees not to use the Participants software for purposes other than indicated herein, without express permission by
23 the Participant. NIST reserves the right to conduct analyses of the output data and measurements beyond those
24 described in this document.

25 **B.4 Parties**

26 **B.4.1 Responsible Party**

27 The Responsible Party is an individual with the authority to commit the organization to the terms in this document.

28 **B.4.2 Point of contact**

29 The Point of Contact is an individual with detailed knowledge of the system applying for participation.

30 The IREX Liaison is the government point of contact for IREX. All correspondence should be directed to irex@nist.gov,
31 which will be received by the IREX Liaison and other IREX personnel.

32 These correspondences may be posted on the FAQ (Frequently Asked Questions) area of the <http://iris.nist.gov/irex> at the
33 discretion of the IREX Liaison. The identity of those persons or organizations whose correspondences lead to FAQ
34 postings will not be made public in the FAQ.

35 **B.5 Access to IREX validation data**

36 The IREX Validation Data is supplied to Participants to assist in preparing for IREX.

37 The fingerprints in the IREX Validation Data are representative of the IREX Test Data only in their format. Image quality,
38 collection device and other characteristics are likely to vary between the Validation and Test Datasets.

1 **B.6 Access to IREX test data**

2 The IREX Test Datasets are protected under the Privacy Act (5 U.S.C. 552a), and will be treated as Sensitive but
3 Unclassified and/or Law Enforcement Sensitive.

4 IREX Participants shall have no access to IREX Test Data, either before, during or after the test.

5 **B.7 Reporting of results**

6 **B.7.1 Reports**

7 The Government will combine appropriate results into one or more IREX Reports. Together these will contain, at a
8 minimum, descriptive information concerning IREX, descriptions of each experiment, and aggregate test results. NIST will
9 include

- 10 — DET performance metrics as the primary indicators of one-to-one verification accuracy,
- 11 — ISO/IEC 19795-4 interoperability matrices as the primary measures of interoperability, and
- 12 — enrollment and verification timing statistics.

13 NIST may compute and report other aggregate statistics.

14 NIST intends to release Phase 1 results to the participant only.

15 NIST intends to publish Phase 2 results in one or more NIST Interagency Reports.

16 The Phase 2 reports will:

- 17 — contain the names of Phase 1 participants,
- 18 — not contain the results from Phase 1 participants' implementations,
- 19 — contain the names of Phase 2 participants, and
- 20 — contain the results of all Phase 2 participants' implementations which will associated with the participants names.

21 **B.7.2 Pre-publication review**

22 Participants will have an opportunity to review and comment on the reports. Participants' comments will be either
23 incorporated into the main body of the report (if it is decided NIST reported in error) or published as an addendum.
24 Comments will be attributed to the participant.

25 **B.7.3 Citation of the report**

26 After the release of the Phase II Final Report, Participants may decide to use the results for their own purposes. Such
27 results shall be accompanied by the following phrase: "Results shown from the Iris Exchange Test (IREX) do not constitute
28 endorsement of any particular system by the U. S. Government." Such results shall also be accompanied by the URL of
29 the IREX Report on the IREX website, <http://iris.nist.gov/irex>.

30 **B.7.4 Rights and ownership of the data**

31 Any data generated, deduced, measured or otherwise obtained during IREX (excepting the submitted SDK itself), as well
32 as any documentation required by the Government from the participants, becomes the property of the Government.
33 Participants will not possess a proprietary interest in the data and/or submitted documentation.

34 **B.8 Return of the supplied materials**

35 **B.8.1 Returning software to vendors**

36 NIST will not return any supplied software, documentation, or other material to vendors.

1 **B.8.2 Returning cards to vendors**

2 NIST will not return cards to the provider. NIST will destroy the cards within ninety days of publication of the results for
 3 that card or notification to the vendor that the card is inoperable. This requirement is needed because template data on
 4 the card is protected and because NIST has no mechanism to assure deletion of templates from the card. However, NIST
 5 to support debugging NIST may, at its sole discretion, return cards during the initial acceptance testing phase.

6 **B.9 Agreement to participate**

7 With the signing of this form, Participants attest that they will not file any IREX-related claim against IREX Sponsors,
 8 Supporters, staff, contractors, or agency of the U.S. Government, or otherwise seek compensation for any equipment,
 9 materials, supplies, information, travel, labor and/or other participant provided services.

10 The Government is not bound or obligated to follow any recommendations that may be submitted by the Participant. The
 11 United States Government, or any individual agency, is not bound, nor is it obligated, in any way to give any special
 12 consideration to IREX Participants on future contracts, grants or other activities.

13 With the signing of this form, Participants realize that any test details and/or modifications that are provided in the [IREX](#)
 14 [website](#) supersede the information on this form.

15 With the signing of this form, Participants realize that they can withdraw from the IREX at any time prior to the end of the
 16 Phase 1 submission window, without their participation and withdrawal being documented in the IREX Final Report.

This form shall be completed by all suppliers electing to participate in the IREX evaluation.				
NIST assigned identifier for the supplied SDK.				
Responsible Party for supplier of fingerprint matcher technology (i.e. any algorithms present on the card or in the SDK library).				
Company / Organization Name				
Title	First Name	MI	Last Name	Suffix
Street Address				
City		State	Zip	Country
Phone		Fax		Email
Technical point of contact		Phone		Email

17 With my signature, I agree that this document is a sufficient description of the test to be conducted.

18 With my signature, I hereby request consideration as a Participant in the Iris Interoperability Exchange Test II (IREX), and I
 19 am authorizing my company or organization to participate in IREX according to the rules and limitations listed in this
 20 document.

21 With my signature, I also state that I have the authority to accept the terms stated in this document

22

23

24

25 SIGNATURE OF FIRST FINGERPRINT SOFTWARE SUPPLIER RESPONSIBLE PARTY DATE

Annex C
NIST mailing address

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3 The address given below shall be used for all mail or courier delivery to NIST. This includes delivery of IREX participation
4 agreements and all IREX cards and software.

IREX Test Liaison
National Institute of Standards and Technology
Information Access Division (894)
100 Bureau Drive
A203/Tech225/Stop 8940
Gaithersburg, MD 20899-8940
USA

5 In cases where the courier needs a phone number please use NIST shipping and handling at 301 nine seven five six two
6 nine six.