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Standard Guide for Scanning Facial Images

1. Scope

1.1 This guideline provides best practice for scanning documents containing facial images for Facial Recognition enrollment or for Facial Image Comparisons.

1.2 This guide is for instances in which a printed facial image requires capture for enrollment into a Facial Recognition system or for use by facial examiners undertaking a facial image comparison.

1.3 This guide will provide no comment on original image capture, printing resolution, any possible image enhancements that may have occurred prior to a facial image being printed or during the preparation of a facial image for the personalization process in identity documents.

1.4 This guide acknowledges that in Appendix F of IAFIS-DOC-01078-9.3[1] the minimum scanner testing requirements are provided, and notes that whilst the core capabilities and attributes for a fingerprint scanner are similar, there are crucial differences for scanning an optimal facial image.

1.5 This guide also acknowledges that there is a list of certified fingerprint scanners on the Criminal Justice Information Services (CJIS) website[2], and notes that some of these scanners are capable of both gray scale and full color scanning.

2. Summary of Practice

2.1 Generally, modern facial images are color or black and white. Color printed images, black and white or grayscale images can be found in historical documents, newspapers, Closed Circuit Television (CCTV) extracts, and some security documents that print to a polycarbonate substrate. Standards for scanning facial images need to reflect the variety of sources that may be encountered.

[1] IAFIS-DOC-01078-9.3 Electronic Biometric Transmissions Specification https://www.fbibiospecs.cjis.gov/

[2] https://www.fbibiospecs.cjis.gov/certifications

2.2 This guideline provides best practice for scanning documents containing facial images for:

2.2.1 Facial Recognition enrollment, or

2.2.2 Facial Image Comparison.

2.3 For any facial image scanning, a scanner must be capable of producing images that exhibit good geometric fidelity, sharpness, and detail rendition, with low noise characteristics. The images must be true color representations of the printed facial image without creating any significant artifacts, anomalies, false detail, or cosmetic image restoration effects.

2.4 It may be necessary to consult an Image Specialist to provide advice on the best method of scanning a facial image in a document, which may have other features impacting the image. Examples are mass produced documents (newspapers, magazines etc.) where a half-tone or similar process has been used.

3. **Referenced Documents**

3.1 ISO 12641 - 1: 2016 Graphic technology - Prepress digital data exchange - Colour targets for input scanner calibration - Part 1: Colour targets for input scanner calibration

3.2 ISO 12641 - 2: 2016 Graphic technology - Prepress digital data exchange - Part 2: Advanced colour targets for input scanner calibration

3.3 ISO 22028-1:2016 - Photography and graphic technology - Extended colour encodings for digital image storage, manipulation and interchange - Part 1: Architecture and requirements

3.4 ANSI IT8/4-2005 Graphic Technology - Input data for characterization of 4-colour process printing

3.5 IAFIS-DOC-01078-9.3: Electronic Biometric Transmissions Specification

3.6 ASTM E2825-12: Standard Guide for Forensic Image Processing

3.7 ISO 21043-2-2018 Forensic sciences - Part 2- Recognition recording collecting transport and storage of items

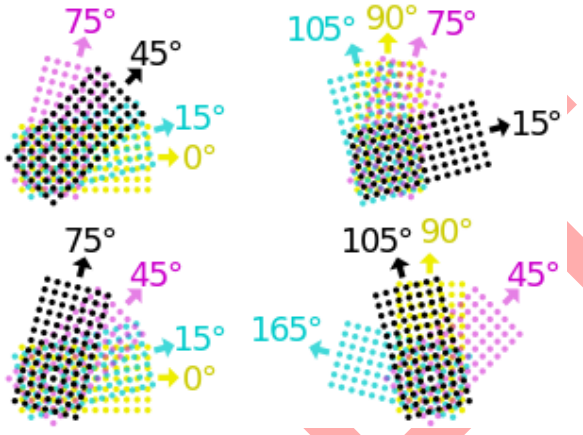
4. **Terminology**

4.1 Definitions*:*

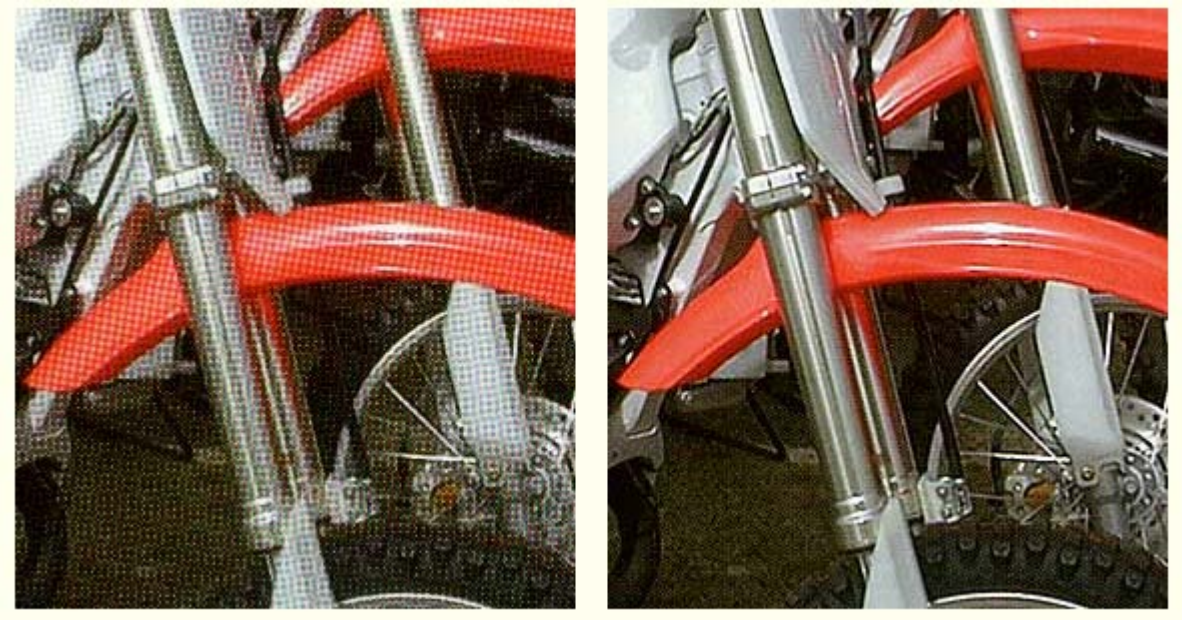
4.1.1 **Color depth:** is the bit scale of the image, e.g. 8 bit grayscale and 24 or 48 bit RGB (Red, Green, Blue).

4.1.2 **CMYK**: is a color gamut spectrum widely used in printing. CMYK stands for Cyan, Magenta, Yellow, and blacK.

4.1.3 **Descreen:** The array of dots used in the halftone or desktop printing processes is called a screen where the color dots are placed at different angles, and a scanning software option can be used to minimize the screen pattern by use of a screen frequency filter algorithm. This filter is called a Descreen option setting.



Examples of screening angles in CMYK printing:



Descreen not used (image magnified) Descreen used (image magnified)

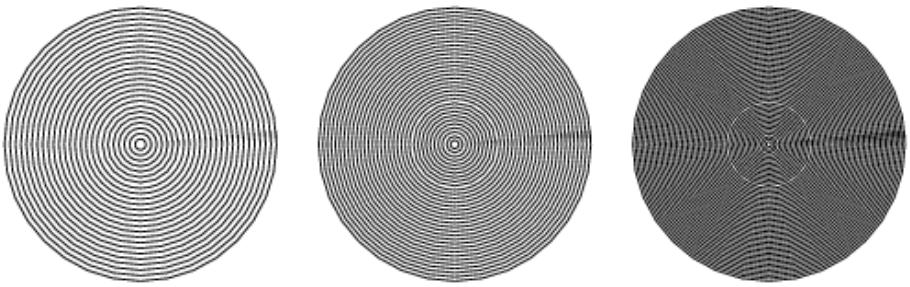
4.1.4 **Dots per inch (DPI)**: In printing, DPI refers to the resolution setting of the printer and resolution capture for printed media. For example, a 1200 DPI resolution printer will deposit a much higher density of ink per inch than a 300 DPI printer. Use of DPI as a resolution term when scanning of printed

media will enable the use of post-scanning descreen software enhancement to more accurately reproduce the original artwork or image.

4.1.5 **Lamina**: A clear/low opacity sheet of film or security designed film that is sealed onto a substrate by cold or hot adhesion.

4.1.6 **Lines per inch (LPI)**. A term in resolution setting in scanner software used for scanning original artwork for printing.

4.1.7 **Moiré**: A moiré pattern occurs when a scene or an object that is being scanned contains repetitive details (such as lines, circles, dots, etc.) that exceed the sensor resolution. As a **result**, many scanners produce a moiré pattern that is not visible in the physical item being scanned.



The illustrations above show a number of concentric circles plotted with a range of uniform spacing. Note the phantom lines and curves that appear. http://mathworld.wolfram.com/MoirePattern.html

4.1.8 **Pixels per inch (PPI)**: Measurements of the pixel density of an electronic image device, such as a computer monitor or camera. For example, a 1200 PPI image will produce a higher quality image than a 300 PPI image. Use of PPI as a resolution term is generally used with digitally captured images (i.e., photography).

4.1.9 **Printed Image:** A printed image is the production of a digital image onto a substrate by a direct or indirect printing process.

4.1.10 **RGB:** is a color gamut spectrum that stands for color channels Red, Green, and Blue. An example of the use of RGB is in the bit depth range where 48-bit refers to 16-bits per color channel, i.e.16 Red, 16 Green, 16 Blue.

4.1.11 **Samples per inch (SPI):** A generic term that can include of DPI, LPI, and PPI. SPI is the measurement of the resolution, in particular the number of individual samples that are taken in the space of one linear inch. Scanner software may not allow for the use of SPI during image capture.

4.1.12 **Substrate:** A substrate in printing terms is a form of media on which a printed image is produced. A substrate, as referred to in this guideline

includes gloss or matte paper, plastic, sensitized material, or polycarbonate.

5. Scanning Overview

5.1 There are various scanning devices (auto-feed, sheet feed, flatbeds), software, physical media type, color calibration targets, calibrated reference target, and processes that can be used to produce a digital facial image from physical media.

5.2 Fingerprint scanners should not be used for scanning color images to avoid:

5.2.1 Having to recalibrate the scanner from a grayscale calibration target for fingerprints to color calibration target for facial images.

5.2.2 Incorrectly scanning a facial image with fingerprint scanner settings, such as scanning in grayscale instead of color.

5.3 To achieve optimal results, the scanner selected should be:

5.3.1 A flatbed device in order to minimize target item movement. Scanners with auto-feed trays should not be considered unless there is a mechanism for securing and flattening an item in situ on the scanning bed.

5.3.2 Calibrated regularly.

5.3.3 Have optional scanner settings, such as descreen turned off to prevent unwanted and unnecessary image processing.

6. Scanner Testing and Calibration

6.1 In assessing whether a scanner is capable of producing good quality images, the following scanner attributes and capabilities should be considered:

6.1.1 Good geometric fidelity (linearity and geometric accuracy)

6.1.2 Sharpness

6.1.3 Detail rendition

6.1.4 Gray-level and color uniformity

6.1.5 Gray-scale and color dynamic range

6.1.6 Low noise characteristics (signal-to-noise ratio)

6.1.7 The output images are true representations of the item being scanned without creating any significant artifacts, anomalies, false detail, or cosmetic image restoration effects.

6.2 In Appendix F of IAFIS-DOC-01078-9.3 there is guidance on the testing parameters and requirements for the following tests for fingerprint scanners that are also applicable for testing color image scanners:

6.3 Linearity

6.4 Geometric accuracy

6.5 Spatial frequency response

6.6 Signal-to-noise ratio

6.6.1 It is important to note that section 2.5 Gray-Level Uniformity of Appendix F in IAFIS-DOC-01078-9.3 is not relevant for testing parameters for color image scanners. For more information on Appendix F of IAFIS-DOC-01078-9.3 see Appendix 2: IQS Appendix F Summary.

6.7 For testing color image scanners, a Color Calibration Target card is the initial step in identifying and managing a scanners capability for color management and output accuracy. As facial images are generally produced in color, the calibration target should incorporate color scales, a gray scale, and a calibrated measurement area. The recommended content of a color calibration target is outlined in ANSI IT8/4-2005[3], which is compliant with ISO standard 12641 parts 1 and 2.[4]

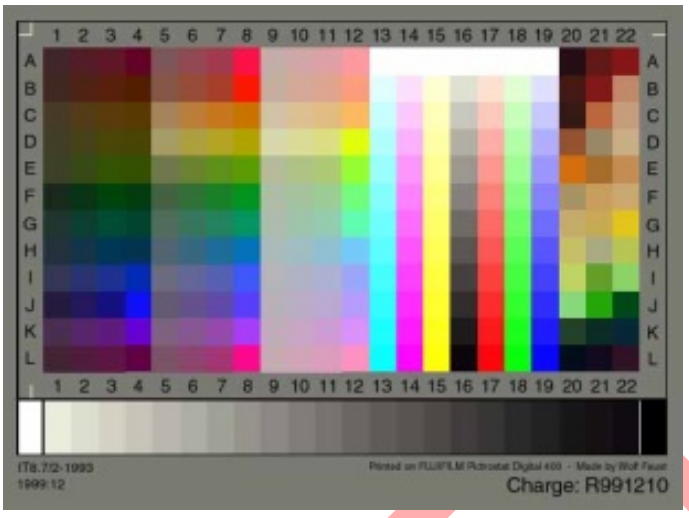
6.8 The minimum testing parameters in an IT8 calibration target card for reflection scanning are:

6.8.1 264 color patches including rows for hue, chroma, and lightness, and columns for RGB and CMYK

6.8.2 24 stepped gray scale

[3] ANSI IT8/4-2005 Graphic Technology - Input data for characterization of 4-colour process printing

[4] ISO 12641 - 1: 2016 Graphic technology - Prepress digital data exchange - Colour targets for input scanner calibration, Part 1: Colour targets for input scanner calibration and Part 2: Advanced colour targets for input scanner calibration



Example of an IT8 calibration target

6.9 Scanner systems may incorporate calibration software and target reference profiles, or have automated calibration, and if not, calibration software can be purchased commercially. Scanner calibration software also typically include measurement targets for the scanner attributes outlined in point 5.2.

6.10 Whilst use of a calibration target card will assist in determining the scanner capabilities and limitations, the target cards can also assist in routinely determining a scanners performance and color management.

7. Scanner Calibration

7.1 Scanner calibration is different to camera calibration in that scanners generally operate with:

7.1.1 Almost constant conditions

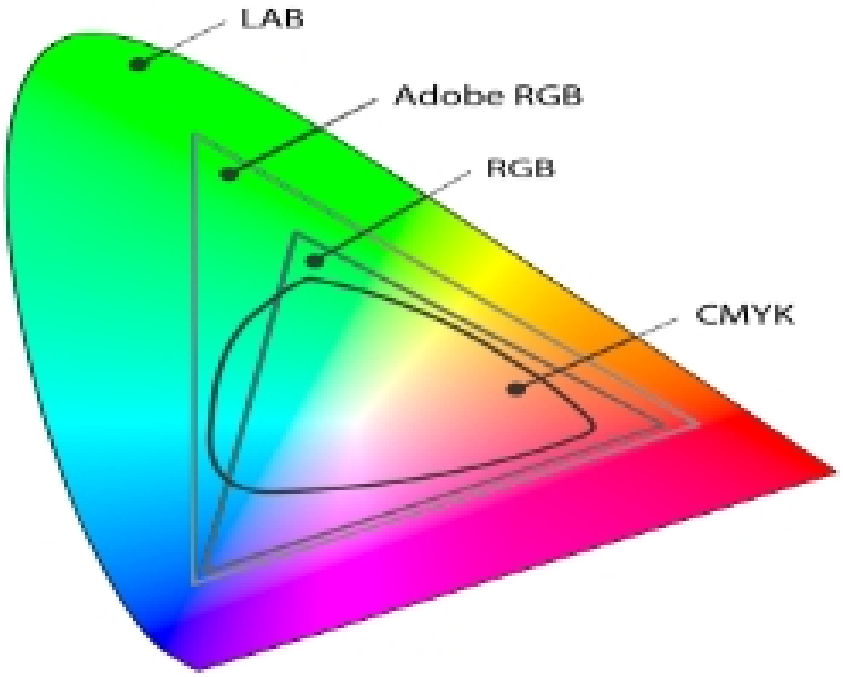
7.1.2 Constant light source

7.1.3 A fixed color temperature

7.1.4 A relatively constant distance between the object and the sensor; as well as absolutes between the object and sensor.

7.2 Depending on the scanning device and calibration software, there may be a choice of different color gamut spectrums such as RGB, CMYK, AdobeRGB, sRGB, etc. for color management or color sync workflow.

7.3 The following image is an example of the differences between color gamut spectrums with LAB being relative to the color spectrum visible by the human eye.



Example of differences between color gamuts

7.4 After running the scanner calibration process, the software will compare the result with the system calibration profile and will either make or suggest recommended corrections.

7.5 A Scanner Calibration Profile will be then be generated, which can be used as an image collection reference for the scanned image. It can also be used for comparative assessment purposes over the life of the scanner, and against other devices where color management or color syncing is required, such as monitors, printers, and imaging software.

7.6 The use of a calibration target and calibration profile will not improve the accuracy of low range scanner products.

7.7 It is essential that in testing the output of scanning products that there is a human assessment of the scanner output for color and image accuracy.

7.8 For more information on scanner calibration and testing see Appendix 1: Scanning Procedures.

8. **Recommended Scanning Process**

8.1 Once it has been determined that the scanner is accurately reproducing the color calibration target card and reference facial image, the scanner can now be used operationally.

8.2 The following scanner settings should be applied for all image capture:

8.2.1 Following scanner adjustment or enhancement options should **not** be selected as any enhancements should occur after scanning:

8.2.1.1 Auto photo orientation

8.2.1.2 Unsharp Mask

8.2.1.3 Descreening (unless print screening angle can be identified)

8.2.1.4 Color Restoration

8.2.1.5 Brightness

8.2.1.6 Contrast

8.2.1.7 Backlight Correction

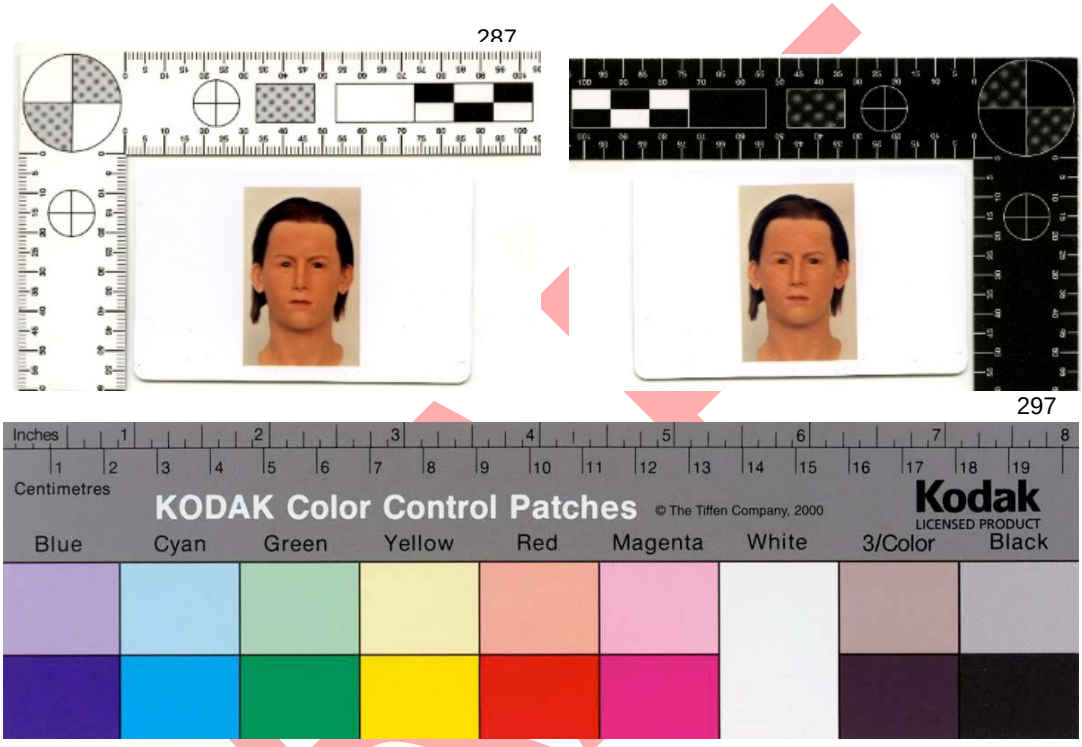
8.2.1.8 Optical Character Recognition, including text enhancement

8.2.2 100% scan with ratio setting 1:1

8.2.3 Lossless output format (TIFF, PNG, etc.)

9. **Calibrated Reference Targets**

9.1 A calibrated reference target (IEEE Standard 167A-1995) includes measurements to accurately reflect the dimensions of the item being scanned. Reference targets should border the item being scanned without encroaching into the area of the item being scanned.



Examples of reference target cards

9.2 In the scanner preview, use the marquee tool or similar to select the target item and the reference target card for scanning. Scanning of the complete item with reference card to create a master image file is generally required for evidentiary purposes and chain of custody requirements.

10. Facial Recognition Minimum Recommended Scanning Resolution Settings

10.1 In addition to the above settings, the minimum recommended scanning practices for Facial Recognition enrollment are:

ITEM TO BE SCANNED	BIT DEPTH MINIMUM	DPI MINIMUM	COLOR CHANNEL
Colored prints	24 bit	300	RGB
Black and White prints	16 bit	300	Grayscale
	24 bit	300	RGB

10.2 If image is to be scanned for the purposes of both Face Recognition and Facial Comparison, it is recommended that the minimum recommended scanning practices for Facial Comparison are used.

11. Facial Comparison Minimum Recommended Scanning Resolution Settings

11.1 To capture images suitable for facial comparison, the following additional scanning practices should be used:

ITEM TO BE SCANNED	BIT DEPTH MINIMUM	DPI MINIMUM	COLOR CHANNEL
Colored prints	24 bit	600 1200 recommended	RGB
Black and White prints	16 bit		Grayscale (May not capture all gray tones)
	24 bit		RGB (Use of RGB enables all gray tones to be captured)

12. Image Recording and Processing

12.1 It is recommended best practice that any image processing occur after scanning.

12.2 There are guidelines and recommended best practices for recording of images and image processing such as:

12.2.1 ISO 21043-1-2018, Part 2 [5]

[5] ISO 21043-2-2018 Forensic sciences - Part 2- Recognition recording collecting transport and storage of items

12.2.2 ASTM E2825-12 [6]

12.2.3 Documents published by the Scientific Working Group Imaging Technology (SWGIT)[7, 8, 9]

12.2.4 The basic image enhancement techniques for facial images after scanning as per SWGIT document Section 11, include:

12.2.4.1 Cropping

12.2.4.2 Brightness and contrast adjustment, including dodging and burning

12.3 Resizing

12.3.1 Image rotation/inversion (normalization)

12.3.2 Color balancing or color correction

12.4 For images to be used for enrollment into Facial Recognition, refer to FISWG Standard Practice/Guide for Image Processing to Improve Automated Facial Recognition Search Performance, which provides information on the recommended image processing techniques and procedural steps for Facial recognition searches.[10]

12.5 Additional image enhancement techniques, using software such as Adobe Photoshop and PaintShop Pro, include but not limited to:

12.5.1 Descreen
http://www.descreen.net/eng/help/descreen/home/descreen_manual.htm

12.5.2 Remove moiré

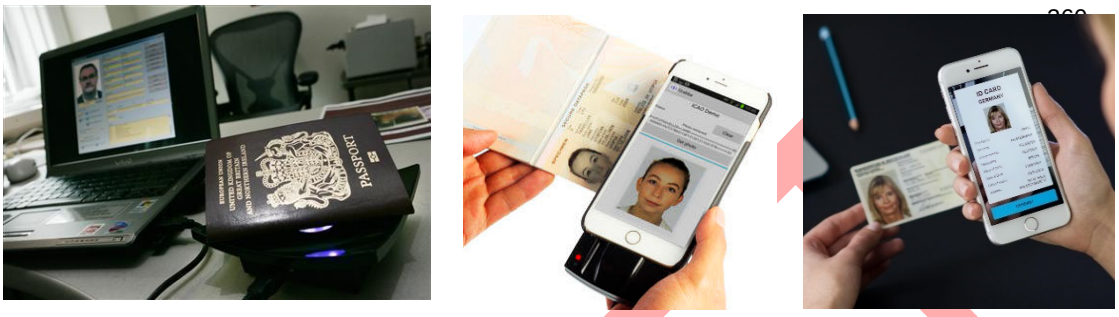
13. Obtaining a Facial Image from an Identity Document

13.1. Identity documents such as passports and identity cards issued since 2005 may contain a chip with details of the document and biometric details such as a digital record of the facial image or fingerprint.

13.2. Where the facial image needs to be captured from the identity document

[6] ASTM E2825-12: Standard Guide for Forensic Image Processing
[7] SWGIT Section 5 Guidelines for Image Processing.pdf
[8] SWGIT Section 11 Best Practices for Documenting Image Enhancement.pdf
[9] SWGIT Section 13 Best Practices for Maintaining the Integrity of Digital Images and Digital Video
[10] FISWG Standard Practice/Guide for Image Processing to Improve Automated Facial Recognition Search Performance

containing a chip, it is highly recommended that the digital image record be extracted from the chip by specialized equipment and software (passport/identity reader or Mobile APP) that is compliant with International Civil Aviation Organization (ICAO) document 9303 Machine Readable Travel Documents.



Examples of Passport/identity reader and Mobile applications

13.3. Where there is no chip within the document or if equipment and software is not available to extract the digital image record, the printed facial image in the security document will need to be scanned.

13.4. The initial step to scanning a printed facial image from a security document is to determine whether there is a security lamina or clear/low opacity film over the facial image.

13.4.1. If there is no lamina/film or if there is only a clear film present, the scanning processes described in section 6 should be undertaken.

13.4.2. If there is a low opacity film present, there is little that can be done to minimize the effects of the film opacity. The scanning processes described in section 6 should be undertaken and the scanning operator may need to consider image processing to mitigate the opacity effect.

13.4.3. If there is a security lamina present, in addition to the scanning processes described in section 6, the insertion of clear plastic film(s) (such as overhead projector sheets) between the glass scanning bed and the document can assist in preventing the diffraction of security feature(s), and will enable a cleaner/more accurate scan of the facial image. If diffractive or moiré patterns appear in the scan and output image, it may be necessary to increase the amount of clear plastic film(s) being used or offset their position. It should be noted that depending on the location of the security features, it may not be possible to totally prevent the security features diffraction from obscuring part of the face.

Appendix 1

Scanning Procedures

The frequency of scanner calibration is dependent on laboratory accreditation requirements, frequency of use, scanner location and maintenance, use of optional settings, and the level of output quality required.

Whilst it is preferable that a scanner is calibrated prior to every scan, it is not always practicable. If a scanner is well maintained, kept dust-free, is installed in a room with regulated temperature, and all pre-scan options such as descreen or unsharp mask are turned off, the scanner may only need yearly calibration or calibrated on a regular basis consistent with laboratory accreditation requirements.

The following steps for scanner calibration describe the basic process:

1. Reset scanner settings to factory default, e.g. all scanner adjustment and enhancement options are de-selected.
2. Clean glass scanning bed/platen with a soft, lint-free cloth and a small amount of fluid using a mixture of 1-part vinegar to 3-parts water, or other agency approved solution.
3. Once glass scanning bed/platen is dry, place IT8 calibration target card on glass scanning bed/platen.
4. Locate scanner software tool for scanner calibration.
5. Run scanner calibration process.
6. Software will automatically generate and update scanner calibration profile.
7. Scan the IT8 target card at 600 DPI with a 100% 1:1 scan ratio to produce an output image for assessment.
8. Compare the scanner output image to the physical IT8 calibration target card to identify whether there are any image quality issues present to determine whether the scanner has been able to accurately reproduce the color, grayscale, brightness/contrast of the content, size, and measurements within the target card.
9. Scan a printed reference facial image at 600 DPI with a 100% 1:1 scan ratio to produce a real-life output image for assessment.
10. Compare the new scanner output image to the physical printed reference facial image to identify whether there are any image quality issues present to determine whether the scanner has been able to accurately reproduce the printed reference.

11. It should be noted that depending on the printing process used to produce the reference facial image, there may appear to be image quality issues, when in fact the scanner has reproduced evidence of the printing process. For example, if the printed reference facial image is produced using a four-color inkjet printer, the output image may have the appearance of pixelation when it is actually the individual color droplets from the inkjet printing visible when the image is viewed at 100%. For more information on potential printing effects in a scanned image, refer to FISWG Guide to the Effects of Printing Methods on Facial Images used for Comparisons.

12. Undertake agency approved image recording procedures and image processing techniques.

The following URL references show examples of commercial solutions for scanner calibration. These are included as references only and not any endorsement of any commercial product for scanner calibration.

- https://www.silverfast.com/PDF/printer_calibration_review_en.pdf
- https://www.silverfast.com/download/docs/SF-IT8-en.pdf
- https://www.silverfast.com/PDF/Epson_V800_long_en.pdf
- https://www.silverfast.com/download/docu/manual,complete_en_2006-11-27.pdf

Appendix 2

IQS Appendix F Summary: As NIST has evolved the Electronic Biometric Transmission Standard (EBTS) they have included guidelines for fingerprint scanners. All sections are extracted from IAFIS-DOC-01078-9.3: Electronic Biometric Transmissions Specification[11]

IQS Appendix F

> These test procedures will be used by the FBI principally for certification of fingerprint systems; they may also be used in acceptance testing and in performance capability demonstrations as an indication of capability to perform. Equipment shall be tested to meet the requirements in normal operating modes, e.g., scanners shall not be tested at slower-than-normal operating speeds in an attempt to meet geometric accuracy specifications. A vendor may recommend alternate testing methods if the test procedures given in this appendix are not applicable or cannot be applied to the particular system under test.[12]

For the purpose of this document, the key section in Appendix F is this: "**they may also be used in acceptance testing and in performance capability demonstrations as an indication of capability to perform**." It is acknowledged that scanning black and white fingerprint images is different than scanning color facial images, the core and basic capabilities of the scanner are still critical to scan a quality resultant facial image.

Scope and Purpose The fingerprint scanner must be capable of producing images that exhibit good geometric fidelity, sharpness, detail rendition, gray-level uniformity, and gray-scale dynamic range, with low noise characteristics. The images must be true representations of the input fingerprints without creating any significant artifacts, anomalies, false detail, or cosmetic image restoration effects.
2.1 Linearity Requirement: When measuring a stepped series of uniform target reflectance patches (e.g., step tablet) that substantially cover the scanner's gray range, the average value of each patch shall be within 7.65 gray-levels of a linear, least squares regression line fitted between target reflectance patch values (independent variable) and scanner output gray-levels (dependent variable).

[11] https://www.fbibiospecs.cjis.gov/Document/Get?fileName=EBTS_v9.1_Final.pdf

[12] https://www.fbibiospecs.cjis.gov/Document/Get?fileName=EBTS_v9.1_Final.pdf

2.2 Geometric Accuracy

Requirement (across-bar):

When scanning a multiple, parallel bar target, in both vertical bar and horizontal bar orientations, the absolute value of the difference between the actual distance across parallel target bars and the corresponding distance measured in the image shall not exceed the following values for at least 99% of the tested cases in each printblock measurement area and in each of the two orthogonal directions.

2.3 Spatial Frequency Response

Requirements:

The spatial frequency response shall be measured using a continuous tone sine wave target denoted as Modulation Transfer Function (MTF) measurement unless the scanner cannot obtain adequate tonal response from this target, in which case a bi-tonal bar target shall be used to measure the spatial frequency response, denoted as Contrast Transfer Function (CTF) measurement. When measuring the sine wave MTF, it shall meet or exceed the minimum modulation values given in Table F-2 in both the detector row and detector column directions and over any region of the scanner‘s field of view. When measuring the bar CTF, it shall meet or exceed the minimum modulation values defined by equation 2-1 or equation 2-2 (whichever applies) in both the detector row and detector column directions and over any region of the scanner‘s field of view. CTF values computed from equations 2-1 and 2-2 for nominal test frequencies are given in Table F-3. None of the MTF or CTF modulation values measured at specification spatial frequencies shall exceed 1.05.

2.4 Signal-to-Noise Ratio

Requirement:

The white signal-to-noise ratio and black signal-to-noise ratio shall each be greater than or equal to 125 in at least 97% of respective cases within each printblock measurement area.

2.5 Gray-Level Uniformity

Requirement – adjacent row, column uniformity:

At least 99% of the average gray-levels between every two adjacent quarter-inch-long rows and 99% between every two adjacent quarter-inch-long columns within each imaged printblock area shall not differ by more than 1.0 gray-levels when scanning a uniform low-reflectance target and shall not differ by more than 2.0 gray-levels when scanning a uniform high-reflectance target.

Requirement – pixel-to-pixel uniformity:

For at least 99.9% of all pixels within every independent 0.25 by 0.25 inch area located within each imaged printblock area, no individual pixel‘s gray-level shall

vary from the average by more than 22.0 gray-levels when scanning a uniform high-reflectance target and shall not vary from the average by more than 8.0 gray-levels when scanning a uniform low-reflectance target.

Requirement – small area uniformity:

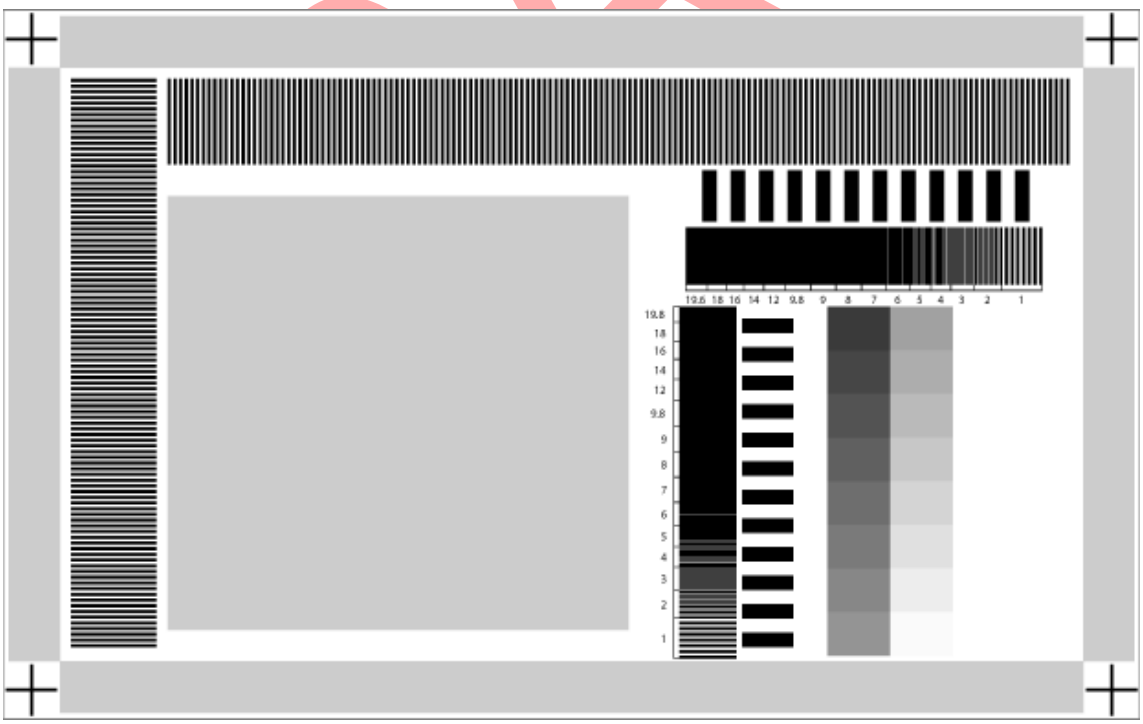
For every two independent 0.25 by 0.25 inch areas located within each imaged printblock area, the average gray-levels of the two areas shall not differ by more than 12 gray-levels when scanning a uniform high-reflectance target and shall not differ by more than 3.0 gray-levels when scanning a uniform low-reflectance target.

All of these tests utilize a specific target which is placed on the scanner after which the specific tests are run on the resultant scanned images:[13]

Catalog Part No: **QA-74-P-RM**

Product Name: **FBI Mitre Scanner Image Quality Test (SIQT) Chart**

Drawing / Photo of part:



The above image is an approximate representation of the actual product.

[13] https://www.appliedimage.com/files/VCX2do/QA-74 FBI Mitre Fingerprint Scanner Test QA-74_spec_v1-04.pdf

Specifications are subject to change without notice.

General Description: This chart is used for evaluation of reflective fingerprint scanners. Test elements contained on this chart can be used for tests as described in, *Test Procedures for Verifying IAFIS Image Quality Requirements for Fingerprint Scanners and Printers.* [13]

Image Description: The test chart includes the following items.

- Sixteen stepped density patches (7 x 11 mm each)
- Resolution bar patterns ranging in frequency from 1.0 to 19.6 cycle per mm, one each in horizontal and vertical orientation
- Reference bars 2.5 x 10 mm (horizontal and vertical, adjacent to resolution groups for geometric accuracy)
- Horizontal and vertical Ronchi patterns (1 cycle per mm for geometric accuracy)
- Mid-scale density patches along each chart-edge (grey areas for uniformity)
- Large mid-scale patch, 75 x 80 mm (grey area for uniformity)

This guideline does not assume that an agency would actually attempt to execute the Appendix F tests, but is included to show the applicability and usage of selecting and using a scanner which has passed Appendix F.

All scanners which have passed Appendix F and been certified by CJIS can be found at: https://www.fbibiospecs.cjis.gov/Certifications