Designation: E2765 – 11

Standard Practice for Use of Image Capture and Storage Technology in Forensic Document Examination[1]

This standard is issued under the fixed designation E2765; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides procedures to be used by forensic document examiners (Guide E444) using image capture and storage technology.

1.2 These procedures are applicable whether the use of the image capture technology involves an item(s) associated with a matter under investigation (questioned or known items), or is for reference.

1.3 These procedures include evaluation of the sufficiency of the available imaging capture and storage technologies.

1.4 Procedures are also outlined for image archiving.

1.5 The particular methods employed in a given case depend upon the nature of the item, or the question at hand, or both.

1.6 This practice might not cover all aspects of the use of image capture and storage technology involving unusual or uncommon items.

1.7 This practice cannot replace the requisite knowledge, skills, or abilities acquired through appropriate education, training (Guide E2388), and experience and should be used in conjunction with sound professional judgment.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E312 Practice for Description and Selection of Conditions for Photographing Specimens Using Analog (Film) Cameras and Digital Still Cameras (DSC)

E444 Guide for Scope of Work of Forensic Document Examiners

E1422 Guide for Test Methods for Forensic Writing Ink Comparison

E1732 Terminology Relating to Forensic Science

E2195 Terminology Relating to the Examination of Questioned Documents

E2388 Guide for Minimum Training Requirements for Forensic Document Examiners

2.2 *SWGIT Documents:*[3]

Section 1 Overview of SWGIT and the Use of Imaging Technology in the Criminal Justice System

Section 2 Considerations for Managers Migrating to Digital Imaging Technology

Section 3 Guidelines for Field Applications of Imaging Technologies in the Criminal Justice System

Section 5 Recommendations and Guidelines for the Use of Digital Image Processing in the Criminal Justice System

Section 8 General Guidelines for Capturing Latent Impressions Using a Digital Camera

Section 11 Best Practices for Documenting Image Enhancement

Section 13 Best Practices for Maintaining the Integrity of Digital Images and Digital Video

Section 15 Best Practices for Archiving Digital and Multimedia Evidence (DME) in the Criminal Justice System

2.3 *SWGIT/SWGDE Documents:*[4]

SWGIT/SWGDE Digital and Multimedia Evidence Glossary

3. Terminology

3.1 For definitions of terms in this Practice, refer to Terminology E1732 and Terminology E2195.

3.2 *Definitions of Terms Specific to This Standard:*

[1] This practice is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.90 on Executive.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Information regarding Scientific Working Group on Imaging Technology (SWGIT) is available from International Association for Identification (IAI), 2535 Pilot Knob Road, Suite 117, Mendota Heights, MN 55120-1120, http://www.theiai.org.

[4] Information regarding Scientific Working Group on Imaging Technology/Scientific Working Group on Digital Evidence (SWGIT/SWGDE) is available from International Association for Identification (IAI), 2535 Pilot Knob Road, Suite 117, Mendota Heights, MN 55120-1120, http://www.theiai.org.

3.2.1 *archive copy, n*—a copy of data placed on media suitable for long-term storage, from which subsequent working copies can be produced. **SWGIT/SWGDE**

3.2.2 *archive image, n*—any image placed on media that is suitable for long-term storage. **SWGIT/SWGDE**

3.2.3 *archiving, n*—the process of storing data in a manner suitable for long-term availability and retrieval. **SWGIT/SWGDE**

3.2.4 *capture, n*—the process of recording data, such as an image, video sequence, or audio stream. **SWGIT/SWGDE**

3.2.5 *capture device, n*—a device used in the recording of data. **SWGIT/SWGDE**

3.2.6 *CD/DVD (compact disc/digital versatile disc), n*—optical disk technology formats designed to function as digital storage media. **SWGIT/SWGDE**

3.2.7 *compression, n*—the process of reducing the size of a data file. (See also **lossless compression** and **lossy compression**.) **SWGIT/SWGDE**

3.2.8 *copy, n*—an accurate reproduction of information. **SWGIT/SWGDE**

3.2.9 *data, n*—information in analog or digital form that can be transmitted, stored, or acted upon. **SWGIT/SWGDE**

3.2.10 *digital image, n*—an image that is represented by discrete numerical values organized in a two-dimensional array; when viewed on a monitor, projected image or printed on paper, it appears similar to a photograph. **SWGIT/SWGDE**

3.2.11 *image, n*—a visually observable counterpart of an object produced by means of imaging technology.

3.2.12 *image, v*—to produce a digital, or analog, observable counterpart of an object by means of imaging technology.

3.2.13 *image averaging, n*—the process of averaging similar images, such as sequential video frames, to reduce noise in stationary scenes. **SWGIT/SWGDE**

3.2.14 *image enhancement, n*—any process intended to improve the visual appearance of an image or specific features within an image. **SWGIT/SWGDE**

3.2.15 *image output, n*—the means by which an image is presented for examination or observation. **SWGIT/SWGDE**

3.2.16 *image processing, n*—any activity that transforms an input image into an output image. **SWGIT/SWGDE**

3.2.17 *image processing log, n*—a record of the steps used in the processing of an image. **SWGIT/SWGDE**

3.2.18 *imaging technology, n*—any system (or method) used to capture, store, process, analyze, transmit, or produce an image. Such systems include film, electronic sensors, cameras, video devices, scanners, printers, computers, etc. **SWGIT/SWGDE**

3.2.19 *intermediate storage, n*—any media, or device, on which data is temporarily stored for transfer to permanent or archival storage. **SWGIT/SWGDE**

3.2.20 *interpolation, n*—a method of image processing whereby one pixel, block, or frame is created, used or stored, based on the differences between the previous and subsequent pixel, block, or frame of information. This is often done to increase the apparent clarity of an image. **SWGIT/SWGDE**

3.2.21 *line pairs per millimetre (LP/mm), n*—a measure of the spatial resolution of an image conversion device. **SWGIT/SWGDE**

3.2.22 *lossless compression, n*—compression in which no data is lost and all data can be retrieved in its original form. **SWGIT/SWGDE**

3.2.23 *lossy compression, n*—compression in which data is lost and cannot be retrieved in its original form. **SWGIT/SWGDE**

3.2.24 *media, n*—objects on which data can be stored. **SWGIT/SWGDE**

3.2.25 *metadata, n*—data, frequently embedded within a file, that describes a file or directory, and which can include the locations where the content is stored, dates and times, application specific information, and permissions. **SWGIT/SWGDE**

3.2.26 *native file format, n*—the original form of a file. **SWGIT/SWGDE**

3.2.26.1 *Discussion*—A file created with one application can often be read by others, but a file's native format remains the format it was given by the application that created it.

3.2.27 *noise, n*—variations or disturbances in brightness or color information in an image that do not arise from the scene. **SWGIT/SWGDE**

3.2.27.1 *Discussion*—Sources of noise include film grain, electronic variations in the input device sensor and circuitry, and stray electromagnetic fields in the signal pathway. It frequently refers to visible artifacts in an image.

3.2.28 *original image, n*—an accurate and complete replica of the primary image, irrespective of media; for film and analog video, the primary image is the original image. **SWGIT/SWGDE**

3.2.29 *primary image, n*—refers to the first instance in which an image is recorded onto any media that is a separate, identifiable object (for example, a digital image recorded on flash media). **SWGIT/SWGDE**

3.2.30 *processed image, n*—any image that has undergone enhancement, restoration or other operation. **SWGIT/SWGDE**

3.2.31 *proprietary file format, n*—any file format that is unique to a specific manufacturer or product. **SWGIT/SWGDE**

3.2.32 *resolution, n*—the act, process, or capability of distinguishing between two separate but adjacent parts or stimuli, such as elements of detail in an image, or similar colors. **SWGIT/SWGDE**

3.2.33 *storage media, n*—any object on which data is preserved. **SWGIT/SWGDE**

3.2.34 *traditional enhancement techniques, n*—digital image processing techniques that have direct counterparts in traditional photographic darkrooms; they include brightness

and contrast adjustment, color balancing, cropping, and dodging and burning. **SWGIT/SWGDE**

3.2.35 *validation, n*—the process of performing a set of experiments, which establishes the efficacy and reliability of a tool, technique or procedure or modification thereof. **SWGIT/SWGDE**

3.2.36 *verification, n*—the process of confirming the accuracy of an item to its original. **SWGIT/SWGDE**

3.2.37 *video, n*—the electronic representation of a sequence of images, depicting either stationary or moving scenes. It may include audio. **SWGIT/SWGDE**

3.2.38 *work copy, n*—a copy (or duplicate) of a recording, or data, that can be used for subsequent processing or analysis, or both. **SWGIT/SWGDE**

4. Significance and Use

4.1 The procedures outlined here are grounded in the generally accepted body of knowledge and experience in the field of forensic document examination, forensic photography, and forensic digital imaging. By following these procedures a forensic document examiner can use image capture technology reliably in support of examinations. This support can include:

4.1.1 Documentation of the item(s) submitted for examination, its condition upon receipt, and its condition at various points during the examination process;

4.1.2 Demonstration of findings and the bases for determinations;

4.1.3 Visualization of features and characteristics not readily perceptible to the human eye.

4.2 The effects of prior storage, handling, testing, or chemical processing (for example, for latent prints) can interfere with certain characteristics to an extent that can limit (or even preclude) subsequent imaging. Whenever possible, capture images of the item to be examined prior to any chemical processing. Handle items appropriately to avoid compromising subsequent examinations of any kind.

4.3 The technological evolution of hardware, or software, or both can impact subsequent ability to access archived images.

NOTE 1—For further discussion see SWGIT, Section 1.

5. Interferences

5.1 Items can have inherent limitations that interfere with the procedures in this practice, such as those due to the condition of the items submitted for examination. Limitations should be noted and documented.

6. Equipment and Requirements

6.1 Image capture device capable of sufficient resolution to reliably record the desired detail.

6.2 Appropriate energy source(s) of sufficient intensity and appropriate spectral energy distribution to allow the desired detail to be distinguished.

6.3 Calibration devices for dimensional, white balance, and exposure determinations.

6.3.1 Appropriate ruler(s) in SI (metric), or IP (inch-pound) units, or both.

6.3.2 Color and neutral gray objects for calibration standards, both reflective and transmitted.

6.4 Image output device(s) (for display or hardcopy production) capable of sufficient resolution and color balance for intended purpose(s).

6.5 Media and appropriate systems for intermediate storage and archiving of images.

6.6 Other apparatus and software as appropriate.

6.7 Sufficient time and facilities to complete all applicable procedures.

7. Procedure

7.1 Perform all applicable procedures. These procedures do not have to be performed in the order given.

7.2 Contemporaneously document the procedures performed in sufficient detail to allow for an independent review and assessment of the images by a forensic document examiner (Guide E444). Include any relevant setting(s) and variable(s).

7.3 At various points in these procedures, an examiner's determination that a particular feature is not present or that an item is lacking in a desired quality can indicate that the procedure(s) involving imaging technology should be discontinued or limited. It is at the discretion of the examiner to discontinue the procedure(s) at that point and report accordingly, or to continue with the applicable procedures to the extent possible. Document the reason(s) for such a decision.

7.4 Calibrate or conduct appropriate performance checks, maintain, and operate equipment in accordance with the manufacturer's(s') recommendations or with a procedure(s) that has undergone validation.

7.4.1 To ensure proper functioning, it can be useful to perform an initial test run, capturing an image of a standardized item that gives known results. Ascertain that the resulting image is acceptable before proceeding; if the test capture is not acceptable when compared to the known capture from the standardized item, make required correction(s) to the equipment or method.

7.5 Conduct an initial assessment of each item to determine the imaging equipment and procedure(s) to be used.

7.5.1 Determine the appropriate image capture device based upon the size and shape of the item, the required resolution and field of view, and any specialized lighting requirement(s).

7.5.1.1 Flatbed scanners can be used for image capture with flat items, such as sheets of paper or photographic prints, and also for three-dimensional objects where a shallow depth of field will suffice.

7.5.1.2 Three-dimensional objects and items needing special lighting set-ups typically require the use of a camera.

7.5.1.3 Infrared imaging requires the use of specialized equipment (Guide E1422).

7.5.1.4 Reflected ultraviolet imaging requires the use of specialized equipment (Guide E1422).

7.5.2 Whenever possible, remove item(s) from protective packaging, as images captured without intervening packaging are preferable.

7.6 Capture images that are accurate representations of the item and that record the desired, or needed, detail.

7.6.1 Capture images at an optical (not interpolated) resolution and a pixel depth necessary to reproduce the desired detail of interest on the output device(s) used for evaluation or observation.

7.6.2 For digital technology, capture images that can be reproduced at a life size (1:1 scale) with a minimum resolution of 300 pixels per inch and 8-bit grayscale. Some items can require higher resolution, or the use of color (24-bit minimum), or both. Higher desired reproduction ratios generally require higher pixel density. As stated above, do not use interpolation to achieve the required resolution.

NOTE 2—Procedures for calibration of lens and camera to achieve a specific resolution are discussed in SWGIT, Section 8.

NOTE 3—The quality of the optics (lens or lenses) used to focus the image on the sensor plays an extremely important role and can greatly limit the overall resolution of the system. For a camera to capture images at reproduction ratios in the close-focus or macro range (roughly 1:5 to 1:1), a lens with macro capabilities is required. The use of a supplemental lens(es) is not, generally, recommended. A single focal length macro lens is, generally, considered preferable to a zoom lens.

7.6.3 For silver halide technology, use a film and lens combination to capture detailed images of the feature(s) of interest. This may require making several images at increasingly higher magnification.

7.6.4 Establish the reproduction ratio through appropriate documentation.

7.6.4.1 When using a camera, include a scale in each image. If the chosen level of magnification reduces the field of view to the point that there is not enough room to include a non-infringing scale, it is suggested that several same magnification images be made, one including an infringing scale and one without a scale.

7.6.4.2 For three dimensional objects, support the scale in the plane of the feature(s) of greatest interest. A flexible scale can be useful on a curved surface.

7.6.4.3 When using a flatbed scanner, a scale in at least one image for a given set-up can suffice.

7.6.5 When using a camera, mount the camera on a rigid copy stand or tripod. Position the subject so the plane of the area of interest is parallel to the plane of the sensor (electronic detector or film).

7.6.6 Establish the color balance (or white balance) of the image through appropriate documentation.

7.6.6.1 Where the lighting conditions can change (for example, with a camera), include a color chart or neutral standard in at least one image for a given set-up, or reset the white balance as appropriate.

7.6.6.2 Where the lighting conditions do not change (for example, with a scanner), calibration or appropriate performance checks of the equipment can suffice.

7.6.7 Select the appropriate lighting or filters, or both, to accurately capture the features of interest.

7.6.7.1 Lighting arrangements that have been found to be useful include diffuse or flat, transmitted, modeling, side, axial or specular, and polarized.

7.6.7.2 Filters can emphasize or eliminate certain colors and can be used to differentiate colors that can appear similar (for example, ink differentiation with dichroic filters in accordance with Guide E1422). Images captured with filters can be enhanced by other techniques.

7.6.8 Capture analog video camera images (for example, from infrared viewing systems) by using video tape, or by digitization, or by printing.

7.6.9 Record the appropriate information relevant to the capture of the image, such as the item being imaged, reproduction ratio (image magnification), date of imaging, image capture equipment, exposure settings, resolution, and lighting through appropriate documentation. This information can be in the metadata generated with or as part of the image itself, such as images of scales, color charts, or labels, which are also considered a form of metadata.

NOTE 4—For further discussion see E312 and SWGIT, Section 2 and Section 3.

7.7 Perform necessary initial processing and storage procedures to the captured image to accurately represent the item and its fine detail and to preserve the image.

7.7.1 For silver halide technology, develop and maintain negatives or transparencies according to the manufacturer's specifications or according to a procedure(s) that has undergone validation.

7.7.2 For digital technology, save all original images in their native file format without processing, other than that inherent in the original creation of the file (such as camera or scanner settings). All processing shall be done only on working copies.

7.7.2.1 Copy the primary images captured on intermediate storage media (for example, flash media, micro-disk, etc.) to the appropriate media to create an archive copy.

7.7.2.2 Uncompressed, or lossless compression, file formats (for example, RAW, TIFF, or BMP) are recommended for these archives. Lossy compression file formats (for example, JPEG) are not recommended.

NOTE 5—Some cameras capture images only in high quality JPEG format. Archive these images as what they are (JPEG files) and also convert to working files that use lossless compression. It is preferable to capture images that are intended for comparative or analytical purposes using uncompressed formats; however, lossy compressed formats like JPEG may be used if the examiner determines that sufficient detail is present in the image for such use.

7.7.2.3 If the image is captured in a proprietary format, or in RAW format, the image should also be saved in a common uncompressed format. A digital camera's RAW format is generally a proprietary file format and might not be supported by all software programs.

7.7.2.4 Preserve any metadata generated with or as part of the image itself, including, images of scales, color charts, or labels.

7.7.2.5 Use a systematic method to identify negatives or named digital image files for filing/archiving purposes so that they can be easily located at a later date. An imaging database can be used for this purpose.

7.8 Perform verification by visual inspection to determine that the captured image accurately represents the item and its fine detail. If the image is not verified, go back to 7.5.

7.9 If necessary, utilize standard and acceptable image processing techniques to accurately visualize features, characteristics, or fine detail.

7.9.1 For silver halide technology, image enhancement is generally done in a darkroom when processing the film or making a print from a negative, or both.

7.9.2 For digital technology, image enhancement is done using only a work copy of the original image.

7.9.3 Basic image enhancement can take the form of traditional enhancement techniques such as resizing (file interpolation); positive to negative inversion; image rotation/inversion; conversion to grayscale; white balance adjustments (color balancing; or color correction, density and contrast adjustments), basic image sharpening and blurring (pixel averaging); and file format conversion.

7.9.4 Advanced image enhancement can take the form of image averaging; Fourier analysis (including the use of fast Fourier transform); deblur; noise reduction; image restoration; color channel selection and subtraction; perspective control,or geometric correction, or both; and advanced sharpening tools, such as unsharp mask.

7.9.5 Make and retain an image processing log, recording information relevant to the enhancement of the image in sufficient detail to allow meaningful review and assessment of the results and permit replication of the processing by another person competent in the field. For certain basic image enhancements, comparison with the primary image may suffice.

NOTE 6—For further discussion see SWGIT, Section 5 and Section 11.

7.9.6 Save the final enhanced image in a lossless file format. Intermediate work copy processed images do not have to be saved unless they demonstrate an intricate process.

7.10 Archive the final processed image and any work copies intended for long-term storage (see 7.6.2).

7.10.1 For silver halide technology, photographic plates, films, and photographic prints have been shown to be appropriate media for archiving purposes, provided they are developed and stored according to industry standards.

7.10.2 For digital technology, there are many types of suitable media. These include optical media (including CD/DVD), magnetic tape, and hard disk drive systems, such as servers or RAID arrays.

7.10.2.1 If optical media is used for storage, it should be specifically designed for archival purposes, and maintaining multiple copies is recommended. Re-writable optical media is not suitable for archiving.

7.10.2.2 Hard disk drive systems should be backed up using an appropriate industry standard method.

7.10.3 Maintain the accessibility and integrity of archived images. Steps should be taken to ensure the operability of hardware and the serviceability of the media by periodically testing, refreshing, and migrating data as required. It is suggested that on-site and off-site back-ups be performed.

NOTE 7—For further discussion see SWGIT, Section 13 and Section 15.

7.11 Produce image output that accurately presents the image.

7.11.1 Image output can involve an image display device (for example, a monitor or a projector) or a hardcopy print.

7.11.2 Differences in presentation methods can limit or enhance the perceived resolution.

8. Keywords

8.1 image enhancement; imaging; forensic document examination; forensic sciences