Standard Guide for Latent Print Evidence Imaging Resolution

Video/Imaging Technology & Analysis Subcommittee
Digital/Multimedia Scientific Area Committee
Organization of Scientific Area Committees (OSAC) for Forensic Science

OSAC Proposed Standard

Standard Guide for Latent Print Evidence Imaging Resolution

Prepared by
Video/Imaging Technology & Analysis Subcommittee
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Disclaimer:

This document has been developed by the Video/Imaging Technology & Analysis Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science through a consensus process and is *proposed* for further development through a Standard Developing Organization (SDO). This document is being made available so that the forensic science community and interested parties can consider the recommendations of the OSAC pertaining to applicable forensic science practices. The document was developed with input from experts in a broad array of forensic science disciplines as well as scientific research, measurement science, statistics, law, and policy.

This document has not been published by an SDO. Its contents are subject to change during the standards development process. All interested groups or individuals are strongly encouraged to submit comments on this proposed document during the open comment period administered by ASTM International (www.astm.org).

Ballot Rationale: The purpose of this document is to update the relevant SWGIT standard practice documents related to the resolution needed to capture third level latent print details.

Standard Guide for Latent Print Evidence Imaging Resolution

1. Scope

1.1. This guide provides procedures for verifying that digital cameras and scanners can capture the necessary details in images of latent print evidence

1.2. The scope of this document is to provide recommendations on the resolving power that enables recording of level 3 details of latent print evidence that are suitable for comparison purposes using a digital camera, a flatbed scanner, or other image capture device. These recommendations take into consideration the minimum resolution requirements for utilizing the photographs for comparison.

1.3. Certain commercial equipment, instruments, or materials are used in this document as representative examples to more clearly explain the procedures. Such use does not imply a recommendation or endorsement.

1.4. 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 Standard Terminology for Digital and Multimedia Evidence Examination E2916-13.

2.2. I Digital Photo Dictionary, www.idigitalphoto.com/dictionary/optical_resolution, accessed 3/22/2018.

2.3. "National Institute of Standards and Technology (NIST) Special Publication 500-271 ANSI/NIST-ITL-2007".

2.4. Photo Review Magazine and Website "Digital Imaging Glossary".

2.5. Popular Photography Editors. The Complete Photo Manual, 2017.

2.6. Robinson, Edward M. Crime Scene Photography, 3rd ed. 2016.

2.7. "SWGDE/SWGIT Digital & Multimedia Evidence Glossary".

2.8. The SWGFAST document "Standard for Friction Ridge Digital Imaging (Latent/Tenprint)".

2.9. SWGIT document "Section 8 - General Guidelines for Capturing Latent Impressions Using a Digital Camera".

2.10. SWGIT document "Section 19 - Issues Relating to Digital Image Compression and File Formats".

2.11. SWGIT document "Section 21 - Procedure for Testing Scanner Resolution for Latent Print Imaging".

2.12. SWGIT document "Section 22 - Procedure for Testing Digital Camera System Resolution for Latent Print Photography".

2.13. US Government. Federal Agencies Digital Guidelines Initiative Glossary, www.digitizationguidelines.gov, accessed 3/22/2018.

3. Terminology

3.1. Definitions

3.1.1. **achievable resolution, resolving power,** n—the measure of imaging system's practical limit to distinguish between separate adjacent elements, typically by imaging a known reference standard. [ASTM E2916 − 13].

3.1.2. **bit depth,** n—the number of bits (binary digits) used to specify the brightness or color range of each pixel in an image sensor.
[Photo Review Magazine Digital Imaging Glossary]

3.1.3. **Dmax**, n-An abbreviation for maximum density. The abbreviation is used in describing both the characteristics of an image and/or an imaging device such as a scanner. [Federal Agencies Digital Guidelines Initiative Glossary]

3.1.4. **dynamic range**, n—the difference between the brightest highlight and darkest value that a sensor can detect and record in a single image. [ASTM E2916 − 13]

3.1.5. **focal length,** n—the distance from the optical center of a lens to its point of focus at the sensor or image plane when focused at infinity. [ASTM E2916 − 13].

3.1.6. **lossless compression,** n—a data reduction process that is completely reversible, such that all of the original data can be retrieved in its original form. [ASTM E2916 − 13].

3.1.7. **lossy compressio**n, n—a data reduction process that is not completely reversible, and some original data is irretrievably lost. [ASTM E2916 − 13].

3.1.8. **machine resolution, optical resolution,** n—a nominal resolution specification for a flatbed scanner based on the actual number of pixels per inch in the sensor array and the number of individual steps per inch that the stepper motor can move the sensor array. This is to be distinguished from the maximum resolution specification that is based on resampling. ~~This is also called optical resolution.~~ [I Digital Photo Dictionary]

3.1.9. **nominal resolution,** n—the number of horizontal and vertical pixels an imaging system or sensor is capable of capturing. [ASTM E2916 − 13].

3.1.10. **normal lens,** n—a lens designed to approximate the field of view of the human eye without magnification or reduction. [ASTM E2916 − 13].

3.1.11. **quadripod,** n—a generic term for a four-legged camera support. [SWGDE]

3.1.12. **resizing,** v—changing the size of an image by changing the number of pixels per unit of measurement without adding or subtracting any pixels from the image.

3.1.13. **resampling,** v—changing the size and/or resolution of the image by adding or subtracting pixels through interpolation. [Crime Scene Photography, 2nd ed.]

3.1.14. **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 [SWGDE/SWGIT - Taken from the Encyclopedia of Photography, 3rd Edition].

3.1.15. **resolving power,** see achievable resolution. [ASTM E2916 − 13].

3.1.16. **tri-linear array,** n—the sensor in a flatbed scanner, or digital scanning back, which is made up of three rows of pixels with a red filter covering one row, a green filter covering the second row and a blue filter covering the third row. [Federal Agencies Digital Guidelines Initiative Glossary]

4. Summary of Practice

4.1. Select Photographic Equipment

4.2. Create a Photographic Procedure Manual

4.3. Verify the Resolving Power of Digital Cameras Used to Photograph Latent Print Evidence

4.4. Verify the Resolving Power of Scanners Used to Scan Latent Print Evidence

5. Significance and Use

5.1. The procedure described in this document is in accordance with current SWGFAST guidelines [Standard for Friction Ridge Digital Imaging (Latent/Tenprint)[1]], as well as National Institute of Standards and Technology (NIST) standard (NIST SPECIAL PUBLICATION 500-271, ANSI/NIST-ITL 1-2007[2]), which specify 1000 pixels per inch (ppi) at 1:1 as the minimum nominal scanning resolution for latent print evidence. This standard appears primarily to be historical and directed towards scanners, rather than cameras, though recent studies suggest that it is suitable for capturing level 3 detail[3].

5.2. While the 1000 ppi resolution standard permits the capture of level three detail in latent prints, it does not mean that any image recorded at a lower resolution would necessarily be of no value for comparison purposes. However, there are some latent print impressions that are so degraded or contain such limited quantity of information that at least 1000 ppi resolution is required to conduct an accurate examination. Some automated fingerprint identification systems require 1000 ppi for submission purposes. The relationship between nominal resolution and achievable resolution (sometimes called "resolving power") can vary greatly by manufacturer.[4]

6. Recommended Photographic Equipment

6.1. A digital camera system with the following specifications

6.1.1. A full frame, or larger, sensor is suggested because it will usually have less image noise as compared to smaller sensors.

6.1.2. Interchangeable lenses.

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[1] www.swgfast.org/standard_for_friction_ridge_digital_imaging_1.0.pdf Accessed January 12, 2010.
[2] http://fingerprint.nist.gov/standard/ Accessed January 12, 2010.
[3] Patrick Wagner Purchase of a film scanner, tips and purchase criteria http://www.filmscanner.info/en/FilmscannerKauf.html last accessed 11 Jan 2011.
[4] Patrick Wagner Purchase of a film scanner, tips and purchase criteria http://www.filmscanner.info/en/FilmscannerKauf.html last accessed 11 Jan 2011.

6.1.2.1. A normal fixed focal length, or longer, macro lens is preferred. Listed below are two common examples of normal focal length lenses for different size camera sensors.

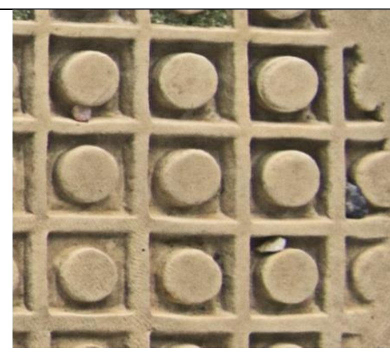
- For a full frame sensor, the normal focal lens is 40mm to 60mm.
- For an APS-C/H sensor, the normal focal lens is 35mm to 45mm.

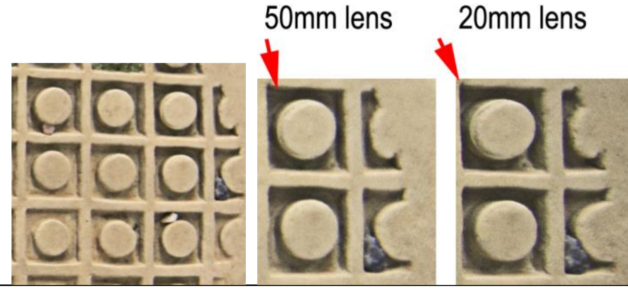
6.1.2.2. A macro zoom lens set to approximately the normal focal length, or longer, based on the size of the camera sensor is acceptable.

6.1.2.3. Optional: a normal, or longer, focal length pc (perspective control) macro lens.

6.1.2.4. Additional Lens Considerations

- When capturing images for comparative analysis, it is important to minimize distortion and obtain the correct perspective. In general, normal focal length prime lenses have less optical distortion as compared to zoom lenses.
- The photographs of the bottom of a shoe illustrate the problems of using a wide angle lens as compared to using a normal focal length lens and filling the frame. The photographs were taken with a 20mm and 50mm lens on a DSLR with a full frame sensor (see figures 1 to 4).

	
Figure 1. This shoe was photographed with a 20mm wide angle lens on a full frame DSLR. The most obvious problem is the distortion that can be seen in the straight horizontal part of the ruler that is recorded as being curved.	Figure 2. This is an enlargement of the heal of the shoe. If you look carefully you will see that the left sides of the cylinders are visible because the camera is too close to the shoe when filling the frame with a wide angle lens.

	
Figure 3. This shoe was photographed with a 50mm normal focal length lens on a full frame DSLR. Notice that with a 50mm lens the straight edge of the ruler is straight in the photograph. With a 50mm lens you will be farther away from the shoe when filling the frame as compared to a 20mm wide-angle lens. Since the close-up range of most point and shoot cameras is in the wide-angle range of their zoom settings, this is one of many reasons why a point and shoot camera should not be used for this type of photography.	Figure 4. On the left and center are enlargements of the photograph taken with a 50mm lens of the heal of the shoe. If you look carefully you will see that the sides of the cylinders (center enlargement) are not visible because the camera is far enough from the shoe when filling the frame with a normal focal length lens to have the flat perspective that is more accurate for comparison purposes. Compare the center enlargement with the right enlargement and observe that when the camera was moved closer to the shoe to fill the frame with a 20mm lens that part of the side of the cylinder is visible.

6.1.3. Manual and aperture priority exposure modes.

6.1.4. Auto and manual focus.

6.1.5. Remote shutter release port or self-timer.

6.1.6. Choice of file format in order of preference

6.1.6.1. RAW file format at a maximum bit depth or RAW + JPEG

6.1.6.2. Uncompressed or lossless compressed image file format such as TIFF

6.1.6.3. If RAW and TIFF are not available, use the highest quality JPEG settings.

6.2. Point and shoot and cell phone cameras are not recommended for taking photographs intended for comparative analysis purposes for several reasons, some of which include, but are not limited to:

6.2.1. The lenses are usually not as well corrected for distortion.

6.2.2. The macro range is usually in the wide-angle zoom range.

6.3. Spare batteries for any camera using removable batteries.

6.4. Appropriate light sources (e.g. floodlights, flashlights, LASER and/or Alternate Light Sources [ALS]).

6.5. Photographic filters.

6.6. Remote shutter release.

6.7. Sturdy copy stand, tripod or other study camera support.

6.8. Flat rulers using standard units of measure which are traceable to a NIST or other national metrological institute standard [see ISO 17025/17020, policy for measurement of uncertainty].

6.9. Level.

6.10. Spare camera memory cards and card storage cases for empty and used camera cards, unless tethered to a computer.

6.11. Lens cleaner and lens cleaning tissue.

6.12. Photographic log/notes.

6.13. Photo labels/ tags

6.14. Computer with appropriate software.

6.15. Camera card reader.

6.16. Archival storage device.

6.17. A magnifier.

6.18. For camera resolution testing, an opaque and/or a transparent resolution test target with resolution bars within the range of 9.8 to 13 cycles per millimeter (c/mm), which is also, call line pairs per millimeter (lp/mm). Resolution targets shall be calibrated by an accredited calibration provider traceable to NIST or equivalent Metrology Institute.

6.19. A flatbed scanner either from the FBI Certified Biometric Products List or with the following specifications:

6.19.1. A preferred machine resolution of 2400 ppi1200 minimum.

6.19.2. A reflected document size of at least 8.5 X 11 inches.

6.19.3. A minimum Dmax rating of 4.0.

6.19.4. A transmitted light (transparency) adapter of at least 4 X 5 inches. 8 X 10 inches is preferred.

6.20. For the flatbed scanner higher resolution targets should be needed to determine at what point increasing the nominal resolution setting only increases the file size, without any increase in achievable resolution. Targets with resolution bars up to 100 lp/mm should be adequate for this task. These higher resolution targets should require the use of a low power microscope to visually verify the line pairs.

Resolution targets shall be certified traceable to NIST or equivalent Metrology Institute.

7. Recommended Protocol for Verifying the Resolving Power of Digital Cameras Used to Photograph Latent Print Evidence.

7.1. As with scanners, camera systems also rarely achieve nominal resolution in practice. One recent study showed that high-resolution black-and-white TMAX film with a nominal resolution of 34.56 megapixels using a stabilized professional camera under studio conditions was able to achieve a pixel-equivalent resolution of 13.75 megapixels.[5]

7.2. There is a dearth of peer reviewed literature comparing nominal and achieved resolution, but the achieved resolution can be approximated. Jain has demonstrated that sampling at a nominal 1000 ppi can provide level three details.[6] Zhang, et al. has similar results.[7] By application of the Nyquist theorem, a 1000 ppi nominal resolution can theoretically achieve a maximum resolution of 500 line pairs. In practice, as noted elsewhere, Nyquist sampling is inadequate; and three to four samples are required instead of two, resulting in resolution between 250 to 330 line pairs per inch, or 9.8 to 13 cycles per mm.

7.3. **Camera Resolution Testing**

7.3.1. This step defines the largest area that can be photographed and still meet the nominal 1,000 ppi resolution standard at an achievable resolution that is adequate to record 3rd level details in a latent print. If the area covered by the latent print evidence and a ruler is smaller than the determined value, the photograph should be taken filling the frame with the latent print evidence and ruler (see figures 5 to 7).

[5] Herbert Blitzer, Karen Stein-Fergusen, Jeffrey Huang. Understanding Forensic Digital Imaging. Academic Press. 2008 Chapter 17, p 320.

[6] Jain, A.K., Chen, Y., and Demirkus, M. Pores and Ridges: High-Resolution Fingerprint Matching Using Level 3 Features. IEEE Trans. PAMI 29 (1): 15-27, 2007.

[7] Zhang D, Liu F, Shao Q., Lu G, Luo N. Selecting a reference high resolution for fingerprint recognition using minutiae and pores. IEEE Trans Instrument. Meas. 2010 99:1-9

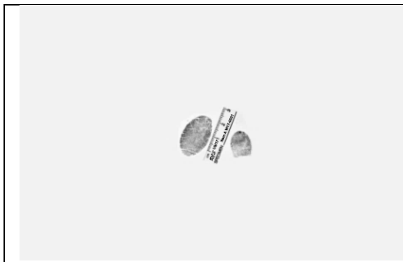


Figure 5. This is not filling the frame.	Figure 6. Many persons mistake filling the short dimension of the viewfinder with the long dimension of the short dimension of the viewfinder.	Figure 7. Filling the long dimension of the viewfinder with the long dimension of the latent print and ruler.

7.3.2. Determine the maximum field of view in which a minimum nominal resolution of 1000 ppi should be achieved for each camera and lens combination to be used to photograph latent print evidence.

7.3.2.1. Determine the effective pixel dimensions of the camera’s sensor as stated by the manufacturer. This can usually be found in an image size setting in the camera menu. For this example a Nikon D810 using a full frame lens (FX or 35mm film camera lens) and the full sensor this would be 7360 X 4912 pixels. However with some full frame sensor cameras such as Nikon, you should have to also determine the smaller pixel dimensions that the camera should default to whenever a lens designed for a smaller sensor (DX lens) is attached to the camera. For a Nikon D810 using a DX lens this would be 4800 X 3200 pixels. This additional resolving power testing also applies only if the camera is to be set to a lower resolution setting.

7.3.2.2. To determine the largest area that can be photographed at a nominal resolution of 1000 ppi, divide each pixel dimension of the digital camera’s sensor by 1000 ppi. Using the full sensor in a Nikon D810 this would equal 7.36 X 4.912 inches. This makes the maximum field of view approximately 7.35 inches x 4.9 inches. If you are using a metric scale, multiply inches by 25.4 to convert inches to millimeters (approximately 187 mm X 124 mm see figure 8).

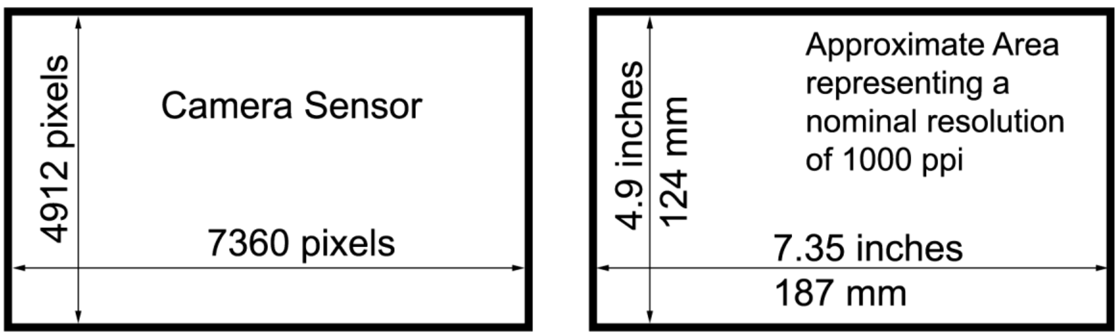


Figure 8. The diagram on the left shows the pixel dimensions of the full frame sensor of a Nikon D810 that was used as a representative sample. The diagram on the right shows the approximate area that represents a nominal resolution of 1000 ppi with the camera set to an image size of 4912 X 7360 pixels.

7.3.2.3. Not all camera optical viewfinders cover 100% of the capture area. Take a test image of a template drawn on a sheet of graph paper lined in tenths of an inch to determine coverage of the optical viewfinder. If the camera has a live view capability, compare the optical viewfinder field of view with both the live view field of view and the captured image.

7.3.2.4. Make a template on precision graph paper to outline the maximum area that can be photographed at the 1,000 ppi nominal resolution standard (see figure 9).

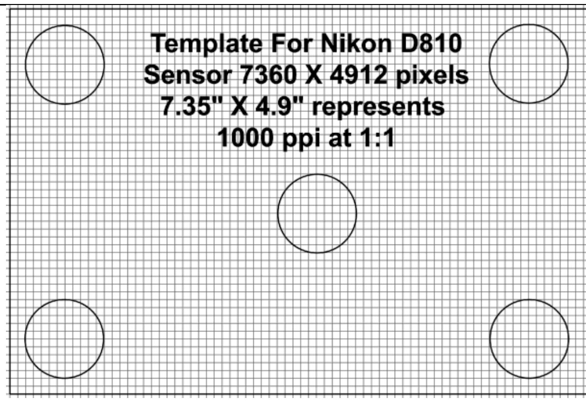


Figure 9. The graph paper was photographed with the black lines at the edge of the optical viewfinder. The area approximately 0.05 inches outside of the optical viewfinder was included in the image but not visible in the viewfinder. However, this area was visible in live view. For the resolving power samples used in this document, the resolution test target was photographed at this magnification. Using precision graph paper also makes it easier to determine if the lens has excessive barrel or pincushion distortion and if the distortion can be corrected in software. The five circles were added to demonstrate how well curved details are reproduced.

7.3.2.5. Place the template on a flat surface.

7.3.2.6. Mount the camera on a tripod or copy stand above the flat surface on which the template rests. Ensure the camera focal plane is parallel with the template.

7.3.2.7. If using a fixed focal length lens, proceed to step 8.2.2.8. If using a zoom lens, proceed to step 8.2.2.9.

7.3.2.8. While looking through the viewfinder, adjust the height of the camera to fill the frame with the template, while keeping the image in sharp focus with the camera set to manual focus and manual exposure. If focus cannot be accomplished for this lens, then the 1000 ppi standard cannot be met and a different lens shall be used. Otherwise, go to step 8.2.2.10.

7.3.2.9. When using a zoom lens, repeat step 8.2.2.8 for each of the zoom settings that will be used for photographing latent prints. This will result in different camera heights for different zoom settings. If focus cannot be accomplished for some zoom settings, then the 1000 ppi standard cannot be met for those settings. If focus cannot be accomplished for this lens at all, then the 1000 ppi standard cannot be met and a different lens shall be used. Otherwise, go to step 8.2.2.10.

7.3.2.10. Using a fixed reference point on the camera body, record the height determined in step 8.2.2.8 or 8.2.2.9. This height is the maximum camera-to-subject distance to provide 1000 ppi resolution. In this example, when the macro zoom lens was set to 50mm, the distance from the top of the camera body strap eyelet was 12.75 inches. When the macro zoom lens was set to 105mm, the distance from the top of the camera body strap eyelet was 19.5 inches.

7.3.2.11. The camera setup is ready to replace the template with the resolution test target that is calibrated to a to NIST or equivalent Metrology Institute Standard. For the example in this document an ultra-high resolution T-90 test target was used that ~~is~~ has one set of the group 2 resolution bars certified traceable to a NIST standard (see figures 6 and 7). This test target has line pairs printed in only one direction. Any standard resolution test target that has printed line pairs in the 9.8-13 cycles per mm range can be used for this resolution test. The test target shall initially include a certificate from the manufacturer or a 3rd party what the accuracy of at least one of the relevant resolution bars and that this certification was traceable to a NIST or other relevant national standard. Be aware that this certification will require an additional substantial fee per set of resolution bars. Examples of test targets that are known to meet these requirements, in addition to the T-90 target, include but are not limited to: NBS 1963A Resolution Target (NSM 1010A), 1951 USAF Resolution Test Chart and the FBI Mitre Scanner Image Quality Test (SIQT) Chart. NOTE: That although all the F-stops were tested for this example, only the F-stop settings that you use for photographing latent prints need to be tested.

7.3.2.12. Visually verify that you can clearly see the 15 lines and 14 spaces on the 12.5 c/mm section of the T-90 ultra high resolution target (see figures 10 and 11) before using the test target.

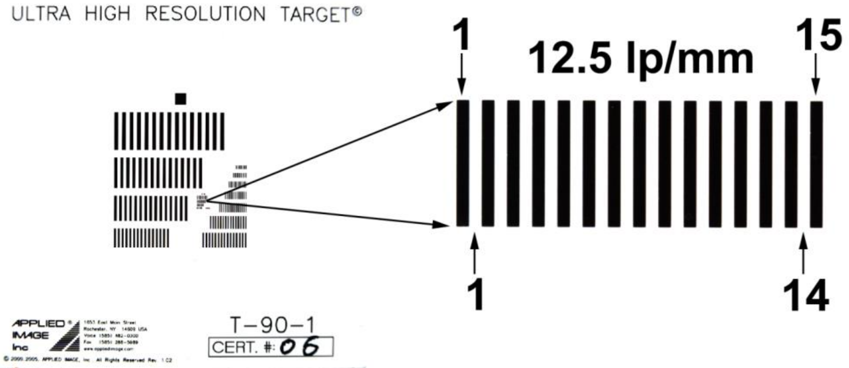


Figure 10. On the left above is a T-90 ultra high resolution target. One set of the group 2 resolution bars in the target was calibrated using an Filar (Ai-209) method of measurement that was traceable to NIST and documented on Linear Dimensions Certificate Number 6. Before using the T-90 test target, use a magnifier to visually verity that you can clearly see the 15 lines and 14 spaces on the 12.5 lp/mm (c/mm) section in group 2.

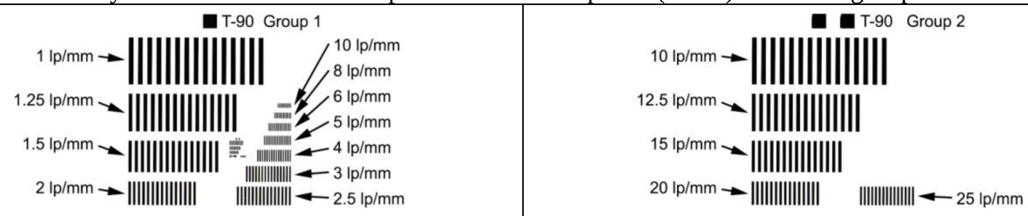


Figure 11. On the left side of the above figure shows the number of lp/mm in Group 1 on a T-90 ultra high resolution target printed on white card stock. On the right side of the above figure shows the number of lp/mm in Group 2 on a T-90 ultra high resolution target printed on white card stock. It is recommended that you use a resolution target that is certified to have at least one set of line pairs was measured with a calibrated measurement device that is traceable back to a NIST standard.

7.3.2.13. Place the test chart on flat surface below camera so the test bars are in a vertical orientation (see Figure 12). The camera back shall be parallel to this surface. You should also want to include a latent or inked print with visible third level details next to the test chart (see figure 12). It is recommended that you use a level to verify that the back of the camera and the T-90 ultra high resolution target are parallel to each other.

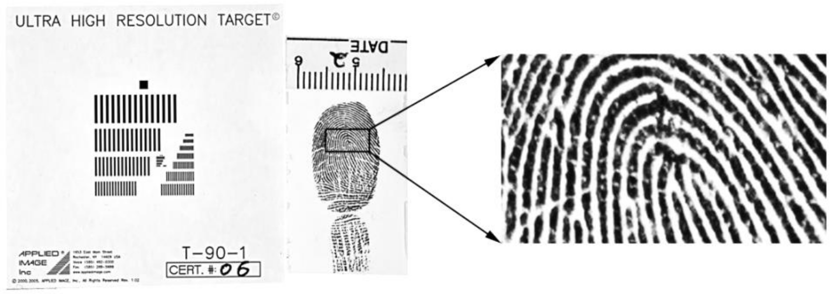


Figure 12. On the left side is a photograph of a T-90 Ultra High Resolution Target with an inked print with third level details. On the right side is an enlarged section of the inked print. It is recommended that a known inked print with visible third level details be photographed with the resolution target.

7.3.2.14. Be sure that the diopter adjustment on the viewfinder is set for your eyesight. Set the camera using manual focus, manual exposure controls, mirror lockup (if this camera feature exists) and a remote shutter release. The mirror lockup referred to is the mirror lockup for taking photographs and not the mirror lockup used for sensor cleaning. You should use painter's or gaffer's tape to tape the focusing and zoom rings to a fixed part of the lens so that the weight of the lens will not shift the zoom and/or focus setting.

7.3.2.15. Select camera settings to capture image files using the same file format used for latent print image capture. NOTE: the use of lossless file formats such as RAW or TIFF is recommended both for this test and when capturing latent print images. The use of file formats that utilize lossy compression can introduce artifacts which could invalidate the test results.

7.3.2.16. Using a remote shutter release or the self-timer, photograph the resolution test target at the following F-stop settings; wide open, closed down 1 stop from wide open, F8, closed down to the next to the last stop and closed down all the way. This will determine the range of F-stops than can be used without a noticeable decrease in resolving power. With most lenses there will be a noticeable decrease in resolving power with the F-stop set to wide open or closed down all the way.

7.3.2.17. Open the files in an image processing application to evaluate the results. Do not process the images.

7.3.2.18. View the region of the test target which depicts 12.5 cycles per mm using the workstation monitor.

7.3.2.19. Starting at a zoom setting of 100%, zoom the image in even multiples of 100% so that the lines and spaces of the region of the test target which depicts 12.5 cycles per mm are clearly visible on the monitor screen. If the camera has accurately captured 12.5 cycles per mm, then it should be possible to distinguish the dark and light line pairs in this region. Do not use image post processing to improve the visibility of the line pairs.

7.3.2.20. To verify the achieved resolution, it is necessary to verify that the correct number of dark and light line pairs per mm have been recorded by counting them and checking this number against the number verified in step 8.2.2.12 (i.e., 15 light and 14 dark)(see figure 10). If the test target, like the one in this example, has resolution lines printed in only 1 direction, the test must be repeated after rotating the test target 90 degrees. If the horizontal and vertical test results are not the same, the lower of the two resolution values is considered the achievable resolution.

7.3.2.21. If the number counted in step 8.2.2.20 matches the number counted in step 8.2.2.12, then you have verified that this camera system configuration can sample at 12.5 cycles per millimeter in the horizontal direction and meets or exceeds the 1000 ppi standard. If not, then this camera system configuration does not meet the 1000 ppi standard. Achieved resolution should be increased by decreasing the field of view (move the camera closer).

7.3.2.22. Evaluating the results for this 28mm to 105mm macro zoom lens. (see figure 13)

- The lens has been tested and can be used at the focal length settings of 50mm and 105mm. Note: The macro range of this lens is from 50mm to 105mm.
- At the 50mm focal length setting the useful F-stop range is from F4 to F22. However, because of the decrease in achievable resolution when closed down to F22, you should want to limit the F-stop range from F4 to F16.
- At the 105mm focal length setting the useful F-stop range is from F4.5 to F22. However, because of the decrease in achievable resolution when wide-open or closed down to F22, you should want to limit the F-stop range from F5.6 to F16.

Sample Resolution Test Results				
	50mm Zoom Setting		105mm Zoom Setting	
F-Stop Setting	Horizontal	Vertical	Horizontal	Vertical
F4/F4.5	12.5 lp/mm	12.5 lp/mm	10 lp/mm	10 lp/mm
F5.6	12.5 lp/mm	12.5 lp/mm	12.5 lp/mm	12.5 lp/mm
F8	12.5 lp/mm	12.5 lp/mm	12.5 lp/mm	12.5 lp/mm
F11	12.5 lp/mm	12.5 lp/mm	12.5 lp/mm	12.5 lp/mm
F16	12.5 lp/mm	12.5 lp/mm	12.5 lp/mm	12.5 lp/mm
F22	10 lp/mm	10 lp/mm	10 lp/mm	10 lp/mm

Figure 13. Example resolution test results taken using a Nikon D810 with a 28mm to 105mm macro zoom lens.

7.4. When To Test

7.4.1. Digital cameras used for latent print image capture must be tested when initially received and after any repairs or updating of the firmware.

8. Recommended Protocol for Verifying the Resolving Power of Scanners Used to Scan Latent Print Evidence.

8.1. Equipment/Materials

8.1.1. Scanner (and associated software and connection to computer and monitor)

8.1.2. Opaque and/or transparent resolution test target

8.1.3. Loupe, magnifier and/or low power microscope

8.2. PROCEDURE

8.2.1. If not printed on the resolution target, be sure that you document the achievable resolution represented by each set of line pairs (See Figures 14 through 17).

Figure 14. This example uses a transparent T-90 high resolution target printed on clear glass with 3 groups of line pairs. A high resolution target printed with chrome on opal glass will also work.

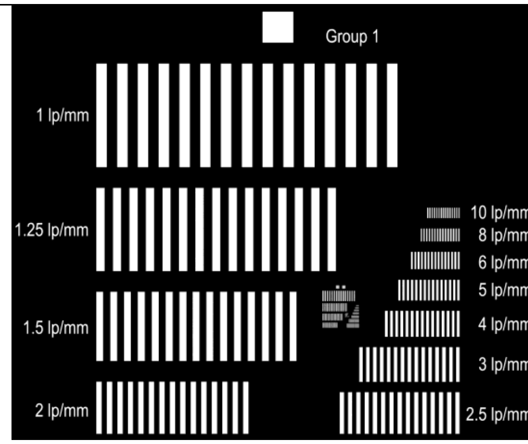


Figure 15. This is an enlarged photograph of the group 1 line pairs documenting the number of line pairs per millimeter for each set of line pairs. This group can be visually verified with a magnifier.

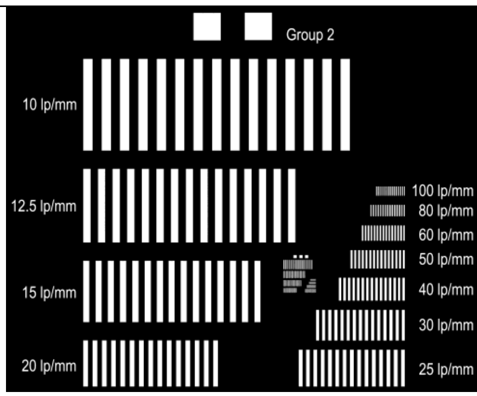


Figure 16. This is an enlarged photograph of the group 2 line pairs documenting the number of line pairs per millimeter for each set of line pairs. A low power microscope should be needed to visually verify the line pairs in this group.

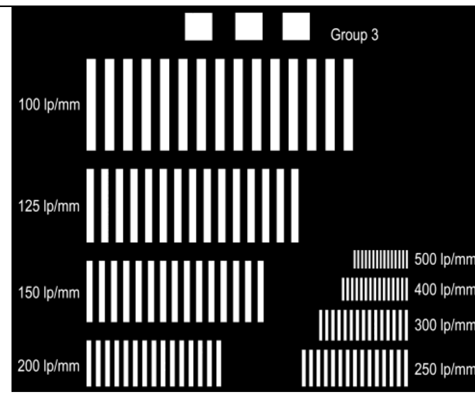


Figure 17. This is an enlarged photograph of the group 3 line pairs documenting the number of line pairs per millimeter for each set of line pairs. A low power microscope should be needed to visually verify the line pairs in this group.

8.2.2. Visually verify (count) the number of dark and light lines and record each (See Figures 14 through 17). It is recommended that a magnifier, loupe and/or low power microscope be used in the counting process.

8.2.3. Determine the machine (optical) resolution setting for the flatbed scanner. For this example, a scanner with a machine resolution of 2400 ppi reflected and transmitted was used.

8.2.4. Determine which nominal resolution setting or settings will be used to image latent print evidence.

8.2.4.1. For this example, it will be assumed that record (inked) impressions are being scanned at 500 ppi and that latent prints are being scanned at a minimum of 1,000 ppi.

8.2.4.2. Although this minimum resolution setting is specified as 1000 ppi, you should set your scanner resolution to an even multiple or fraction of the machine (optical) resolution of the scanner's tri-linear array to avoid resampling of the image during the initial scanning process. For example, if the tri-linear array has a nominal machine resolution of 2400 ppi, use a setting of 1200 ppi instead of 1000 ppi to avoid interpolation of the image in the original scanning of the latent print.

8.2.4.3. It is recommended that 16-bit Grayscale, or 24-bit color settings be used to capture the maximum dynamic range in the latent print.

8.2.5. Determine which nominal resolution settings should be tested. It is recommended that this range of nominal resolution settings include all the present nominal resolution settings (in additional to 500 and 1000 ppi if they are not a preset) from the lowest to twice the lowest nominal resolution setting to twice the machine resolution of the scanner. A scanner over 3 years old with a machine resolution of 2400 ppi was used with the following nominal resolution settings:

8.2.5.1. 500 ppi. Not recommended because it requires scanner interpolation.

8.2.5.2. 600 ppi.

8.2.5.3. 1000 ppi. Not recommended because it requires scanner interpolation.

8.2.5.4. 1200 ppi.

8.2.5.5. 2400 ppi.

8.2.5.6. 4800 ppi. Not recommended because it requires scanner interpolation.

8.2.6. Place a latent print or inked impression (reference standard) with 3rd level details and the resolution test target on scanner platen with top of chart at the top of scanning region. This will allow the user to measure the resolution in the horizontal direction.

8.2.7. Scan these 2 items at each of the nominal resolution settings determined in step 9.3.5.

8.2.8. Rotate the T-90 resolution test target 90 degrees and repeat the scans.

8.2.9. Save the files using either lossless compression or no compression (such as TIFF or Bitmap).

8.2.10. Open the files in an image processing application.

8.2.11. Zoom image to 100% to determine the achievable resolution. Do not use image post processing to improve the visibility of the line pairs.

8.2.12. To confirm accurate capture, it is necessary to verify that the correct number of dark and light line pairs per mm have been recorded by counting them (e.g., 15 light and 14 dark).

8.2.13. If the number counted in step 9.3.12 matches the number counted in Step 9.3.2, then you have verified that your scanner can sample at 12.5 cycles per millimeter in the horizontal direction and exceed the 1000 ppi standard. If not, then your scanner does not meet the 1000 ppi standard and the scanner should be set to a higher nominal resolution and retested. Note that some scanners exhibit higher achievable resolution in the center of the scan area. Thus, it should be appropriate to retest at different locations on the scanner.

8.2.14. Sample Resolution Test Results

Sample Resolution Test Results		
Nominal Resolution	Reflected Resolving Power	
	Horizontal	Vertical
500 ppi	6 lp/mm	6 lp/mm
600 ppi	8 lp/mm	8 lp/mm
1,000 ppi	12.5 lp/mm	12.5 lp/mm
1,200 ppi	15 lp/mm	15 lp/mm
2,400 ppi	25 lp/mm	25 lp/mm
4,800ppi	25lp/mm	25 lp/mm

Figure 18. Example resolution test results taken using an Epson flatbed scanner with an optical (machine) resolution of 2400 ppi. As the nominal resolution setting was increased beyond the optical resolution of the scanner that there was no increase in resolving power in spite of a large increase in both nominal resolution and file size.

8.3. **Example Test Target**

8.3.1. To determine that a scanner is capable of capturing an image at a given resolution, it is necessary to use a test target. The test target used in this procedure is the T-90-N-CG "Ultra High Resolution Target", from Applied Image, Inc., Rochester, NY. This target is used only as an example. Other suitable test targets are available, such as from the International Organization for Standardization (ISO), which has a standard target for measuring resolution of scanners "ISO-16067-1 Reflective Scanner Test Chart."

8.4. **When To Test**

8.4.1. Flatbed scanners shall be tested prior to use for casework, as well as after being moved and/ or Because of the moving parts that can wear out and therefore affect achievable resolution, all flatbed scanners shall be retested every year.

8.5. **Keywords**

8.5.1. **3rd level details**

8.5.2. **1000 ppi standard**

8.5.3. **achievable resolution**

8.5.4. **camera equipment**

8.5.5. **cycles per mm**

8.5.6. **f-stop**

8.5.7. **field of view**

8.5.8. **flatbed scanner**

8.5.9. **flatbed scanner specifications**

8.5.10. **focal length**

8.5.11. **focal plane**

8.5.12. **imaging resolution**

8.5.13. **inked print**

8.5.14. **interpolation**

8.5.15. **latent print**

8.5.16. **latent print photography**

8.5.17. **latent print scanning**

8.5.18. **lens**

8.5.19. **line pairs**

8.5.20. **machine resolution**

8.5.21. **megapixels**

8.5.22. **nominal resolution**

8.5.23. **pixels per inch**

8.5.24. **ppi**

8.5.25. **resolution**

8.5.26. **resolution test target**

8.5.27. **t-90 high resolution test chart**