

Resolution as it Relates to Photographic and Electronic Imaging

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Technical Report for Information and Image Management —

Resolution as it Relates to Photographic and Electronic Imaging

An ANSI Technical Report prepared by
the Association for Information and Image Management International

Approved as an ANSI Technical Report

June 20, 2000

Abstract:

This technical report provides a tutorial on image resolution for micrographics and electronic images. The difference in the use of the term resolution in photographic and digital systems is clarified in this technical report.

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Foreword

(This Foreword is not part of ANSI/AIIM TR26-2000 – *Technical report – Resolution as it relates to photographic and electronic imaging.*)

This technical report was prepared by AIIM Standards Committee C10, Micrographics Quality and Control. The report provides a tutorial on image resolution for micrographics and electronic images. While the technical report represents the consensus of those listed below, the majority of the text was prepared by Don Williams of the Eastman Kodak Company. Additional work on image quality is currently in progress in other AIIM standards committees. Information on these projects is available from AIIM.

Three annexes are included with this technical report: annex A, Converting between digital resolution and dot pitch for commonly used measures; annex B, Converting from numbers of bits to number of grey levels; and annex C, Sample Quality Index calculations (with examples).

Suggestions for improvement of this technical report are welcome and should be sent to the Chair, AIIM Standards Board, 1100 Wayne Avenue, Silver Spring, Maryland 20910-5699.

At the time it approved this technical report, the AIIM Standards Board had the following members:

<u>Name of Representative</u>	<u>Organization Represented</u>
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1 Scope and purpose

1.1 Scope

Resolution became an important image quality factor centuries ago when optical systems were first used to look at the stars. It was used to measure an optical system's ability to separate two closely spaced objects (e.g., stars). It was thought that if images of these objects were separated, then the information they conveyed to an observer would not be ambiguous. Since then, resolution has proven to be a useful tool for evaluating the image quality performance of imaging hardware and media. Electronic image management (EIM) applications have begun to refer to the term resolution as the sampling interval of a scanner or the addressable points on a display or printer. Therefore, the EIM definition may be half or less than expected when using the definition for classical resolution.

1.2 Purpose

The combined use of photographic and electronic technologies in today's imaging systems has made the use and interpretation of the term resolution complex. In order for resolution to effectively maintain its past utility, a basic understanding of resolution and its various interpretations is required. This technical report helps clarify the difference in the use of the term resolution in photographic and digital systems.

2 References

All standards, reports, and publications are subject to revision. When the following documents are superseded by an approved revision, that revision may apply.

ANSI/AIIM MS23-1998, *Recommended practice — Production, inspection, and quality assurance of first-generation, silver microforms of documents*

ANSI/ISO 3334-1991 (ANSI/AIIM MS51-1991), *Micrographics — ISO resolution test chart no. 2 — Description and use*

2.1 Referenced publications

ANSI/AIIM TR2-1998, *Technical report for information and image management — Glossary of document technologies*

2.2 Related publications

Alexander, George A. "Digital halftones: Guide to improving quality", *The Seybold Report on Desktop Publishing* 3(10).

Ulichney, Robert. *Digital Halftoning*. Cambridge, MA: MIT Press, 1987.

Dainty, J.C. & Shaw, R. *Image Science*. London: Academic Press, 1975.

3 Definitions

The following definitions apply to terms that appear in this technical report. Additional terms are defined in ANSI/AIIM TR2.

3.1 American Standard Code for Information Interchange (ASCII): American National Standard Binary-coding scheme consisting of 128 eight-bit patterns (7-bits plus a parity check bit) for printable characters and control of equipment functions.

3.2 Aperture: (1) Rectangular opening in an aperture card that is specifically designed to hold a chip of microfilm of a specified size. (2) In an optical system, an opening through which light can pass.

3.3 Charge-coupled device: Semiconductor that can collect, store and move charges in packets.

NOTE: An imaging charge-couple device responds to light and provides electrical signals. Synonymous with CCD.

3.4 Compression: See Data compression, 3.6.

3.5 Contrast: Expression of the relationship between the high and low brightness of a subject or between the high and low density of a photographic image.

3.6 Data compression: Conversion of a digital image to a lower number of bits for storage.

Example: A series of 0s or 1s could be counted and replaced with a code that represents the number of 0s or 1s in that position.

3.7 Data decompression: The regeneration of a bit-map from a compressed representation.

3.8 Decompression: See Data decompression, 3.7.

3.9 Digital: Use of binary code to record information. "Information" can be text in binary code, e.g., ASCII, images in a bit-mapped form or sound in a sampled digital form of video.

NOTE: Recording information digitally has many advantages over its analog counterpart, mainly ease in manipulation and accuracy in transmission.

3.10 Electronic image management (EIM): Techniques associated with recording, storing, retrieving, and transmitting documents by electronic means. Also called electronic imaging.

3.11 Enhancement: Technique for processing an image so that the result is visually clearer than the original image.

3.12 Focus: (1) Plane in which rays of light reflected from subject converge to form a sharp image after passing through different parts of a lens. (2) To adjust the relative positions of the lens and film or light detector to obtain the sharpest possible image.

3.13 Granularity: Measure of grain distribution in a uniformly exposed and processed area of photographic material.

3.14 Line pairs: See Resolving power, 3.20.

3.15 Lines per inch (or millimeter [mm]): In electronic imaging, the number of scanning lines or recording lines per unit length measured perpendicular to the direction of scanning.

3.16 Luminance: Luminous flux emitted from a surface. Former term: photometric brightness.

3.17 Microdensitometer: Instrument for measuring optical densities in areas too small to be measured without magnification.

3.18 Quality Index (QI): Subjective relationship between legibility of printed text and resolution pattern resolved in a microimage.

NOTE: Used to predetermine camera/microfilm requirements to ensure legibility in the resulting microimages.

3.19 Resolution: (1) Relative degree of an image's visual acuity. (2) In electronic imaging, specific pattern and number of pixels sampled. (3) Measure of capability to delineate picture detail. (4) In micrographics, the ability of a photographic system to record fine detail.

3.20 Resolving power: Numeric expression of the ability of an optical or photographic system to distinguish or separate two entities spaced closely together.

NOTE: In micrographics, it is the product of the number of the pattern resolved in the ISO test chart no. 2 multiplied by the reduction and is expressed in line pairs per millimeter.

3.21 Scanning: (1) In electronic imaging, conversion of human-readable images from paper or microform into a stream of numeric values, called a bit-mapped image. (2) In electronic imaging, optical character recognition (OCR) scanning is the conversion of printed or other symbolic information from paper or microform into ASCII code. (3) In micrographics, movement of an image on a reader screen in a direction perpendicular to the direction of roll-film transport. (4) The systematic examination of data.

3.22 Transmission: Sending information to one or more locations or recipients.

4 Photographic resolution: the classical analog approach

4.1 General

This section gives an explanation of resolution as it is used for evaluating imaging methods other than electronic.

4.2 What it is, and how it is measured

The term resolving power is used when measuring and assigning a numeric value to the ability of an optical or photographic system or component to distinguish or separate two entities (usually lines) spaced closely together. Frequently in practice (and in this technical report), the two terms (resolution and resolving power) are used interchangeably and have units of either line pairs per millimeter (lp/mm) or line pairs per inch (lp/i).

In the United States, the most commonly used resolution targets are composed of a series of alternate equal width, line and space bars. In micrographic systems, resolving power is the product of the number

of the smallest lp/mm pattern resolved in an image of an ISO resolution test chart no. 2 multiplied by the reduction ratio and is expressed in lp/mm. A method of determining resolution by measuring the minimum size of detail recognizable in a processed microform is specified in ANSI/ISO 3334 (ANSI/AIIM MS51). See figure 1, Arrangement of test patterns in ISO resolution test chart no. 2. A target certified to meet this standard is available from NIST and is known as Standard Reference Material (SRM) 1010a.

Until recently, technical literature used the term lines per millimeter; now line pairs per millimeter (lp/mm) is used. Originally, a line consisted of a black line (or black space) and an equally wide white space (i.e., one real line, which when scanned requires at least two scan lines).

Figure 1, Arrangement of test patterns in ISO resolution test chart no. 2 (actual size), is a ruler for measuring resolution. The width of each dark line is equal to the width of the adjacent space. Such a line and space are called a line pair – the associated number gives the number of line pairs per millimeter (lp/mm). These test targets are imaged (through a lens) onto the imaging component (e.g., film) being evaluated and visual judgements are made on the image of the target with a magnification aid. The group of most finely spaced visible lines is noted. This is the group where all five lines and spaces can just be distinguished or resolved in both directions by the observer. The spatial frequency of this line group is the resolution for the imaging component of conditions under evaluation. Because the spatial frequency of this line group measures the limiting spatial frequency capabilities, it is sometimes also called limiting resolution.

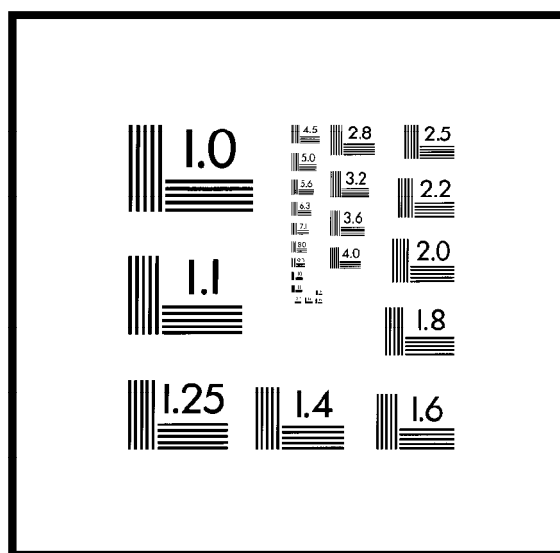


Figure 1 – Arrangement of test patterns in ISO resolution test chart no. 2 (actual size)

Note: Illustration not to be used for testing.

To determine resolution, one image is a known target and visually determines the finest pattern on the output image that is just detectable. Resolution is a detection criterion. If our visual system detects it, it is resolved; if not, it is not resolved. See annex A, Converting between digital resolution and dot pitch, for commonly used measures, for an explanation of conversion from lp/mm to lp/i and other conversions.