The Secret of Image Quality – Dynamic Range and Resolution

Many consumers consider a scanner's resolution, measured in dots per inch (ppi), as the most important characteristic when it comes to image quality. First, there is a big difference between physical and optical resolution, which is often mixed up, but explained below. However, the most significant indicator for a scanner's quality is its Dynamic Range, that we cover first.

1. SilverFast Multi-Exposure® – Increasing Dynamic Range

Multi-Exposure is one of the most popular SilverFast features and among the most important inventions in digital imaging. It records an original's maximum Dynamic Range by performing a double scan with an increased exposure time of the second scan. This procedure captures the light image area's details in the first pass and the shadow details in the second. Afterwards an algorithm calculates the final scan, which now contains any detail, from each single scan.

normal scan

Multi-Exposure scan

Multi-Exposure for Film Scanners

The dynamic range of a scanner, also referred to as density range or contrast range, is a measurement for a scanner's capability to recognize contrast levels.
Color negatives and slides consist of multiple film layers, which respond to light differently. Therefore, transparent originals achieve a high Dynamic Range when captured, which usually exceeds a scanner's capabilities.

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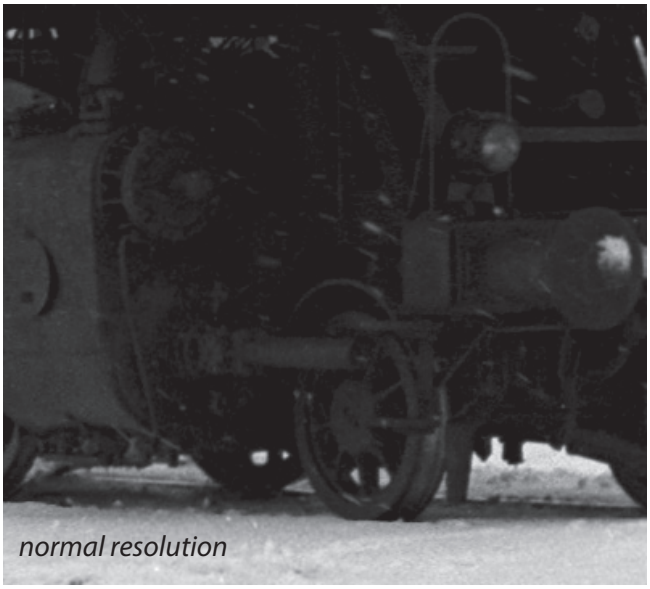
Increasing the resolution of a scan to improve image details and quality has its limits. For displaying an image on a monitor screen or printing it for a magazine, there will be no difference between scanning it with 300 ppi or 1200 ppi. Screen as well as printing press do not need a resolution beyond 300 ppi, they simply cannot use it.

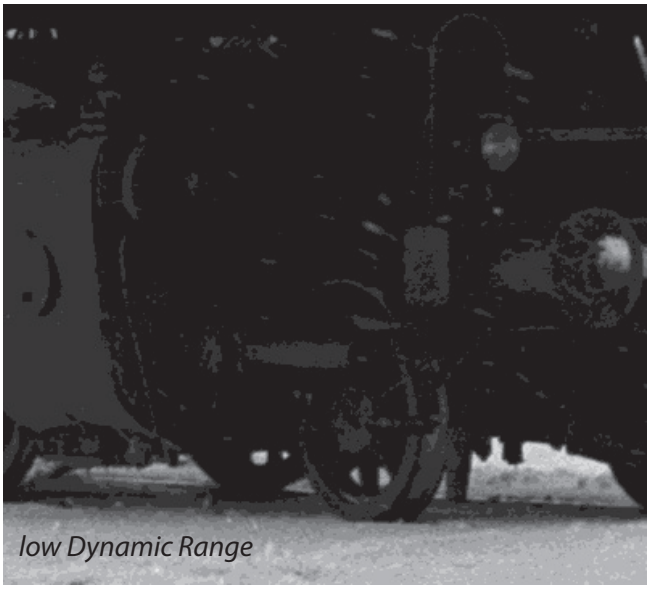
For best image quality and most details, a suiting scanning resolution, chosen depending on intended use, and a maximum Dynamic Range is the optimum combination.



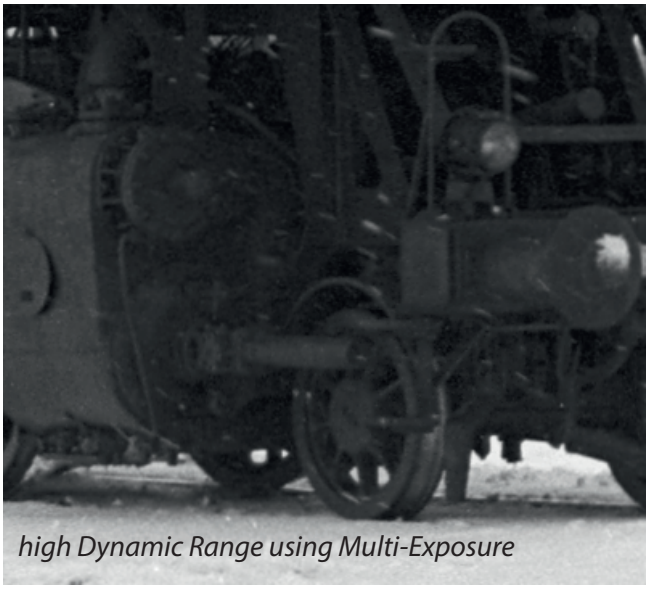
normal resolution

very high resolution

Raising scanning resolution beyond a certain level does not help to get more image details. A computer screen for example, has a resolution of just 72 ppi. There is no difference visible between a 300 ppi and a 1200 ppi scan.



low Dynamic Range



high Dynamic Range using Multi-Exposure

A low Dynamic Range is equivalent with a small number of grayscales. Using SilverFast Multi-Exposure, many more shades of gray are captured, resulting in more image details.

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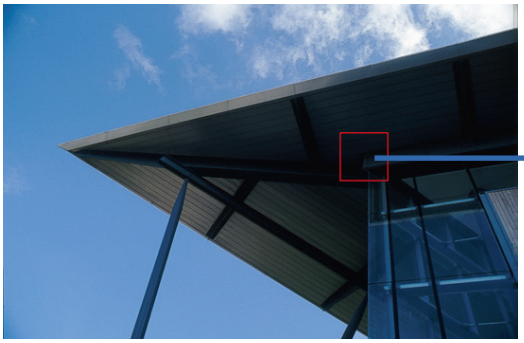
What is behind this standard and what do the results mean in practice?

The ISO 21550:2004 specification defines methods for measuring and evaluating the Dynamic Range of electronic scanners for digitizing analog photographic material.

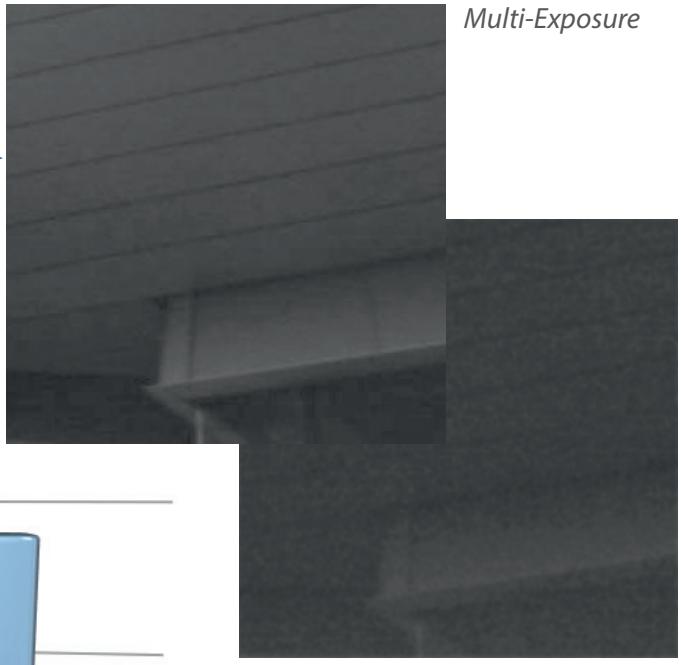
The values that result form the measurement are indicated as decade logarithm of the reciprocal of light transmittance. In plain language this means a scanner that is able to achieve a Dynamic Range of 2.0, can implement a contrast ratio of 100:1. Because it is a logarithmic function, an apparently small increase form 2.0 to 3.0 corresponds to an actual tenfold increase in the number of perceptible gray scales to 1000:1. The chart below shows a measurement values according to ISO 21550:2004 for the Epson Perfection V750 Pro.

Dynamic Range	2.0	3.0	3.2	3.5	3.8	4.0
Gray Scales	100	1000	1585	3162	6310	10000



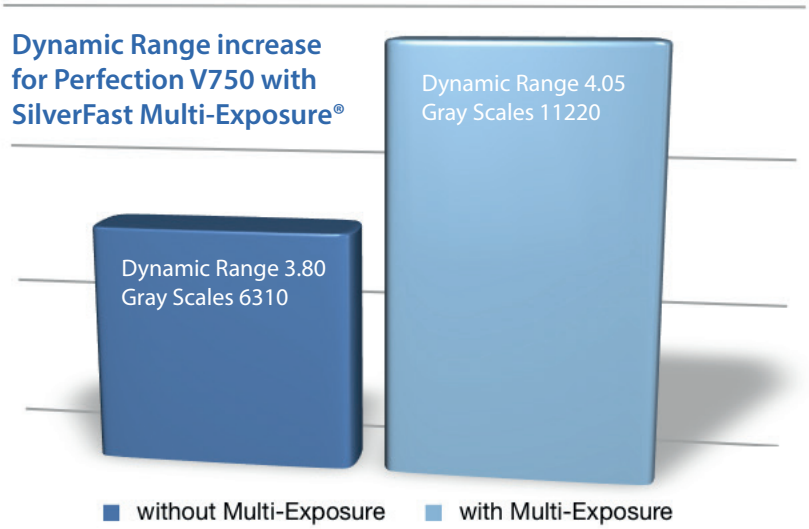
35mm color scan

detail



Multi-Exposure

normal scan



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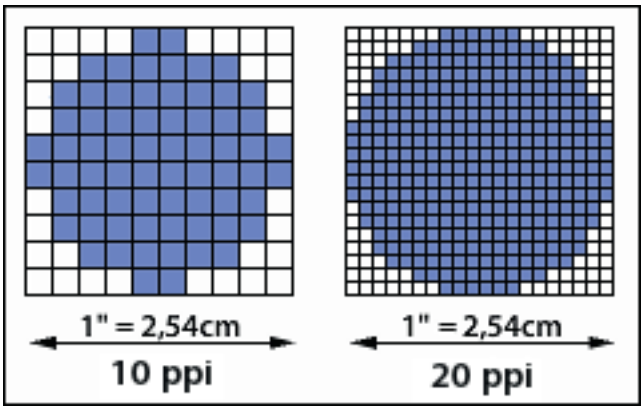
2. Scanner Resolution – CCD and Optical Resolution

ppi, what exactly is it ?

Besides its Dynamic Range, an important parameter for describing the quality of a scanner is its resolution. Resolution is a measure of the accuracy with which an image can be recorded; it is usually denoted in ppi (pixel per inch). A higher resolution allows to capture more image details per inch. A scanner with a resolution of 1200 ppi can thus theoretically detect 1200 different pixels per inch (2.54 cm).



How a scanner is constructed

Both flatbed and film scanners generally record the image of the original line by line using one-dimensional CCD sensors (charge-coupled device). These light-sensitive components consist of many photocells arranged in a row. The more densely the CCD sensor is populated with individual photocells, the higher the resolution across the width. Lengthwise, a stepper motor is used to move the CCD sensor line by line across the original. The fineness of the steps this motor can take thus determines the lengthwise resolution.

The horizontal and vertical resolutions of a scanner, therefore, aren't necessarily the same. Usually the horizontal resolution, that is, the resolution of the CCD sensor, is lower. It should also be noted that a CCD sensor built into a flatbed scanner can resolve an original much less precisely than the same CCD sensor in a film scanner. The reason therefore is the different width for originals of about 20 cm for flatbed scanners and only about 3.5 cm for film scanners, both of which are projected onto the width of the sensor by lenses.

Physical vs. Optical Resolution

Modern scanners' data sheets often show amazingly high resolution values. Nowadays CCD sensors and the fine mechanisms of the stepper motors are accurate enough to permit these physical resolution values. **However, there are a series of factors, why the physical CCD resolution can usually not be used as the optical resolution for scanning an original.**

Mirrors and lenses project the large scanning area to the smaller CCD sensor. Interpolated resolution should never be seen as a usable optical resolution. Resolution of the stepper motor should not be confused with that of the CCD sensor, and the complex optics within the device can cause blurriness during the scan at the resolution limit, particularly at the edges of the image.

SilverFast Resolution Target (USAF 1951)

Based on the USAF-1951 standard, LaserSoft Imaging has developed the SilverFast Resolution Target to make the actually usable resolution of a scanner measurable. This target is a trans-parent original, which is suitable for either film or flatbed scanners with transparency unit.