Technology Comparison of Film and Electronic Photography: Digital Photography is not the Best Imaging Technology. Film Photography is

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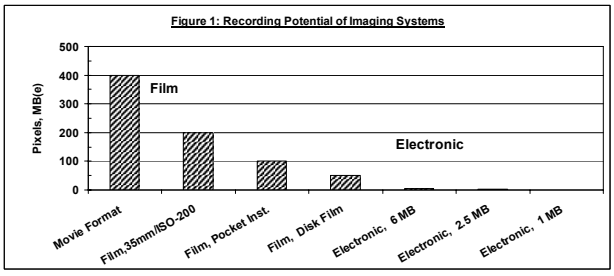
On a financial, business, or technical basis, silver halide photographic companies cannot compete with the electronic industry in electronic imaging. Thus, the retention of the silver halide photographic systems must be their primary concern for their survival. This presentation provides information which supports the continuing viability and superiority of silver halide photographic systems for a great variety of imaging properties.

Technologically and for practical image recording, silver halide photography offers many advantages, like

- Superior recording speed, sharpness, image tone, depth recording, flexibility, archivability.
- Two hundred (200) mega pixel (Mp) recording (Agfa, 200 speed color negative)[1] vs. less than seven (7) Mp for amateur electronic cameras. In Figure 1, a comparison of the recording capacity of the recording media is shown which highlights the qualitative differences quantitatively.
- Up to twelve overlaying color sensing layers vs. side-by side recording color for electronic chips.
- Ninety four choices of color films per camera vs. one chip only for an electronic camera.
- True full color imaging and enlargement vs. mathematically expanded images
- ISO-Speed ranges from fifty to two-thousand in the same camera vs. a single two hundred photographic rating for electronic cameras.
- Full retention of recorded image in the negative vs. losses due to image conversion and compression in digital cameras.
- Significantly greater image information retrieved by scanning than recorded in electronic cameras.
- Significantly (~30x) greater available retrieval of image details from film images.
- Faster access of printed hard copies, e.g., one-hour processing (unprocessed film to prints) for film (24 or 36 images).
- The high density recording quality of silver halide images is transferred to analog copies on paper.
- Unsurpassed for amateur, professional, movie, x-ray, and archival image recording.



Film cameras provide their own high density image storage in the film negative, while electronic cameras generally need additional storage media. The image storage of common storage media is compared to that of ASA 200 film negatives in Table 1. Included in Table 1 is also the cost for the storage media. For film, the storage medium is included in the price of the recording medium. If a dump-medium, like a computer, is not available, electronic cameras need a number of recording media which significantly increases the cost of electronic pictorial image recording.

Table 1	Memory Giga Bytes		Film Equivalent Picture Storage		Storage Cost
Memory	Min (GB)	Max (GB)	Min	Max	US$
Film, ASA 200	**4.80**	**7.2**	**24**	**36**	**$2- $ 5**
Micro drive Cards	0.51	4.0	2.56	20.0	$77 - $369
Compact Flash, Type I	0.01	2.0	0.04	10.0	$18 - $489
Compact Flash, Type II	0.01	2.0	0.04	10.0	$19 - $489
Secure Digital (SD)	0.03	1.0	0.16	5.0	$29 - $289
Memory Sticks (Sony)	0.03	1.0	0.16	5.0	$29 - $285
Multimedia Cards (MMC)	0.03	0.5	0.16	2.6	$23 - $149
XD Picture Cards	0.03	0.5	0.16	2.6	$19 - $157
Mini-SD	0.03	0.03	0.16	0.2	N/A

From a scientific point of view, electronic imaging is an analog process, where subsequently to image capture an analog to digital (AD) conversion is added to obtain digitized image information. This electronic image conversion process is accompanied by reduction in image information. Silver halide photography is a digital process, since each imaging center (crystal) provides a digital, on-off, response. Thus, 'digital imaging' for electronic imaging is only partially correct.

Pollution. Silver halide processing takes place in highly controlled and government regulated and controlled manufacturing environments. Chemicals used in the processes are recycled and reused. Film processing thus has low impact on the general population and on pollution and landfills. In contrast, the equipment used for processing digital images, scanners, computers, printers, and imaging chemicals, are generally and widely disposed of in landfills. Chemicals which are present and contain health hazards (arsenic, gallium, lead, selenium, etc) are generally not recovered or recycled. Contrary to public opinion, due to the wide distribution of the equipment and chemicals used for electronic imaging, digital imaging provides a significantly more severe ecological hazard than traditional film processing.

Archivability. Silver halide technology has a proven record of archival retention since its inception for over one hundred fifty years. In contrast, the technology underlying the electronic photography, software, hardware, and hard copy, has a history of technological obsolescence (loss of technology) in less than ten years. These and other advantages of film over electronic imaging are significant to provide professionals and amateurs with the desired high quality recordings and image retention which is essential for historically significant image recordings. Images of babies, parents, and grand-parents cannot be recreated at will.

The movie industry is similarly profiting from the advantages of silver halide technology. The recording area of movie film is twice that for the thirty-five millimeter negative. For two hundred speed negative film this accounts to four hundred Mp per negative

Movie film is routinely recorded at over one thousand speed, vs. electronic imaging at two hundred speed. This allows for reduction in exposure time and reduction in illumination equipment, which allows shooting of images where digital equipment is inefficient or unwieldy. For film recordings, the need of battery packs and electric connections is significantly reduced. High-density recording in the film system makes the high-cost digital image storage and manipulation unnecessary. Film recording is also the only high-quality system that allows for loss-less and high-quality conversion to all digital electronic imaging systems, e.g., television formats, video, DVD, and HDTV.

Present projection rates of 24 images per second amounts to nine thousand six hundred (9600) mega pixels per second in the film movie theater. The present image recording and projection rate is beyond the capability of electronic imaging equipment. The film projection speed and quality is achieved by equipment that projects at less than ten kilowatt per hour (less than five Dollars). In contrast, electronic projection will use expensive electronic equipment with high energy consuming image output. The

energy and equipment requirements, and the frequent replacement of digital vs. film projection systems are generally obscured.

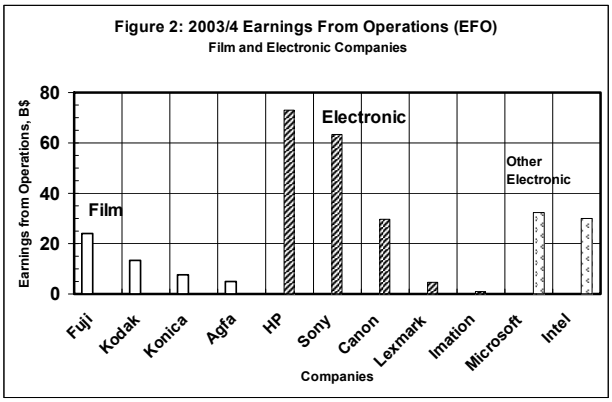
At the start of the movie industry the projection speed was kept far below the optimum level of projection rate (24 vs. 33 images/second, 9,600 vs. 13,200 Mp/second), leading to less than optimum viewing quality. Increasing the projection rate to and above the optimum level will significantly improve the projection quality of movies. The necessary changes for higher rate recording and equipment are relatively low. The cost for recording film is significantly less than for other costs in film production so that the cost for an increase in the rate of film recording and projection would be insignificant vs. the projected quality increases.

Film also provides a cost effective starting recording for world-wide distribution, since several competing projection systems, e.g., in the television industry are incompatible. Film provides the image quality for the most demanding electronic projection systems, e.g. high-definition television. It's archival stability also extends the time for profitable distribution (example: 'Gone with the Wind', 'Wizard of OZ').

X-ray, magnetic resonance, and ultrasound imaging systems provide complementary information. X-ray imaging can provide images in less than two minutes as high resolution hard copy (exposure, handling, and processing) and reliable quality. The consistency of x-ray film and processing provide for consistency of the resulting image over time and between different laboratories. In contrast, a standard MRI exposure takes over twenty minutes, plus significant image manipulation and time for print-out. Also, the print-out quality for digital hard copies, like MRI, is not reproducible without extensive comparison with previous imaging.

While electronic imaging has advantages in certain areas, silver halide imaging retains the high quality advantage by a wide margin and offers other significant technological advantages not matched by electronic technology.

The question arises if the Photographic Industry can for the long term efficiently compete in electronic imaging. In Figure 2, the economic power of the photographic industry is compared to that of its electronic competitors.[2] For comparison, the annual revenue and earnings from operations (EOF) are used. It is apparent that the economic power of the electronic industry exceeds that of the photographic industry by several multiplication factors. These data make it doubtful that the photographic industry, without the film earnings, can survive a significant effort of the electronic industry to dominate the electronic imaging market. This inequality is further increased by the fact that the photographic industry is acquiring most of its electronic material from its competitors in the electronic industry. Thus, the electronic industry enjoys a significant advantage both in price as well as in the control of the electronic/digital imaging technology.



Considering that the photographic industry cannot profitably compete in electronic imaging with the electronic industry, the retention of the silver halide photographic systems must be their primary concern for their survival. This presentations provides factual information which supports the continuing viability of the silver halide photographic system.

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[1] Folienserie des Fonds der Chemischen Industrie, Textheft 26, Photographie, authors: Team of the Agfa-Gevaert AG, Fonds der Chemischen Industrie, Frankfurt, Germany, 1999.

[2] I am indebted to J. McCue, Rochester, NY, of Merrill Lynch Corp., for the financial information