Slide Duplication Project Summary

(Heike Koenitz)

The report is based on the results of the diploma dissertation completed in 2006 at the University of Applied Sciences (FHTW), Berlin. The dissertation dealt with the subject of "Duplication of slides, using as an example a slide installation by Nan Goldin, Hamburger Kunsthalle".

Introduction

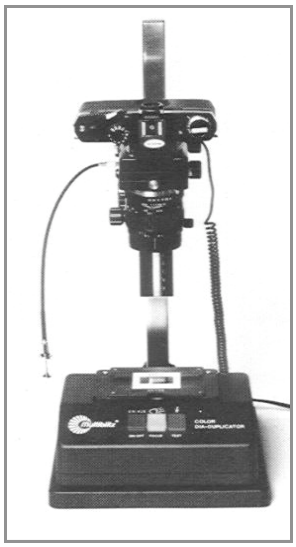
Slide projections became art objects for the first time in the 1960's[1]. Picture projection provided art and artists with a new medium of expression and offered the viewer a new experience of space-time simulation in still images. The carousel slide projectors introduced in the 60's and still popular today also allowed images to be projected in an endless loop.
The lighting enables a slide to be shown in projection, while at the same time being one of the causes of the irreversible damage to its sensitive colour image. Heat generation and light intensity during projection result in irreversible damage to the original, which manifests itself in the form of fading, yellowing and colour shift. The original is also susceptible to mechanical influences and, if used incorrectly, suffers scratching and scuffs. The process of decomposition is accelerated, if residues from unsatisfactory photochemical processing are left in the slide material or damaging environmental influences like acid gases or high humidity are active. However, it is not only external factors like light, chemicals, heat, moisture, manner of storage and projection which determine the durability of a slide but *inner* factors as well. Even without projection changed colour images are produced in the slide through ageing. Responsible for this are the colour couplers, sensitizers or stabilisers which are stored in the layers and may undergo chemical changes over time[2]. Once the colours have faded, they can never be restored on the original slide again. They must then be reconstructed expensively in copies[3].
To protect valuable originals against degradation, the use of duplicates is therefore unavoidable. This way the original slides can be preserved, while high-quality copies are used as replacements for projection. One of the priority tasks for slide duplication is to keep the loss of information in the case of duplicates as low as possible.

Slide duplication process

Two different processes may be used to obtain slide duplicates.
Analogous duplication is the conventional photographic reproduction of a slide on a film carrier with the aid of a slide duplicator (see Fig. 1). To reduce any tone value losses to a minimum, special slide films known as duplicating films, which are intended to prevent an increase of contrast, are used. The necessary filtering out is done with yellow, magenta and cyan filters at different density gradations. No more than 3 filters should be used in succession to avoid blurring and grey toning in the duplicate. After exposure the film also has to be

[1] ALEXANDER 2004, 3f
[2] GSCHWIND/FREY 1998, 147
[3] SCHMIDT 1998, 187

developed.
Digital duplication is a hybrid process. It combines both analogous and digital technology. The analogous master, the slide, is scanned, processed on a computer and finally recorded. During scanning RGB data are generated, which the scanner picks up with its CCDs[4] (see Fig. 2). The brightness and colour values of each picture point in the slide are converted to signal voltage. The generated data sets can then be reconverted to an analogous form. Digitalisation and recording can be undertaken with the aid of various optical systems. For KB slides high-grade scanners (e.g. virtual drum scanners) or digital cameras with scanback on a copy stand with transmission light unit are suitable. Both digital photographic systems are fitted with line sensors to achieve an improved colour reproduction[5]. As the desired output size of the image is very small, scanning must be done with a very high resolution. Recording is done either by means of traditional cathode ray film recorders[6] (see Fig. 3) or modern laser recorders (see Fig. 4) on slide film (see table computer-to-film recorder technologies). The recording of digital data has been common practice in the field of cine film exposure (e.g. Arrilaser, IPM Fraunhofer) for some time.
Problems are caused both in the case of analogous and digital processes by dust in the vicinity which is also photographed but is considerably easier to remove again in the digital field by image processing. A further digital advantage is the simplified restoration of colour in the duplicate and the minimisation or exclusion of ageing features like scratches and scuffs. Moreover, profiles stored in the file enable greater reproducibility of results. A disadvantage of analogous duplication is its generation loss, which occurs with any further duplication. A further disadvantage is not being able to carry out image corrections until after the first test results.



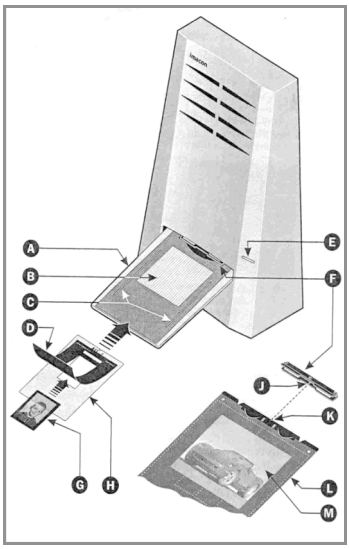
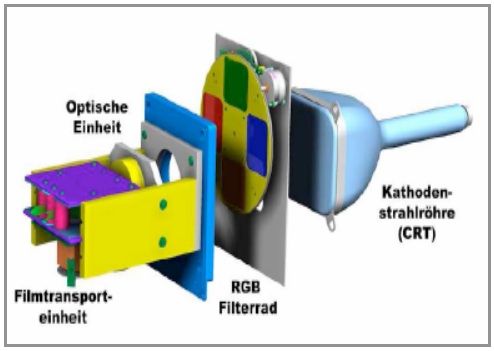
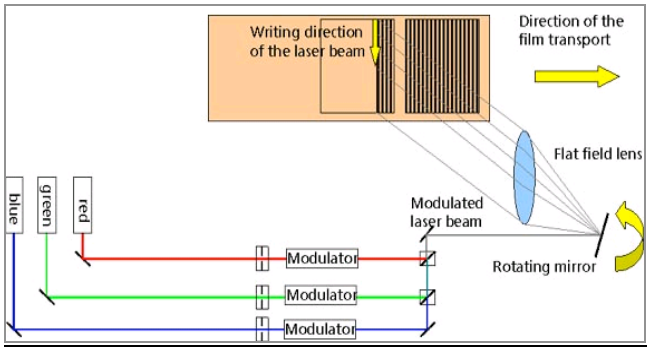


Fig. 1 and 2: left analogous slide duplicator, Source: Marchesi (n.d.), p. 33, right virtual drum scanner. Source: Imacon A/S (2004), p. 8

[4] charge-coupled device, light sensitive image sensors provided with colour filters
[5] Information kindly provided by Mr. Benjamin von Kreutzbruck, Anagramm GmbH, 28.04.2006
[6] CRT



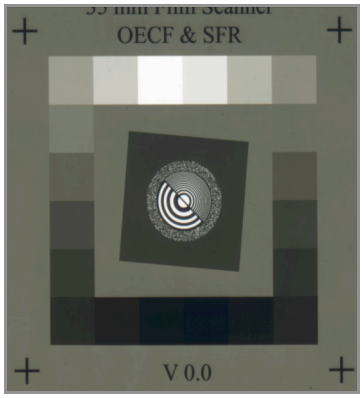


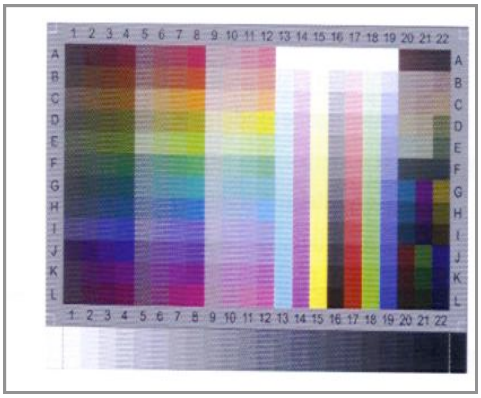
Figs. 3 and 4: left CRT film recorder, source: http://www.mikrosave.ch/d/aktuell/pdf/FMI%20Farbfilm.pdf, S. 20, right laser recorder for recording of data sets on slide film, source: http://www.ipm.fraunhofer.de/fhg/ipm_en/extra/bigimg/laserbelichtung/arrilaser/funktionsprinzip_arr.jsp

Qualifying criteria, -controll und -access

To assess the slide duplicates and the instruments and techniques involved in the duplicating process, set quality criteria are applied. With the help of these auxiliary quantities the duplicating processes and the qualities of the duplicates obtained by them can be better assessed.
The highest requirement made of a duplicate is the picture quality[7], which is made up of image and colour resolution[8] as well as colour fidelity. However, quality criteria are needed not only with regard to duplication but also for long-term archival[9]. These include in the digital field primarily the production of an uncompromised file and calibration of the instruments.
To make the instruments and films involved in the duplicating process suitable, standardised colour masters and test marks for resolution, tone value, colour and graininess (see Figs. 5 and 6), which pass through the analogous and digital duplicating process, are used. These are then tested objectively (with measuring instruments) and subjectively (visually).
The subjective assessment consists in the visual assessment without the assistance of any instruments. Particularly colour and brightness shifts can be analysed this way. The objective analysis is by means of colour measuring instruments (colorimeter or spectrophotometer).
Quality assurance is done, for one thing, by deliberate exertion of influence with the aid of a suitable film material provided with special properties. These include the steepness of gradation, the resolution and the degree of contrast[10]. For another thing, it is achieved by monitoring the processes in the laboratory, the fixing of technical parameters for duplication, the provision of the file with metadata and the setting up of a suitable workstation. In the digital field calibration and the use of colour management for all the instruments for colour-fast, instrument-independent and permanently reproducible exposure with identical results which are involved in the duplicating process are important aspects for quality assurance.

[7] FREY 1997, 14; GSCHWIND et al. 2002, 36; POLLMEIER 1998, 123
[8] Tone value range
[9] GSCHWIND 2002, 32
[10] Distance between lightest and darkest point





Figs. 5 and 6: left resolution target for scanner links, source: Image Engineering (2006), right IT.8.7 colour target, source: Steinhoff (2006) p. 87

Test series

Both test marks and conventional image motifs on various film materials of different ages were used as analogous material for the tests. Purely graphic representations were not included in the analysis. The results therefore relate exclusively to figurative images. Individual facts must be taken into consideration for each new application. The analogous and digital duplication of the test slides was done by a specialist photographic laboratory in collaboration with its partners. No price comparison of other service providers was undertaken. At this point the results regarding a) colourfulness and b) resolution are presented.

Production of duplicates - test slides

	analogous	digital
Instruments:	• Duplicator: Homrich DDM-S duplicate machine • Light: artificial halogen light (3200 Kelvin) • Filtration: CC filter in cyan, magenta, yellow, max. two per take • Lens: Karl Zeiss S-planar for M=1:1, 1:4/f=74 mm • Exposure: shutter 22 / 1 sec.	• Scanner: Imacon Flextight 848 (virtual drum scanner) • Density range ($D_{max.}$): 4,7 • Input resolution: 4000 pixels (long side), equivalent to about 80 lines/mm • Computer-to-film recorder: LVT laser recorder, maximum output resolution 3000 dpi
Target film - duplicates:	• Designation: Kodak EDUPE • Format: small picture 24 x 36 mm • Development: E-6 process • Cost per duplicate: € 6.00	• Designation: Kodak Ektachrome electronic output film, 100 ASA, • Format: flat film 20 x 25 cm • Development: E-6 process • Cost per duplicate: € 28.00[11]

[11] comprising digitalisation € 20, recording € 8

Results of test series

It must be emphasised that these relate to results in the present case and not to statements valid for all cases.

a) Colourfulness: the photographed Gretag Macbeth ColorChecker colour checking chart (see Fig. 7) as used as a master for the test slide with the designation *"colour card"*. The spectrophotometric colour measurements of measuring fields 1-18 in the original slide yielded curves lying close together with regular line spacing (see Fig. 8). In the *analogous duplicate* the curves are shaped similarly to those of the original slide, but are further apart from one another at the end (see Fig. 9). The curve shapes of the digital duplicate already start spaced widely apart and retain this spacing to the end (see Fig. 10). In the overall result both the analogous and digitally duplicated slides show higher transmission levels and thus are lighter than the original slide and reproduce these differences in colourfulness in the form of an altered curve run. It must be noted that the analogous duplicated slide is also visually nearer to the original.

The pronounced outliers of the blue curve in measuring field 17 (magenta) in Fig. 9 (analogous duplicate) and the drop in the brown curve at in the end part of measuring field 6 (purplish blue) in Fig. 10 (digital duplicate) are presumably due to a measuring error.

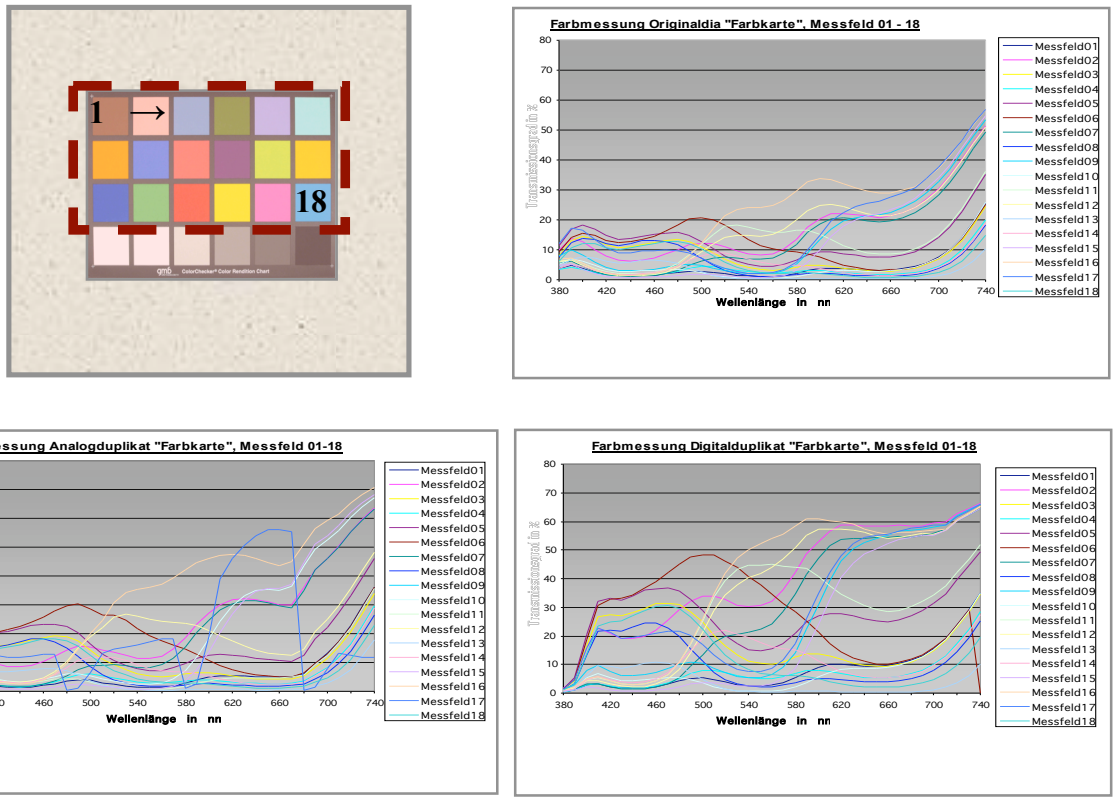
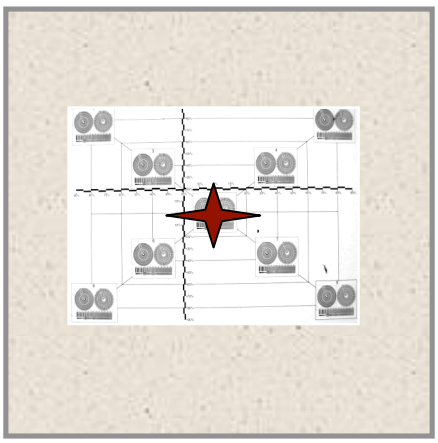


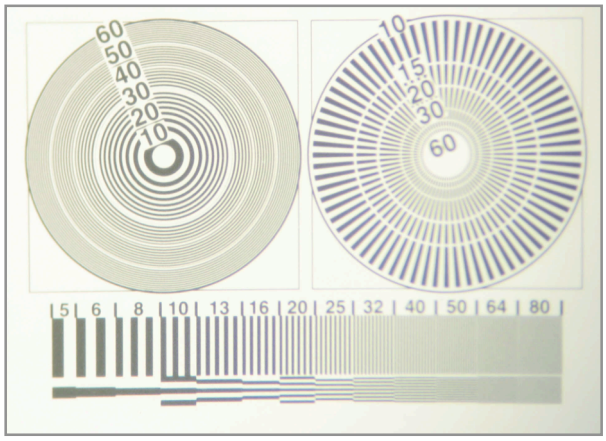
Fig 7 to 10: top left "colour chart" test slide with dark red marking of measuring fields 1 to 18, right top spectrophotometric measurements original slide, bottom left analogous slide duplicate, source: Heike Koenitz

b) Resolution: To assess the quality with regard to resolution in the duplicates, a black-and-white *"resolution chart"* was reproduced on film[12] analogous and digitally. The test chart shows line structures, with the distances between the individual lines becoming shorter and shorter (see Fig. 12). The standard of resolution is the number of lines which can be reproduced next to one another and be perceived separately.
Counting of the lines showed that, as expected, both duplicating methods entail resolution losses. In a direct comparison the digital duplicate shows much more serious losses than the analogous duplicate (see Fig. 13 + 14). Because of the poor resolution the digital duplicates produced are unsuitable for projection. However, there may also be a deficiency in the production of these duplicates here. It must be assumed that in the present case the loss of quality did not occur until the recording stage. After the scanning all the lines could still be completely counted on the monitor. With digital duplication, therefore, it is mainly the current resolution of the recorder that determines the final result.

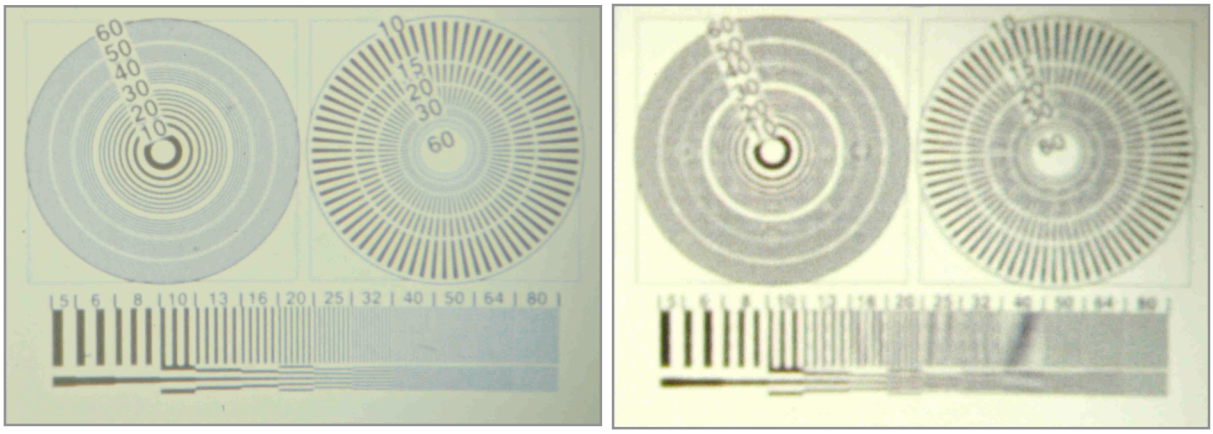
Visual comparison of original slide "resolution chart" and duplicates

	Visual assessment original slide	Visual assessment analog duplicate	Visual assessment digital duplicate
Test slide "resolution chart"	Back-and-white, very well defined, 80 line pairs/mm countable (see Fig. 12)	Grey-blue shift; somewhat softer; moderate blurring: 40-50 line pairs/mm countable (see Fig. 13)	Blurred reproduction of details: 30 line pairs/mm countable at resolution 2032 dpi (see Fig. 14)





[12] Manufacturer B.I.G., negative film, 35 mm industrial photo production



Figs. 11 to 14: top left test slide "resolution chart" with picture section marked red, section top right original slide, bottom left analogous duplicate, bottom right digital duplicate with 2032 dpi resolution, magnified twenty times, photos: Heike Koenitz

The results of the tests were applied to the "All By Myself" slide installation (1993-1996) by Nan Goldin. Maintaining the strongly saturated colours takes on a special importance. The installation comprises a total of 98 colour and black-and-white slides in small-picture format and is intended by the artist for continuous operation with the aid of carousel projectors (see Fig. 15). The slide series comes from the stock of the collection of the Hamburg Kunsthalle. It stands for the challenge of presenting art in its original context, making duplicates and at the same time properly preserving original slides for archiving. It follows on the museum's experiences with an unsatisfactory digital duplication of the slide series with regard to colourfulness and a desired increase of contrast.

Fig. 15: Part of the stock of original Nan Goldin "All by Myself slides, photo: Heike Koenitz

The duplication of a small selection of representative slides from the Nan Goldin installation corroborates the results of the previous trials with the test slides:
The *analogous duplicates* in the first generation have the quality of sufficiently sharply reproducing the picture content. Furthermore, in contrast to the digital duplicates they retain

the complete picture section. It should be noted that only the digital slide duplicates shown here do not have the whole of the picture content. Possibly there is a fault in the application. It is conceivable that the complete picture section can be retained, if the slides are scanned completely with an emphasising mask. A disadvantage could possibly be the absence of a flat position and so inhomogeneous definition.

Cost comparison

When the cost calculation was carried out, at the time of the analysis and in the present case the analogous duplicating method proved more cost effective than the digital. It must, however, be noted that a cost comparison of two different providers has not been carried out or any further advance cost estimates obtained. The costs are based on this one laboratory with a lot of experience in handling slide duplication.

Further analysis options

There is the cost-effective variant of placing about 30 reproductions of scanned in slides as a kind of contact sheet on a single 8 x 10 inch flat-film format[13] and recording them: it should be noted that a higher resolution than standard resolution means higher costs.
There is in the area of digital LVT technology experience with the duplication of slides and black-and-white negatives by Doug Munson (Chicago Albumen Works) with highly promising results. He, too, expressed the need for standards in duplication[14].
Since no CRT recorders are manufactured anymore, one of the future possibilities is the presentation of purely digital data sets. Resolution and range of contrast are insufficient for an equivalent substitute. However, technology is developing constantly.

Computer-to-film recorder technologies

	Laser recorders	CRT recorders
Examples:	• LVT recorders[15] • Fire 100[16]	• CCG PCR8 • Polaroid ProPalette 8000
Instrument structure	• 3 laser (beams), system comprising mirror, lenses, perforated disks	• comprising a screen, colour disk with filters in red, green and blue, lenses and camera back for the appropriate format • Electron rays from cathode ray tubes
Recording	• Modulated light from three lasers in red, green and blue • Description linear	• The three additive colours are recorded one after the other (partial recording) • Description point for point

[13] Equivalent to 20 x 25 cm
[14] MUNSON 1997
[15] Manufacturer Light Valve Technology, subsidiary of Kodak
[16] Manufacturer Cymbolic Sciences, subsidiary of Gretag Imaging

Advantages and disadvantages	• Higher picture quality, colour fidelity and definition, high speed, high purchase and maintenance costs	• No high colour density, sow recording times, high sensitivity and so graininess, limited resolution and quality

Conclusion for duplication

At present no definite answer can be given to the question of which duplicating method is the most practical. Which duplicating method is selected is a matter of individual decision. A statement which is valid for all cases is not possible at present and because of the limited analyses.
One way of utilising the advantages of both processes might be the following:

1. For immediate availability of duplicates duplicate the original slides *analogous*. The originals remain as far as possible unimpaired, if a number of duplicates is produced from a master in a single pass. The cost is considerably lower as a result.
2. As a long-term safety measure for picture information, the original slides can be *digitalised*. The currently valid technical parameters for this are: resolution ≥ 2700dpi, colour depth 48 bit, file format TIFF, RGB mode, embedded colour profile, stored metadata[17], calibration/colour management of all instruments used in the system. Suitable input instruments are e.g. virtual drum scanners or digital cameras with scan back section and appropriate optical equipment. An important thing is the preparation of an own-made mask, as the cover mask variants offered by the manufacturer reduce the picture section.

It goes without saying that all measures must be supervised by qualified laboratory staff. Duplication projects should also always be overseen critically by clients, if possible, with a photograph restorer present. Preliminary discussions should at all events be conducted with the laboratory staff carrying out the work, in order to avoid interference with the file aimed at improving or beautifying the object.

[17] Information on the artefact

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