

DISCUSSION PAPER: **Digital versus Slide Projection**

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[Editing and comments - Mark Buckley-Sharp, Technical Standards Committee](#)

1. Test Image

The base comparison material used in this analysis is a Leitz test slide, glass mounted (and dirty for added spot resolution!). It is on slow slide film which is probably capable of resolving some 80 line-pairs / mm (lp). It has gratings of up to 56 lp in vertical and horizontal formats and in both black on white and white on black variants. The slide was scanned to give a file of ~30 MB which in turn was converted to a high quality JPEG of some 3.5 MB for projection – see Appendix 1. (NB. Some quality loss was observed when images were converted to jpeg at the native resolution of the projector. More research needs to be done in this area but the indication is that high resolution jpegs are preferred, or bitmap/tiffs if downscaled to the projector resolution.)

The scanned image of 3957 by 2613 pixels just manages to discriminate the 56 lp horizontal grating but not the vertical 56 lp grating. 40 lp gratings look o.k. when zoomed on a monitor. The drop off at 56 lp is probably due to the horizontal accuracy of the slide scanner.

2. Slide Resolution Data

Leitz TEST SLIDE (34.7 x 22.9 mm)							
Line-pairs / mm (lp)	7	10	14	20	28	40	56
Line width(mm)	0.071	0.0500	0.036	0.025	0.018	0.013	0.009
Minimum vertical resolution(pixels)	321	458	641	916	1282	1832	2565

The minimum vertical resolution is the number of pixels which would be theoretically required to discriminate black and white lines for a full height image of 22.9 mm.

3. Comparison Method

A Braun 35mm projector with a Rollei Projar S lens was used to project a 60 inch wide image. A Panasonic AE 700 digital projector was used to produce a 720 pixel high image on the projector's 1280 by 720 réseau with the image again projected 60 inches wide. No attempt was made to colour balance the two images (a problem for another day!). The two images were both present simultaneously and could be seen individually by covering the lens of one projector at a time. A rapid A / B comparison was therefore possible.

The exercise was repeated using a Toshiba TLP-T60M digital projector – an XGA (1024 by 768) multimedia projector.

4. Observations

The slide image was clear and “smooth”. Text on the screen was easy to read. The 40 lp grating was clear and clean in both the white on black and black on white gratings.

The Panasonic digital image was clear from a 3 metre viewing distance but was subjectively not smooth. Close up there were obvious artefacts and the réseau was visible. The 20 lp grating was just about visible as lines - better on the white on black - but higher resolutions could not be resolved, dissolving into artefacts and “mush”. The 14 lp grating was reasonably clear but with some artefacts. Text was readable but unclear and “blocky”. ...

The results for the Toshiba were broadly similar but with detail differences: The resolution cut off point on the Toshiba was much sharper with the 14 lp grating fairly clear particularly on the vertical white on black grating but with a complete absence of information on the 20 lp and above. Within its resolution limit however there seemed to be fewer artefacts. In contrast the Panasonic showed something in the 20 lp grating although it could be artefacts!

The réseau was very clearly seen. Probably the Panasonic smoothing filter made it less noticeable on that machine (as intended).

From a 3 metre viewing distance the Toshiba picture appeared rather more slide like (but a low res slide!) than the Panasonic with more acceptable colour rendition (although still considerably more blue than the projected slide) and a smoother image.

Text on the screen was somewhat clearer [on the Toshiba](#) than on the Panasonic and therefore marginally easier to read.

5. Display Modes and Data formats

Slide projectors display within a square (1:1) viewing space. This ensures that portrait and landscape images are in the same proportions for equal impact. Digital projectors invariably use horizontal formats and non-square aspect ratios. Therefore, in order to emulate slides, digital images need to be framed within a square space which results in unused pixels. This limits the number of vertical pixels in landscape images and horizontal pixels in portrait images, which further reduces the maximum line-pair resolution and sharpness. [A table of projector modes and resolutions is a supplement to this paper.](#)

6. Projector Technologies

[\(Descriptions of LCD, DLP, LCOS omitted here\)](#)

7. Conclusions

The data predicts that a vertical resolution of 720 pixels is enough to display the 14 lp grating but insufficient to render the 20 lp grating correctly. Interference artefacts are bound to occur and both these expectations are borne out by the A/B subjective test. It seems that we would need a projector resolution of say 2400 x 1800 or higher to compete with slide projector image sharpness.

The highest resolution, commercially available projectors are currently UXGA (1600 x 1200) and are prohibitively expensive. New Projectors from CANON using LCoS technology are delivering resolutions of 1400 by 1050 with no visible réseau but they are priced higher than their LCD and DLP counterparts.

Digital projectors that are currently affordable by the average camera club cannot compete on image quality with a good 35mm slide projector. Their quality is adequate for workshops, A.V.'s, demonstrations, and lecture illustration, but for competitions, particularly external competitions, they are not capable enough to take over from slide projectors. Writing digital images to slide film using a professional lab service offers an interim solution until high resolution digital devices become affordable.

However for the future and probably as a current adjunct to slide technology the advantages that digital projection can offer should be summarised:

- Digital competition will open up opportunities for photographers who create digital images but who do not have the skill, equipment, or budget to compete in print competitions.
- Digital provides a universal format for scanned film, scanned slides, scanned prints, original digital images and processed images.
- Focus is typically consistent for all images, i.e. no focus drift, incorrect focus or change of focus due to warped slides.
- No dirt or scratches can accumulate on an author's work.
- There is potential to use e-mail or file sharing to eliminate media costs and consumer waste.
- Using digital competition software, titles and scores can be automatically calculated and displayed.

Appendices

Display mode data relating to section 5.

Editorial Comments.

In an introduction to this paper, not included here, Bill Cooper points out that standard human visual acuity is perception of an object subtending 1 minute of arc. At a distance 'r' metre, this is an object size of $0.291r$ millimetre. On a 2m wide screen, each pixel of a 1024 wide image is 1.95mm, which predicts that such a pixel should be distinguishable when viewed from nearer than 6 or 7 metres. Given typical viewing distances of projected images at Club level, this in turn suggests that XGA is a long way below requirements. Is this a realistic conclusion?

At 1m viewing distance, I cannot really distinguish the individual markings on a millimetre ruler, let alone imagining markings of 0.3mm. Physiological acuity also depends on contrast. Typical photographic images do not consist entirely of sharp contrast edges, and oversharpened images just look unpleasant. The most testing situations may be (1) a stuck pixel in a plain area of the image, or (2) a sloping line with alias effects. Otherwise, the typical defects of human vision, suggest that XGA is a reasonable resolution for projected images. Close inspection of an XGA image is agreed not desirable, not only for the pixellation, but for the chicken-wire effect clearly visible between the

pixels especially on an LCD projector. It is as reasonable to rely on the physiological deficiencies of viewing static images, as it is to rely on such deficiencies, including persistence, to make moving images feasible.

We may also be concentrating too much on the projector, since the graphics card is also very important in rendering the image. Looking at the specifications and test reports on modern high quality graphics cards shows the huge investments made in processing algorithms on cards to improve rendering, and aliasing. The Third Interim Report of the Technical Standards Committee (3IR) remarks on how authors and event organisers share the processing load on the image data as the image passes from capture to display. Event organisers need to be aware of why and how they might processing image data, especially if that processing could degrade the image. Sizing is processing which should be done by the author. Colour profile management should be done by an organiser, and profiling works at the individual pixel level. Anti-aliasing on the graphics card works on multiple adjacent pixels: it is changing the author's image selectively and unpredictably, even if the end result may be perceived as a better projected image.

In Bill Coopers research, there is no description of how the images were sized for projection. Were they sized and optimised first, or was there reliance on scaling algorithms in the projector itself? He scanned the test slide at 2900 ppi. When I resampled the image to 1024 pixels wide, using the preferred bicubic interpolation method, the result was at least as bad on my monitor as when it was projected (comparison with sample images not included here). The lack of resolution was therefore not due to the projection process itself.

There is no description of the graphics cards driving either projector, nor the settings of the graphics drivers. No amount of processing can ever add useful data to an image. As can be seen by resampling the images before projection (above), graphic driver settings may not have helped in this case. Even so, the issue of graphics drivers and their settings is merely unexamined rather than settled.

Table by Bill Cooper of XRR PS (CACC). Edited by mbs

Data on Projector Display Modes, Formats, and File Sizes (24 bit RGB BMP)															
Display mode	XGA	XGA square	2:3 image XGA portrait	WXGA (720p)	WXGA	SXGA	SXGA+	SXGA+	SXGA+ square	3:2 image SXGA+ portrait	UXGA	WUXGA (1080p)	WUXGA	2K	4K
Resolution (pixels) (1)	1024x768	768x768	512x768	1280x720	1366x768	1280x1024	1365x1024	1400x1050	1050x1050	700x1050	1600x1200	1920x1080	1920x1200	2048x1080	4096x2160
Aspect ratio (horiz:vert) (2)	4:3	1:1	2:3	16:9	16:9	5:4	4:3	4:3	1:1	3:2	4:3	16:9	16:10	~19:10	~19:10
Pixel count (megapixels)	0.79MP	0.59MP	0.39MP	0.92MP	1.05MP	1.31MP	1.40MP	1.47MP	1.10MP	0.74MP	1.92MP	2.07MP	2.3MP	2.2MP	8.8MP
File size (megabytes) (8)	2.25MB	1.69MB	1.13MB	2.64MB	3.00MB	3.75MB	4.00MB	4.21MB	3.15MB	2.10MB	5.49MB	5.93MB	6.59MB	6.33MB	25.3MB
CRT monitor	Y					Y					Y				
LCD monitor	Y				Y	Y		Y	Y	Y	Y		Y		
Business/multimedia projector	Y	Y	Y			Y		Y	Y	Y	Y				
Widescreen projector				Y	Y							Y	Y	Y	Y
NOTES (see below)		3	4	6	5		5		3	4		6		7	7

1. Screen modes below XGA such as VGA, SVGA and SVGA+ are ruled out as too low in resolution for large screen, photographic images.
2. Four-thirds Forum (Olympus/Kodak/...) have adopted a 4:3 aspect ratio as standard for cameras.
3. Square formats are required for equal size presentation of portrait and landscape images. This results in unused or wasted pixels of 25% and 44% for XGA and WXGA respectively.
4. This indicates the effective size of a 2:3, 35mm style full-frame portrait image displayed in a square format space.
5. 1366x768 and 1365x1024 do not compute exactly to the closest corresponding aspect ratios, 16:9 and 4:3.
6. 720p, 1080p, etc are television standard descriptions
7. 2K and 4K are cinema standards defined by the Digital Cinema Initiative (DCI). Various aspect ratios are possible, including 2.39:1(scope), 1.85:1(flat) and 16:9(HD).
8. File size in BMP format does not include overhead for an embedded colour profile as would/should be included in TIF format files.

For comparison with prints, A4 series paper (ISO 216) has an aspect ratio of v2:1 which approximates to 10:7 or 16:11.