Evaluating print image quality for small and large format digital printing processes

Source: LFP-Designer Guide

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Backup ⇒ Details

Agenda

1. Who and what is Fogra?
2. From ISO 12647-x to ISO 15311-x
3. Digital press categorization
4. The ISO 15311-1 concept [backup]
5. Image appraisal types (for digital printing)
6. The challenges for image quality assessment
7. Measurement Details
8. Der Fogra PSD
9. Ausblick

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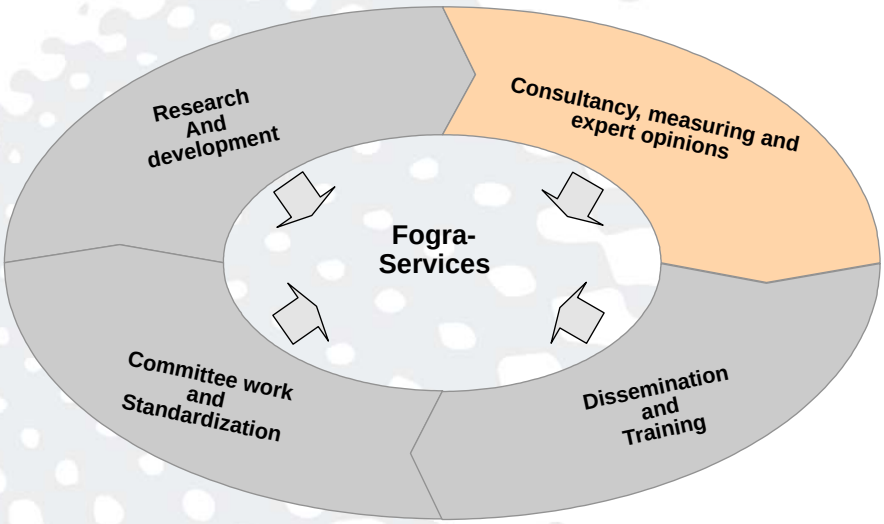
1. The industry needs independent research

- In 1951 the german printing industry (small and medium enterprises) decided to put some money together
- Aiming for an “lawyer of the printer” - an manufacturer independent organization
- Fogra stands for “Forschung im grafischen Gewerbe” - research in the graphic arts
- Similar organizations in US (GATF), UK (PIRA), Switzerland (Ugra), Spain (AIDO), etc
- Fogra is “governed/owned” by its members (including the board of directors) ⇒ neutrality
- Fogra is financed (ca. 5 Mio turnover) by
  - 1 Mio. membership feeds
  - 2 Mio. research funds from the country/state/EU (based on extensive application)
  - In order to compensate for the remaining losses, Fogra provides regular services such as control wedges, certifications, symposia etc

ICC Digital Print Day, June 15th, 2011

1. Fogra - the service provider in the graphic arts industry



Fogra, active in four fields of activities

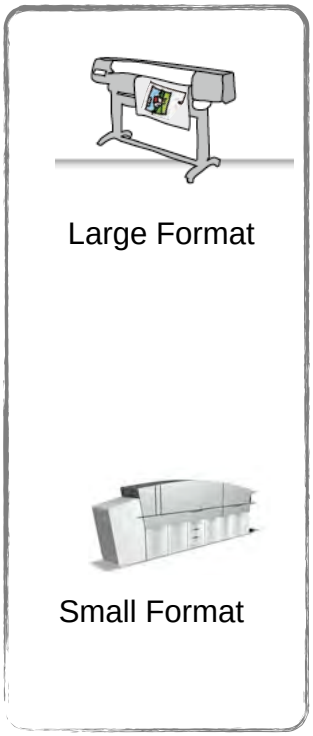
2. From ISO 12647-x to ISO 15311-x (see Craig)

- From technology dependent categorization to uses cases
- Providing more quality levels to better reflect industry practices
- Providing three types of image appraisal
  - Identical colours (CIE 1931 match⇒ sidy by side)
  - Media-relative colours (reflect to need to switch of paper simulation by achieving a similar result ⇒ small gamut differences
  - Common Appearance (consistent colour reproduction among different output gamuts
- Straddle between a finally published ISO standard and the industry need to quickly provide guidelines
- It is up to us to help make this happen, if not, we will probably be unwillingly participating to the decline of the printed media.

3. Digital press categorization

A plethora of categorization principles are doable

Format



- Imaging process
  - Inkjet (sled), rarely Toner (e.g. Kip 80)
- Colorants (based on size, quality and use case
  - water-based, solvent, UV, Latex und sublimation
- Format
  - up to 1,5 m [LFP], to 3 m [Wide], > 3 m [Super Wide]
  - Roll ⇒ Roll, Sheet/boards
- Productivity [m^2/h]
  - up to 600 m^2/h ⇒ Quality versus Production

- Imaging process
  - Electrofotography and Inkjet (Single Pass)
- Colorant
  - Toner (liquid and dry), ink
  - black/white, colour
- Format
  - Sheet: max. 364 x 521 mm (iGen 4)
  - Roll to Roll: max. Width 60 cm
- Productivity
  - “Lite”, “Middle”, “High” and “Ultra High” Production

4. The ISO 15311-1 concept [Backup]

… taken from ISO 15311-1 - Intro

…. The evaluation of perceived image quality in prints, through the definition of measurements of print quality attributes that correlate with visual perception, even when the print samples span across many printing technologies, i.e., technology-independent measurements is an active field of research and complex due to the subjectivity and dimensionality. It is influenced by a number of different quality attributes. It is often difficult and complicated to evaluate the influence of all attributes on overall image quality, and their influence on other attributes.

4. ISO 15311-1 content and scope

1 Scope

This part of ISO 15311 defines and explains print quality attributes and associated test criteria for ensuring similar visual characteristics of the printed matter when the same digital image file is printed by a variety of digital printing systems. It serves as the framework for the following parts, which address particular use cases and provide specific values or conformance levels if deemed appropriate.

4. Laboratory and Practical criteria

		Laboratory	Practical
4.3.2	**Colour and surface finish**		
4.3.2.1	Requirements of unprinted substrate	?	?
4.3.2.2	colour accuracy requirements		
4.3.2.3	Consistent reproduction of tone values		
4.3.2.4	Ink Set Gloss		
4.3.2.5	Further criteria		
4.3.3	**Homogeneity**		
4.3.3.1	Streakiness		
4.3.3.2	Background Haze	?	?
4.3.3.3	Graininess and Mottle		
4.3.3.4	Fill (caries)		
4.3.3.5	Inking variation across the format and within the printing direction		
4.3.3.6	Further criteria		
4.3.4	**Resolution**		
4.3.4.1	Line Width		
4.3.4.2	Native Addressability		
4.3.4.3	Effective addressability		
4.3.4.4	Raggedness		
4.3.4.5	Blurriness	?	?
4.3.4.6	MTF (Modulation transfer function)		
4.3.4.7	Register		
4.3.4.8	Patterning		
4.3.4.9	Further requirements		
4.3.5	**Artefacts**		
4.3.5.1	Contouring	?	?
4.3.5.2	Spreading (misdirected dots, satellites)		
4.3.5.3	Use case specific criteria		

dedicated criteria for systems, sites & printer

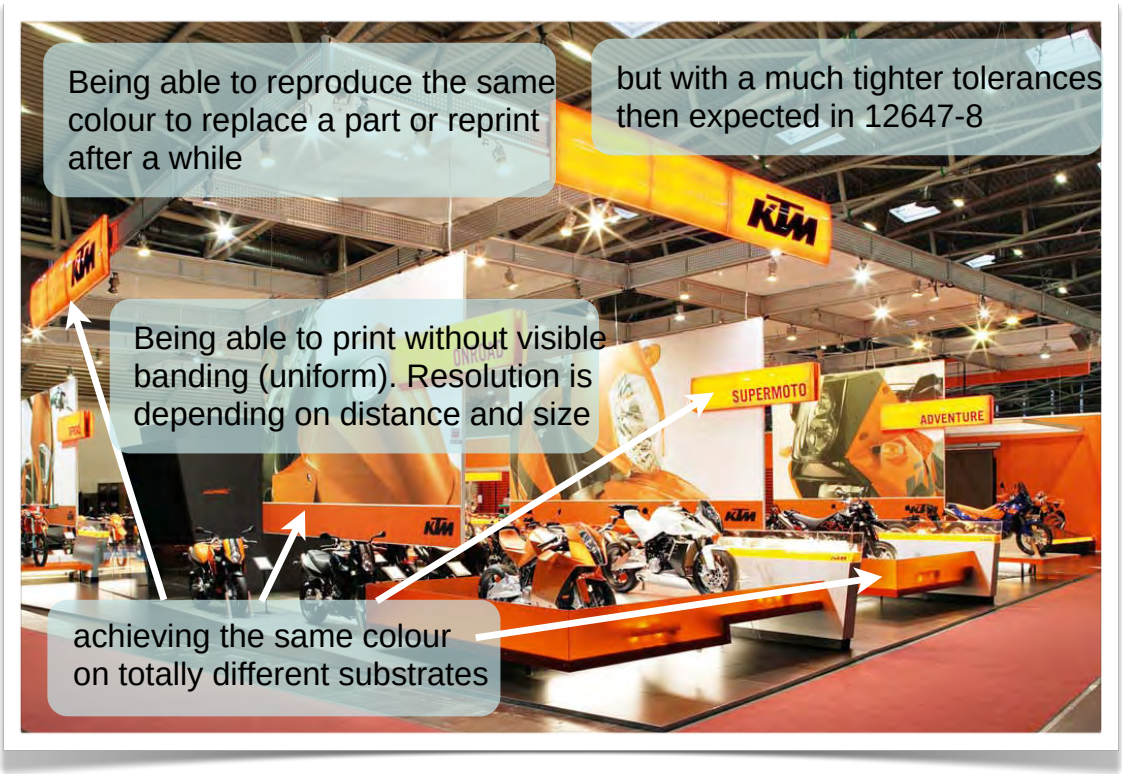
4. Typical uses cases versus complex client needs

- Workflows that differ in the degree of flexibility can lead to the possibility of uncertainty or error.
- Data and associated information shall be enough/ready for final print production
- Try to restrain from paragraphs such as 4.2.4.2 of ISO/DIS 12647-6

“Verification of the accuracy of these values shall be based on agreement between provider and receiver concerning the measurement system to be used, including any relevant settings and conditions, for measuring dot area on the printing forme. This requires that the control patches be exposed independent of the image content.”

The exchange of data and meta-data (communication) should not require no prior knowledge of the sending and receiving environments (“blind” exchange)

5. Digital Printing - Types of image appraisal



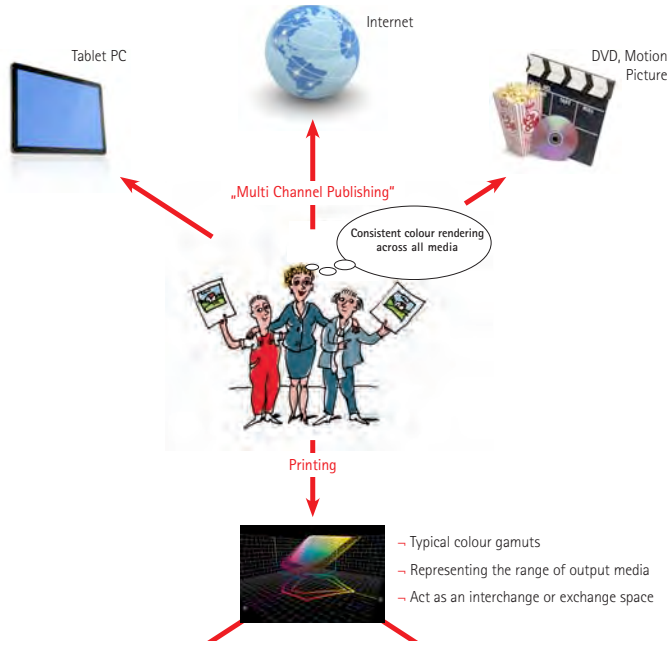
5. Colour Reference concepts

fogra at drupa 2012 printing theexpected

What is the expectation?

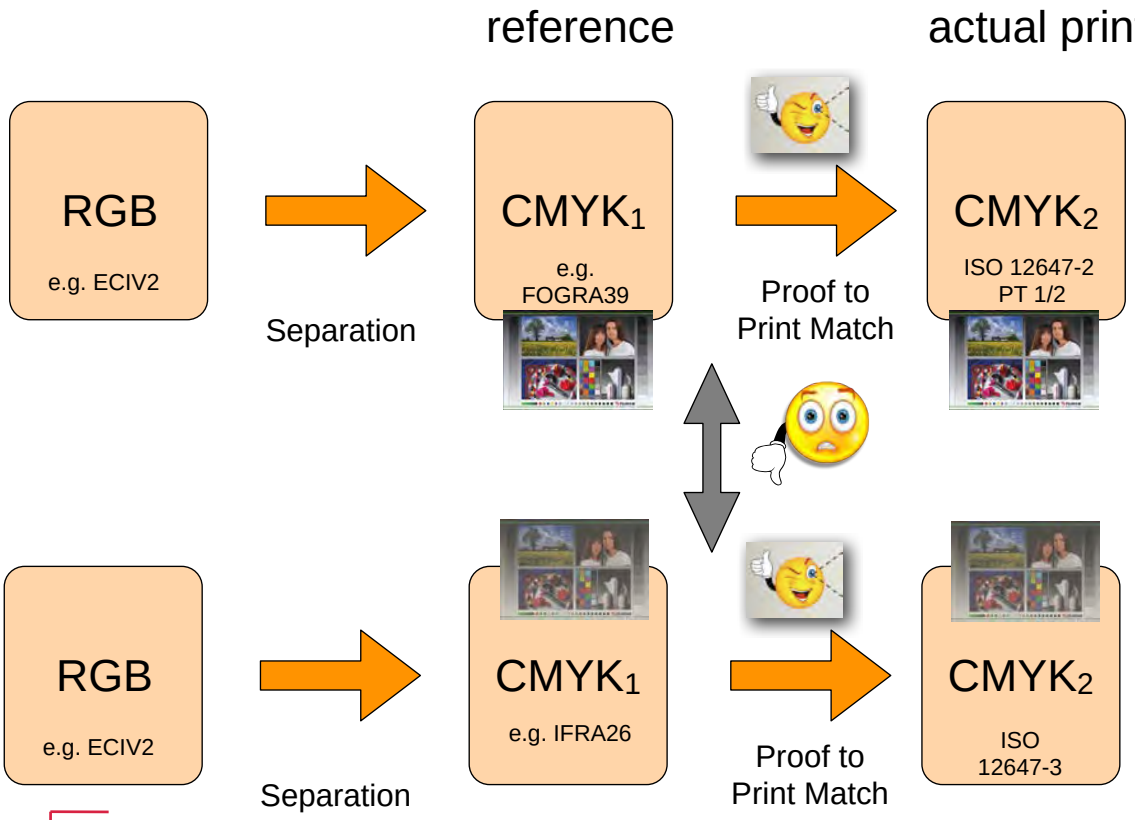
Predictability [Consistency] of the colour results in the creation phase

ISO 15930-7: permit the predictable dissemination of a compound entity to one or more locations.



Conventional Printing Digital Printing

5. Common appearance in a nutshell



5. ISO 15311 provides 3 levels of predictability

Identical colours

¬ Proofing [ISO 12647-7]
¬ Validation Print [-8]
¬ PSO ISO 12647-2
¬ PSD ISO 15311-x

⇒ Side-by-Side

media-relative colours

¬ PSD ISO 15311-x
¬ small gamut-difference between ref. and print

⇒ Comparison w. memory

consistent colours

¬ PSD ISO 15311-x
¬ “Common Appearance”
¬ große Gamutunterschiede

⇒ Side-by-Side

Predictability of the final colour upfront

Full Colour Ref - Absolute | Full Colour Ref - Media Relative | Partial Colour Ref.

6. Challenges for image quality assessment

„When you can measure what you are speaking about and express it in numbers, you know something about it"

Lord W. T. Kelvin, Lecture to the Institution of Civil engineers, London, 3 May 1883

→ We need objective measures
(if possible based on agred upon standards)

„The ultimate test of any colour reproduction is the opinion of the person who views it. But opinions differ..."

R. W. G. Hunt. In: The reproduction of color

→ We need to focus on use cases which provides (full) reference (contrary to no reference)

6. How is print image quality define so far?

ISO 12647-7/8

- 1,2,3 - Scope, normative references, terms & definitions
- 4 - requirements
  - 4.1 data
    - data
    - halftone
  - 4.2 digital print
    - substrates
    - coloration
    - rub resistance
    - ink set gloss
    - reproduction limits
    - tone value repro
    - vignettes
    - resolving power
    - margin info
    - gamut
- 5 - Test methods
  - 5.1 control strip
  - 5.2 test objects, measurements, visual
- Annexes [A: metal slab | B: Certification]

6. The famous image quality circle

The general definition of image quality modeling is the creation of a mathematical formula that is capable of predicting human perceptions of quality

1999, Engeldrum, Image Quality Modeling

- Try to separate to overall image perception into appropriate “Nesses”
- Use cases (advertisers and print buyer requirements balanced with technical realizability) ⇒ customer rating
- Use either a comparison to a reference (e.g. the printing condition such as FOGRA39) or an absolute assessment (e.g. the evaluation of graininess or homogeneity)
- An image quality model and the technology variables are not explicitly needed

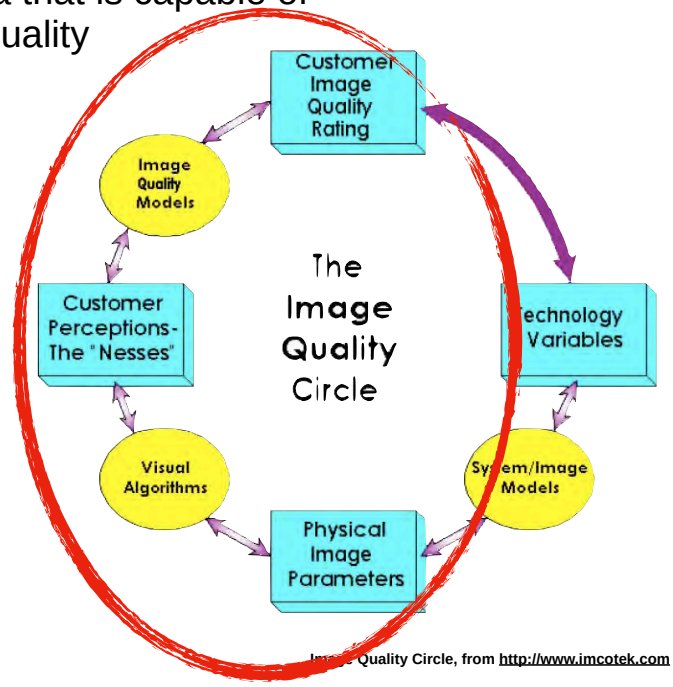


Image Quality Circle, from http://www.imcotek.com

6. Categorization of the “Nesses”

Colour reproduction

Uniformity

Resolution

Artefacts

Permanence

Health, Safety, Environment

System

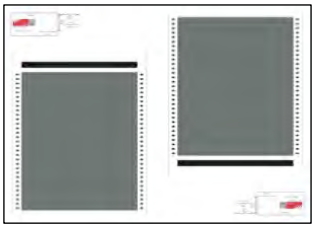
Functional performance

- Productivity
- “Memory”
- on site reliability
- one copy vs. light production

7. Image quality attributes in details

concept: Individual attributes contribute to a recognized overall image quality. (compare the rating of food)

Colour



Homogeneity

Perceptual Resolution

Artefacts

+ individual needs

7.1 Evaluation of the colour reproduction

- Different tolerances for the three quality levels
- Different tolerances for spot colours
- Appropriate tolerances for the image appraisal types (identical and media-relative)
- Common appearance to be added later

Table 1: Deviation tolerances for FCR-Side-by-Side reproductions.

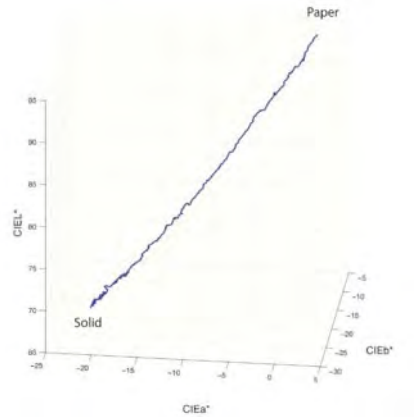
Patch in digital printing form	Level C	Level B	Level A
Patch f) of 5.2 for substrate	$\Delta E^*_{ab} \le 5$	$\Delta E^*_{ab} \le 4$	$\Delta E^*_{ab} \le 3$
All other patches of 5.2	Maximum $\Delta E^*_{ab} \le 12$ Average $\Delta E^*_{ab} \le 5$	Maximum $\Delta E^*_{ab} \le 10$ Average $\Delta E^*_{ab} \le 4$	Maximum $\Delta E^*_{ab} \le 8$ Average $\Delta E^*_{ab} \le 3$
Patches a) of 5.2 (C,M,Y,R,G,B)	Maximum $\Delta H^*_{ab} \le 6$[a]	Maximum $\Delta H^*_{ab} \le 5$[a]	Maximum $\Delta H^*_{ab} \le 4$[a]
Patches d) of 5.2	Average $\Delta C_h \le 4.5$[b]	Average $\Delta C_h \le 3.5$[b]	Average $\Delta C_h \le 2.5$[b]
For extended scrutiny only.			
Outer gamut patches of as defined in ISO 12647-8	Average $\Delta E^*_{ab} \le 8$	Average $\Delta E^*_{ab} \le 6$	Average $\Delta E^*_{ab} \le 4$
All patches of ISO 12642-2	Average $\Delta E^*_{ab} \le 8$ 95 % percentile $\Delta E^*_{ab} \le 8$	Average $\Delta E^*_{ab} \le 5$ 95 % percentile $\Delta E^*_{ab} \le 7$	Average $\Delta E^*_{ab} \le 3$ 95 % percentile $\Delta E^*_{ab} \le 6$

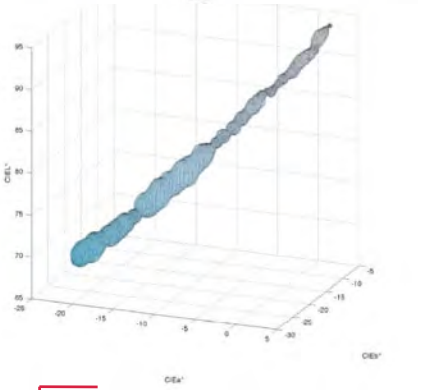
[a] Due to the sign character of ΔH the absolute values ought to be used before averaging

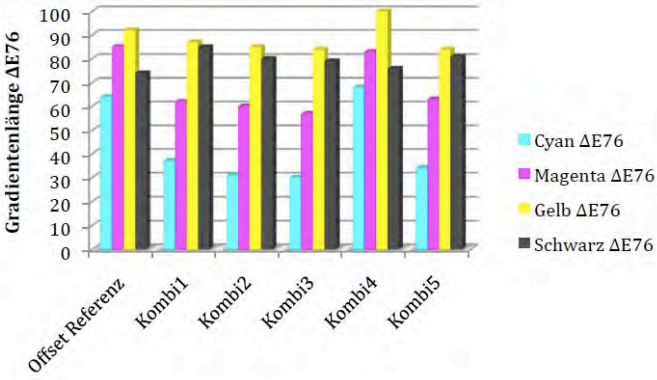
[b] ΔC_h is the CIELAB chromaticness difference between two colours of approximately the same lightness projected onto a constant lightness plane in the CIELAB colour space. This is calculated the same way as ΔE_c stipulated in ISO 12646.

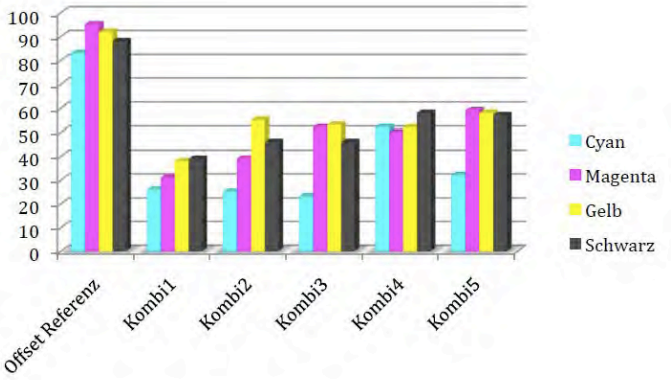
current candidate of ISO 15311-2

7.1 Colour: Number of visual & technical discernable tonale steps

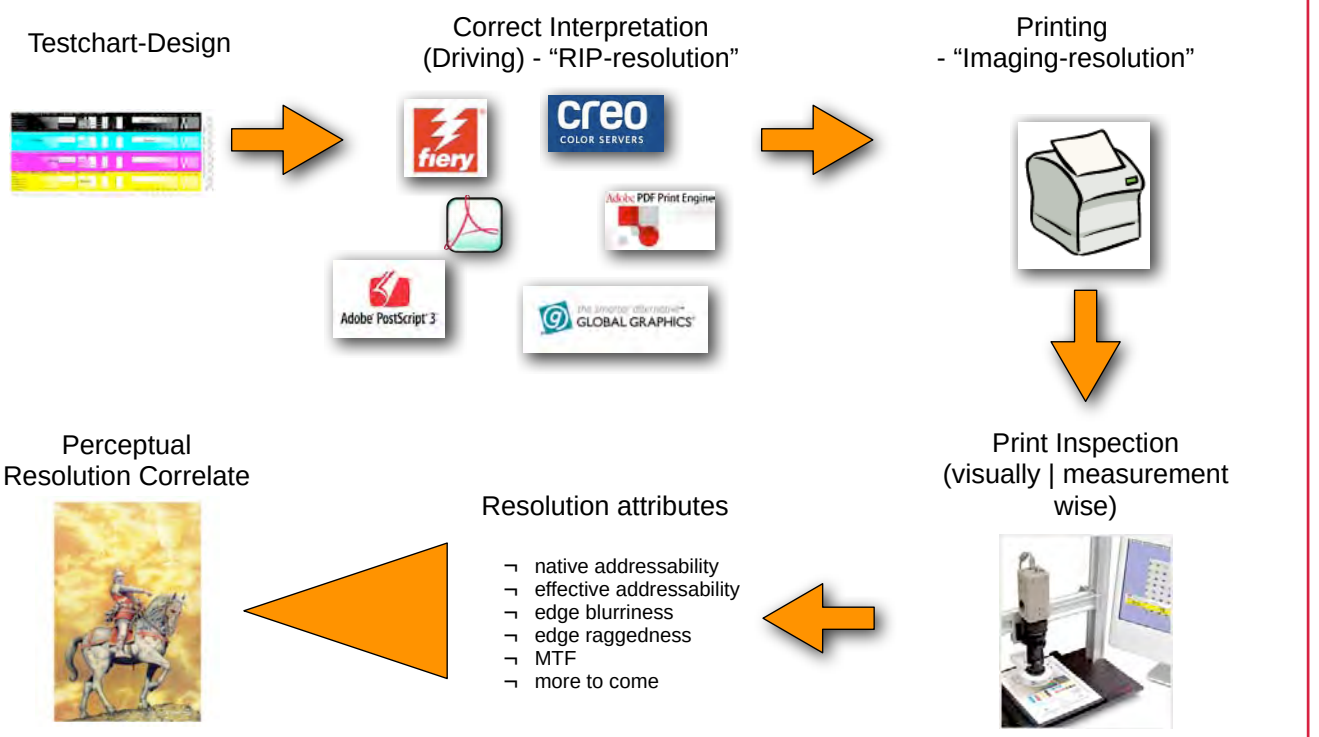






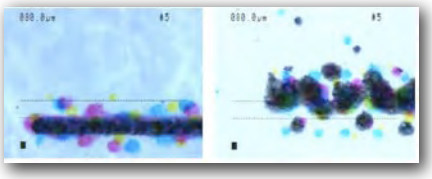


7.2 Perceptual resolution - concept



7.2 Perceptual resolution - mis-registration

- Different tolerances for the pertinent quality levels
- edge blurriness and edge raggedness, MTF etc
- legibility



Registration Type	Quality Level		
	A	B	C
Misregistration	<= 80 µm	> 80µm <= 120 µm	> 120 µm <= 160 µm
Front/Back register	<= 100 µm	> 100 <= 200 µm	> 200 <= 300 µm
Form register	N.A.	N.A.	N.A.
Crop mark	<= 100 µm	> 100 <= 200 µm	> 200 <= 300 µm

Table 1: Registration tolerance for the three quality levels.

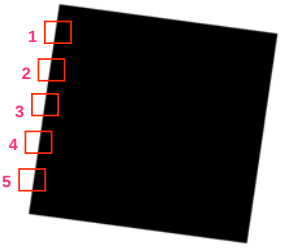
ISO 15311-2 candidate

7.2 Correlates tested so far at Fogra

- Edge Sharpness (inverse of blurriness)
  - a measure of the average edge profile transition width in the direction perpendicular to the edge
  - using the square

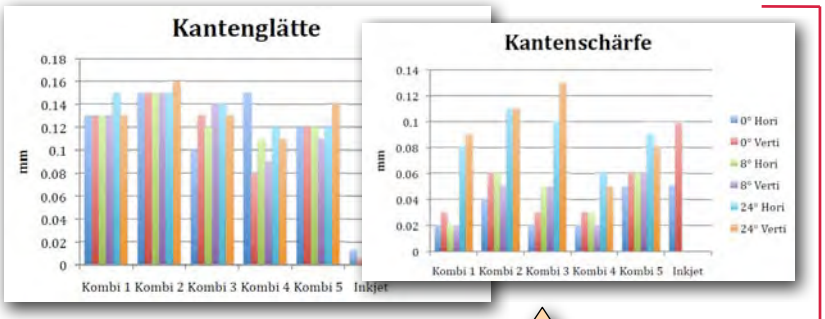
- Edge Raggedness
  - a measure of the average edge profile variation (50%) in the direction parallel to the edge
  - using the rotated squares with 8 degree

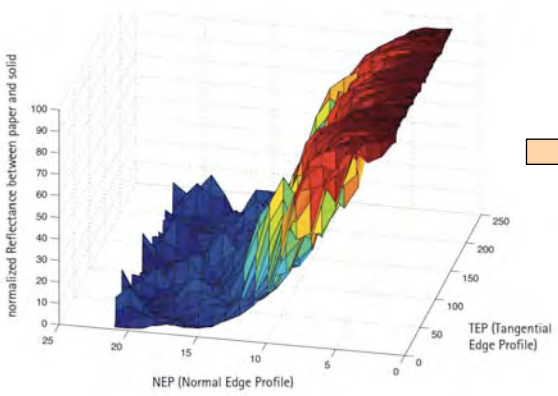
JTC1, SC28 WG4 works actively on these measures
- Further fine tuning is needed
- Round robin tests are underway
- Practical aspects of scanner influence, repeatability and reproducibility are yet to be evaluated

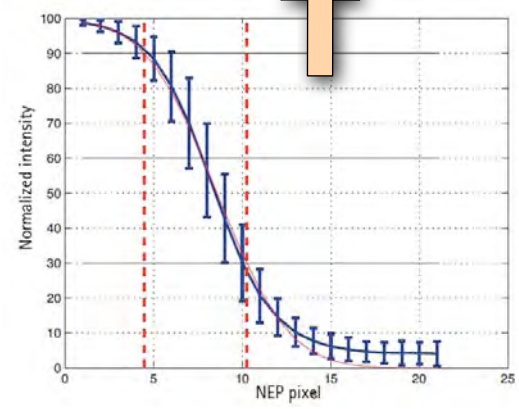


7.2 blurriness and raggedness in detail

Scan







Kodak Prosper 5000:
Blurriness: 0°: 0.059 mm 90°:0.168 8°: 0.065 mm
Raggedness: 0°: 0.011 mm 90°:0.013 8°: 0.009 mm

7.3 Evaluation of homogeneity

Homogeneity (uniformity) ⇒ subjective impression of colour uniformity across a large image that is intended to have a uniform colour.

Refers to all types of colour variation:

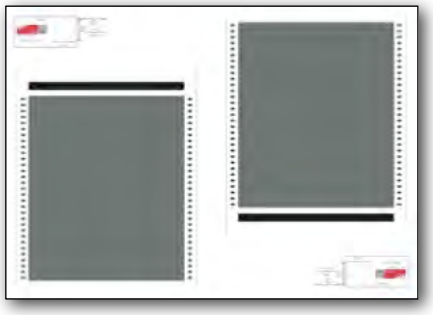
¬ lightness, hue, saturation

¬ derivatives of these measures separately or in combination

Variation geometry:

¬ 1D, 2D, periodic, aperiodic, localized, large-scale, and small-scale variation, separately or in combination such as streaks, bands, gradients, mottle, graininess and moiré.

7.3 Evaluation of homogeneity



⇒ Development of M-Score: ⇒ 0 .. 100

1. Compute the CIELAB colour differences ΔE00 between neighbouring patches

$$\Delta E_{row\ j} = 10 \times \sum_{i=1}^{n-1} \Delta E\left(Lab_i, Lab_{(i+1)}\right)$$

$$\Delta E_{column\ i} = 10 \times \sum_{j=1}^{m-1} \Delta E\left(Lab_j, Lab_{(j+1)}\right)$$

2. Sum measurements for rows and columns and normalize them.

$$\Delta E_{total} = \frac{\sum_{i=1}^{n-1} \Delta E_{column\ i}}{n-1} + \frac{\sum_{j=1}^{m-1} \Delta E_{row\ j}}{m-1}$$

3. Calculate M-Score

$$\text{M-Score} = 100 \times \left(\frac{1}{2^{\left(\frac{2-\Delta E_{total}}{15}\right)}} \right)$$

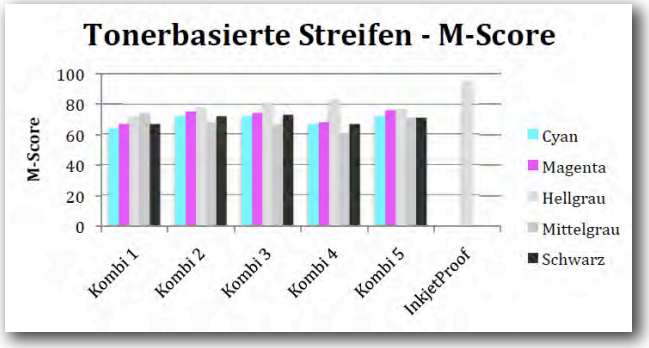
7.3 M-Score in detail

M-Score	Meaning	Comments
≥ 95	**Perfect**	Inkjetprint on proofing substrate showing no visible inhomogeneities
> 80	**Very Good**	Print with slightly visible inhomogeneities (e.g. some Mottling). No visible stripes.
> 70	**Good**	Print with visible inhomogeneities (Mottling) but almost no visible stripes.
> 60	**Satisfactory**	Mottling and stripes visible. Is still accepted by most observers.
> 50	**Adequate**	Print with clearly visible mottling and/or stripes. Acceptance is highly dependent on the printed image.
< 50	**Poor (But sellable)**	Clearly visible mottling and stripes. Not accepted as high quality print

7.3 How to use M-Score in a standard ….

	Quality Level		
	A	B	C
M-Score (dark grey tint)	>= 80	>= 60 < 80	>= 40 < 60
M-Score (mid grey tint)	>= 80	>= 60 < 80	>= 40 < 60
M-Score (light grey tint)	>= 80	>= 60 < 80	>= 40 < 60

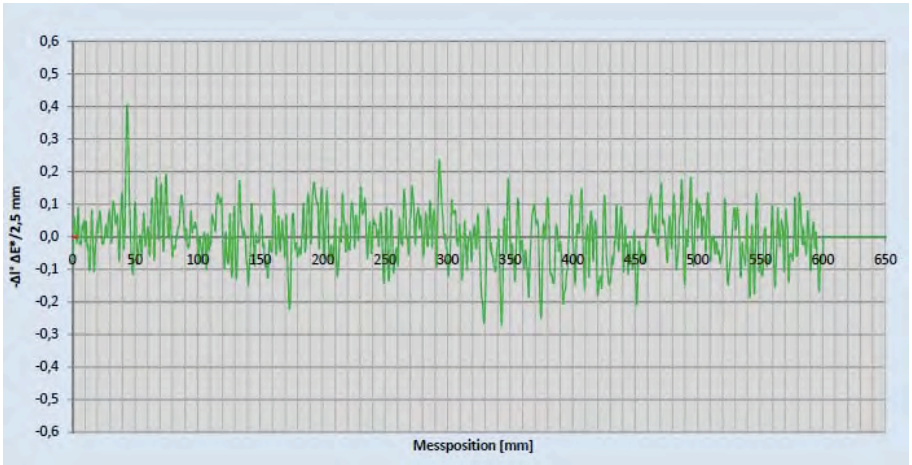
ISO 15311-2 candidate



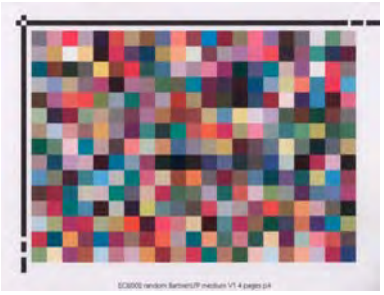
based on a evaluation of photo books (toner based systems)

7.3. Homogeneity: Next steps

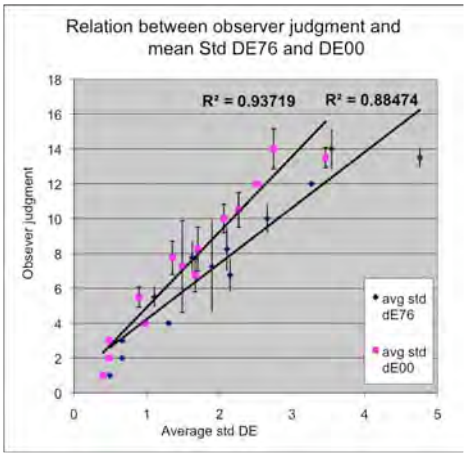
- M-Score works good for toner based systems (i.e. it correlates well with absolute (magnitude estimation) and relative scales (rank order))
- It ought to tested how much similar metrics such as ISO 13660 mottle improve the performance
- It will be evaluated also for inkjet prints
- Streaks will be evaluated by the “Offset method”



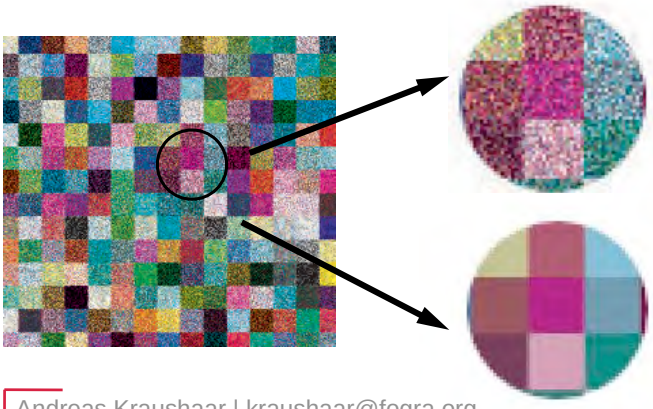
7.3. Homogeneity: One word about graininess



Rank order experiment



test charts ⇒ different levels of graininess

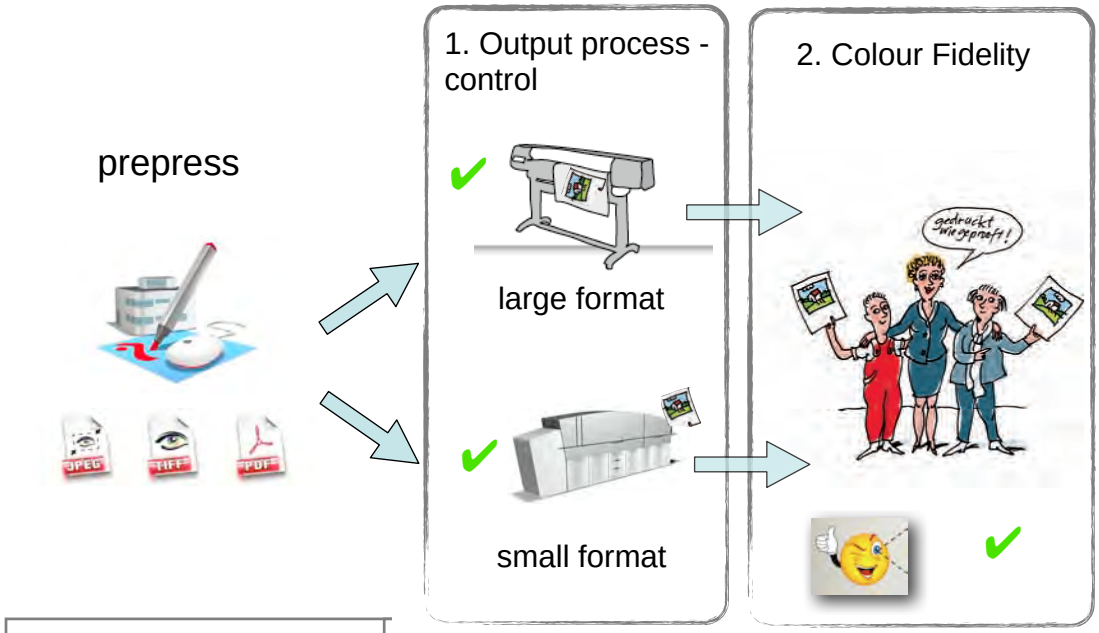


- We propose three default viewing distances (50 cm [reading], 100 cm [POP] and 1,5 m [Large Format]
- Simple evaluation of standard test chart with a standard scanner

8. Brand-new ⇒ Fogra PSD

ProcessStandard Digital PSD

8. The PSD-conzept: An overview



3. Workflow

⇒ Consistency ⇒ Match

- ✔ Preflight
- ✔ PDF/X-Creation
- ✔ PDF/X-Output
- ✔ Altona Test Suite V1 & V2
- ✔ Profile-handling
- ✔ Light-Audit

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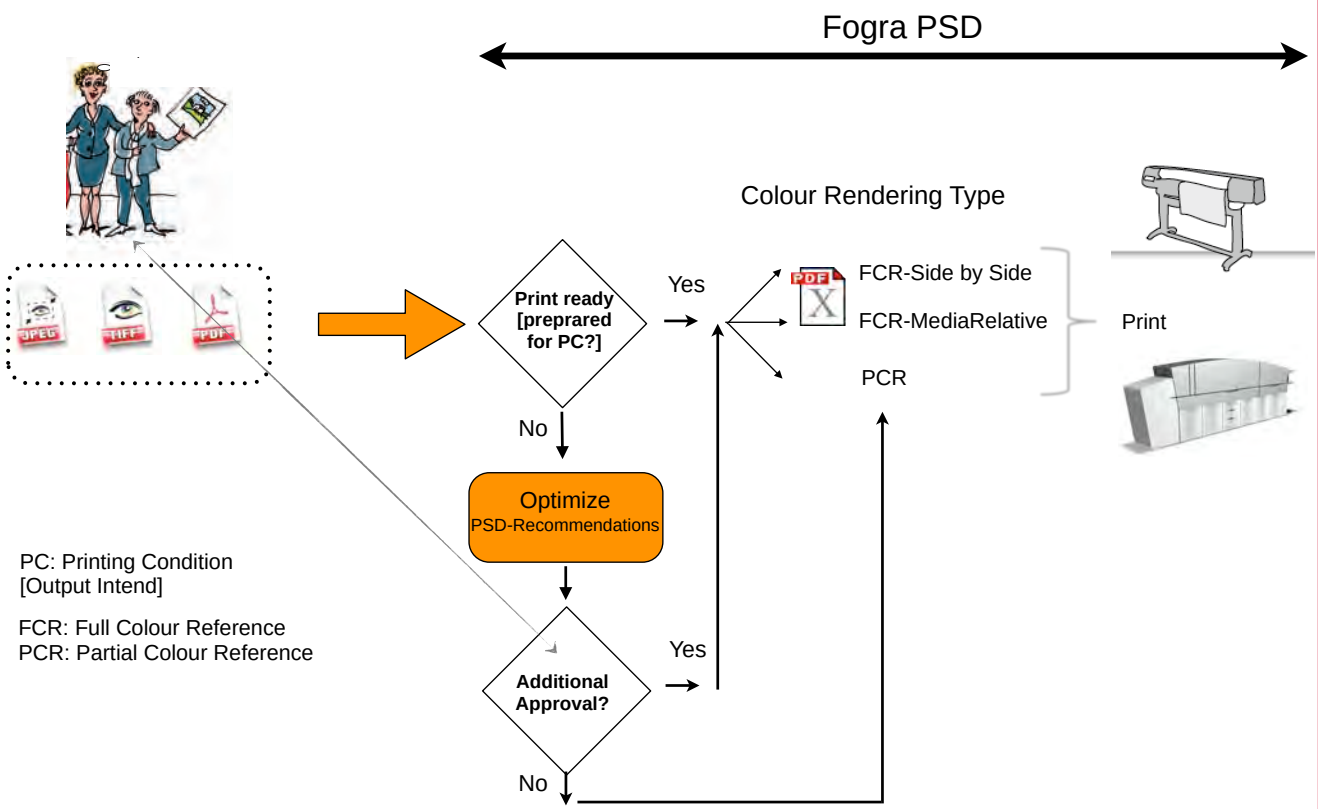
8. The PSD-workflow



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9. Together we can do it

"The best person to decide what research work shall be done is the man who is doing the research. The next best is the head of the department. After that you have the field of best persons and meet increasingly worse groups. The first of these is the research director, who is probably wrong more than half the time. Then comes a committee, which is wrong most of the time. Finaliy there is the committee of company vice-presidents, which is wrong all the time."

Dr. C. E. K. Mees
(Kodak)

The next DPWG meeting will be in wednesday Feb 1st 2012.