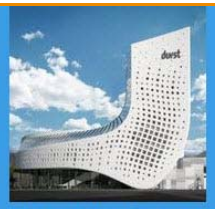
ICC COLOR EXPERTS DAY
MAY 24, 2019

Colour Management for
Wider-Format Printing
on Non-Paper
Substrates

Hosted by Barbieri Electronic



HQ Durst Phototechnik AG
Bressanone, Italy

COLOUR MANAGEMENT FOR BACKLIT APPLICATIONS

Mission:
Printing the Expected Backlit

Highlights

For later reading

CURRENT BACKLIT APPLICATIONS IN PRACTICE

- ⇨ **Different lighting technologies and SPD's**
- ⇨ **Different substrate properties (colour, fluorescence)**

Source: Thomas Liesner - Vignold

FOGRA RESEARCH PROJECT – COLOUR MANAGEMENT FOR BACKLIT MATERIALS

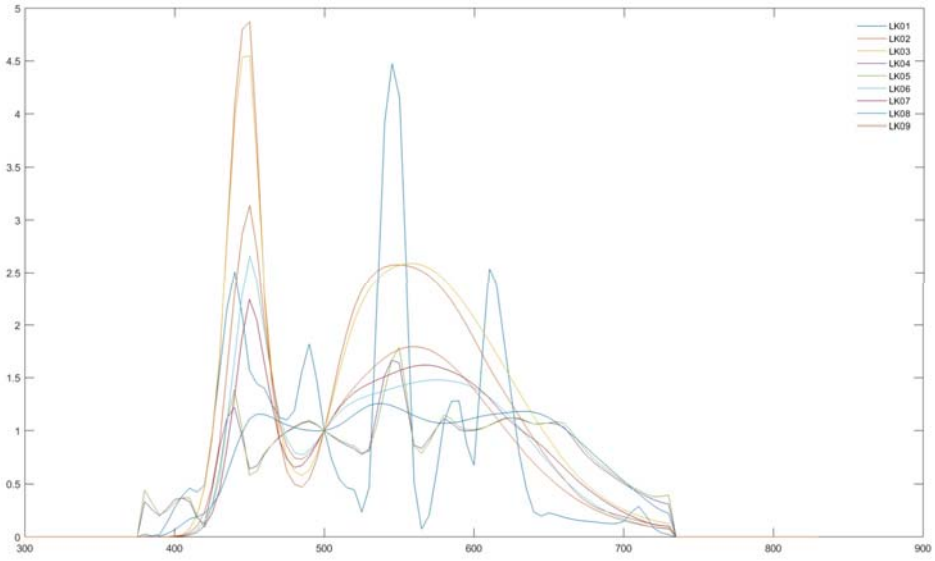
- **Concept for standardization (ISO 3664 and ISO 13655) by providing tools and guidelines for measuring, profiling and visual matching of transparent media**
- **https://fogra.org/en/fogra-research/wc-digital-printing/digital-printing-current-projects/backlit-2-623/colormanagement-for-backlit-materials.html**
- **Printing the Expected objective: adaptability to expectations**
  - Fogra ProcessStandard Digital – PSD industrial procedure
  - Fogra System and Process Check for Large Format Printing application (paused ISO project ISO/DTS 15311-3)

dp Arbeitskreis Digitaldruck
Digital Printing Working Group
Fogra

ProcessStandard Digital
fogra PSD

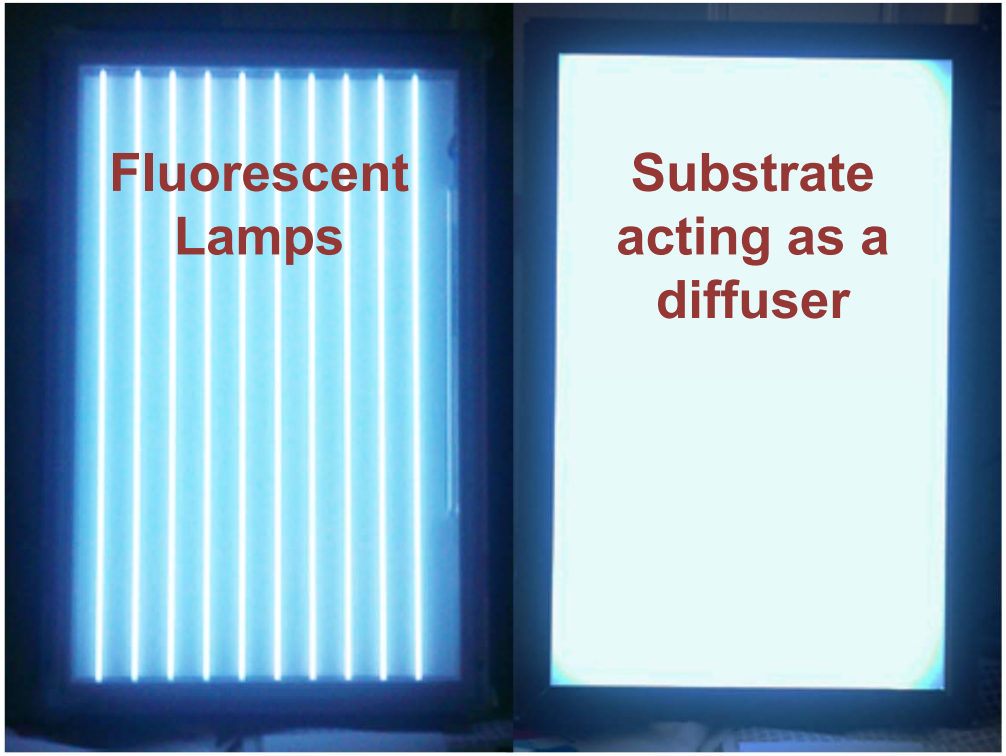
LK1..LK9 DESIGNATED LIGHTBOXES USED FOR THE PROJECT

- **Different types and with different SPD were selected to provide the backlight using various lighting technologies**
  - Fluorescent tubes (LK1 and LK5)
  - Edge lit (side) LED (LK3, LK7 w/ diffuser, LK8 w/ diffuser and LK9)
  - Backlit LED (LK2, LK4 and LK6)



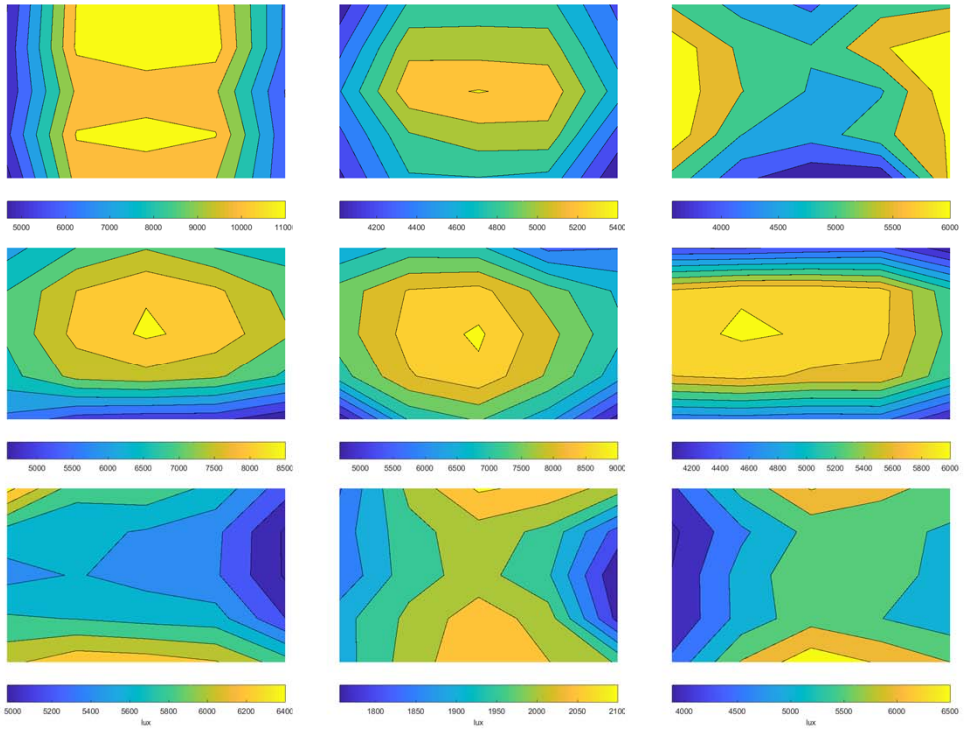
CHROMATIC ADAPTATION TO THE LIGHT BOX

- ⇨ Relative substrate measurement count toward "Measure as we see"
- ⇨ Light in the box count toward what we see



Lightbox without Substrate

Lightbox with Substrate



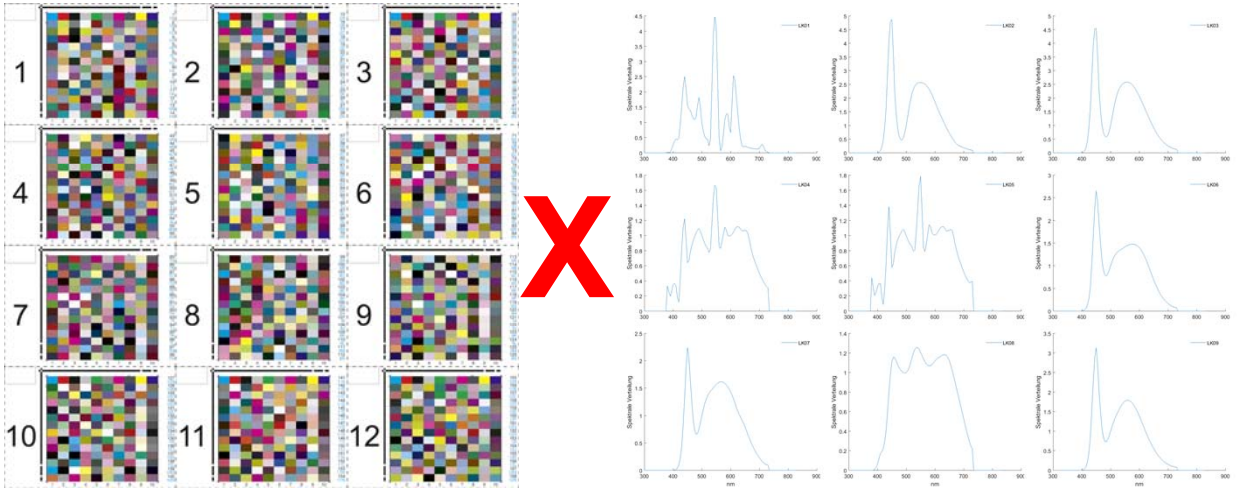
LK1..LK9 luminance variation relative to each lightbox min and max lux determination

COLOUR MANAGEMENT METHOD

⇨ **The combination of CMYK driving values with the spectral stimuli hitting the human eye is based on the additive model with the two sets being multiplied together wavelength by wavelength resulting the combined colour spectrum for each of the 1680 colour patches**

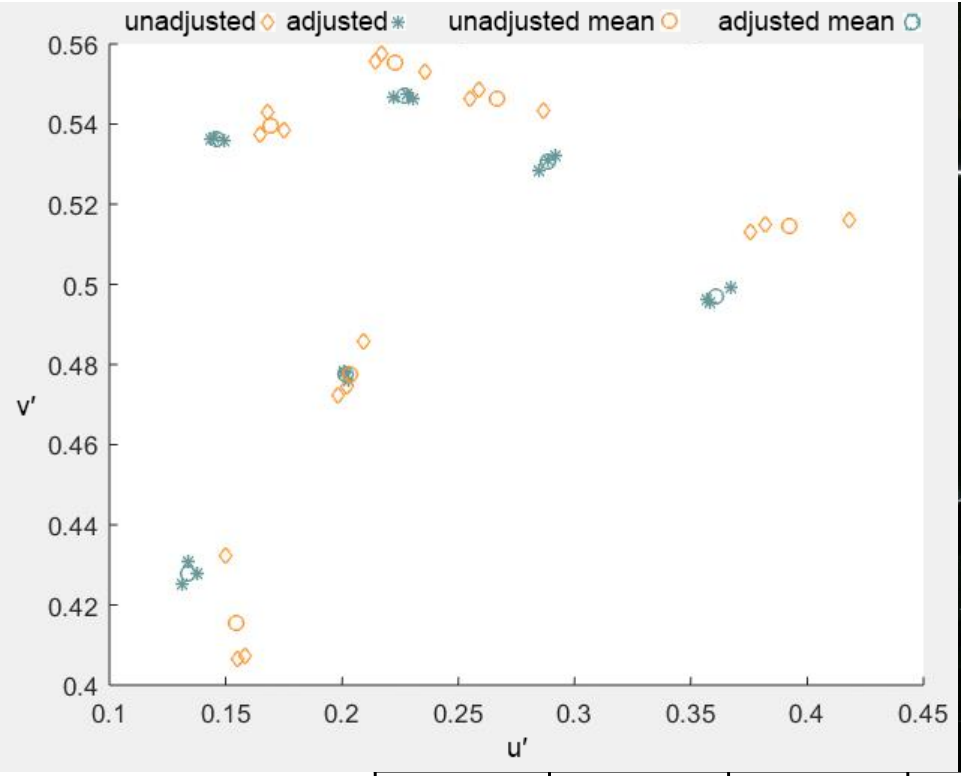
$$CS(\lambda) = T_{mr}(\lambda) \times S_{el}(\lambda)$$

λ is the wavelength, in nanometers (nm) in the available 380 nm to 780 nm range (min. from 400 nm to 700 nm range);
$CS(\lambda)$ is the combined transmittance at wavelength λ;
$T_{mr}(\lambda)$ is the media-relative transmittance at wavelength λ;
$S_{el}(\lambda)$ is the spectral power distribution of the light emitted through the substrate at wavelength λ.



VISUAL: BACKLIGHT OFF/LIGHT ON VS. BACKLIGHT ON/LIGHT OFF

CIEDE2000 (ΔE*00) MCDM FOR SELECTED HUES OF THE COLORCHECKER 24



	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Unadjusted	7.89	6.01	4.69	5.43	5.43	1.74
Adjusted	1.76	2.27	1.02	1.97	1.48	0.66

DAY – NIGHT PRINTING APPLICATIONS (BACKLIGHT OFF/ON)

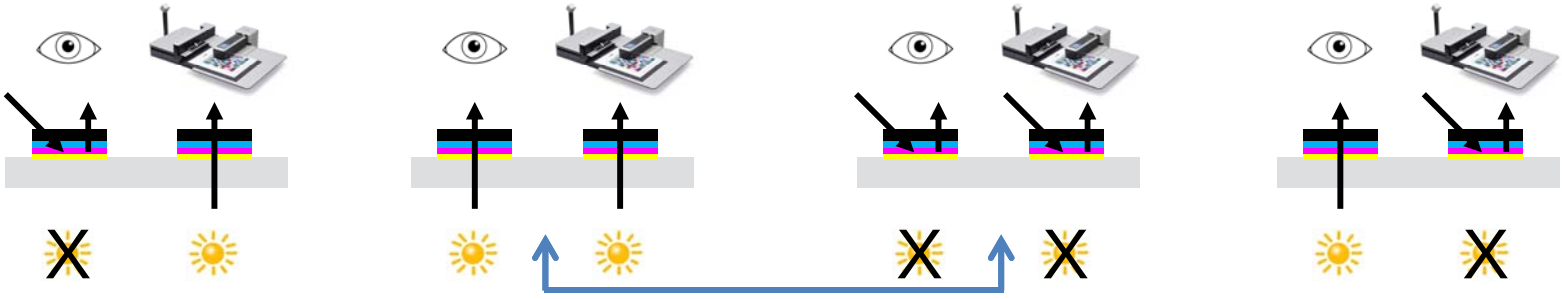
⇨ **The challenge:**

Backlight off
Transmissive setup

Backlight on
Transmissive setup

Backlight off
Reflective setup

Backlighit on
Reflective setup

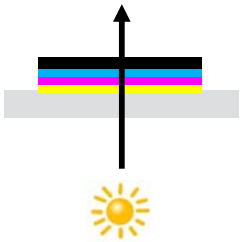


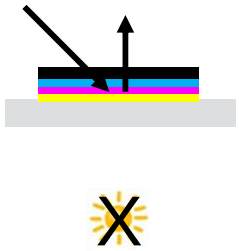
Backlight on/off – One setup to fulfill “Measure as we see”?

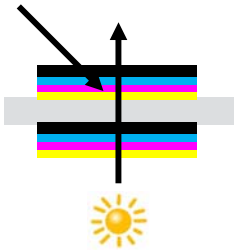
DAY – NIGHT PRINTING APPLICATIONS (BACKLIGHT OFF/ON)

- **Conclusion:**
  - Reproductions based on transmissive measurements will look correctly under backlight (light on) and too dark (no details, dull colours) under reflective light only (light off)
  - Reproductions based on reflective measurements will look correctly under reflective light only (light off) and too bright (no contrast, no chromatic colours,

Night ') unde **Day** ı) **Day / Night**







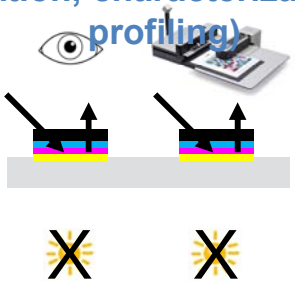
DAY – NIGHT TYPICAL APPLICATIONS IN PRACTICE

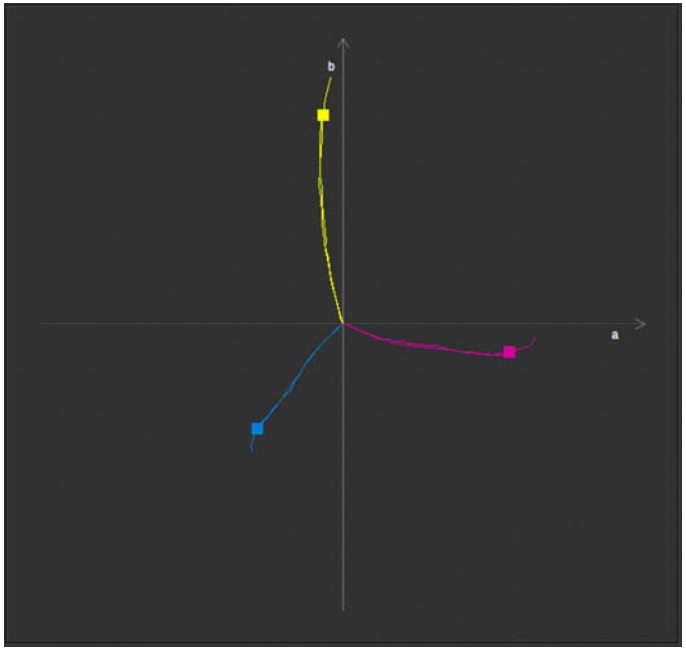
- **Double sided printing**
  - Roll-to-roll digital printing systems with double-sided print feature to allow registration of the front and back side
  - Typical substrates: Backlit PVC Banner, Citylight Paper
  - Setup mode:
    - Frontside - Reflective setup
    - Backside content is mirrored, ink is printed similar or as a fixed % of the Frontside
  - Method to do: find how to print Backside in relation to Frontside so both will match for their respective viewing condition
- **One sided printing using a white ink layer between two color layers**
  - Flatbed digital printing systems with White ink, printing with accurate positioning either as one time or multiple times over
  - Typical substrates : transparent substrates like Acrylic, Glass, Transparent SAV
  - Setup mode: Reflective setup/1st layer, White layer/2nd layer (Method to do: determine white ink % for optimum scattering), Reflective setup/3rd layer
  - Method to do: find how to print 2nd layer in relation to the 1st layer side so both will match for their respective viewing condition

COLORANT RESPONSE IN TRANSMISSION

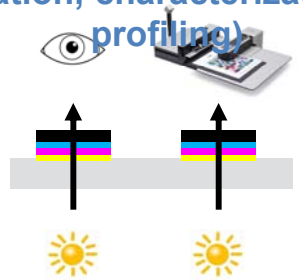
⇨ **Comparison and analysis of three setups related to the same printing combination**

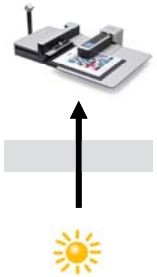
A – Reflective Frontside as reflective setup (adjustment, calibration, characterization and profiling)



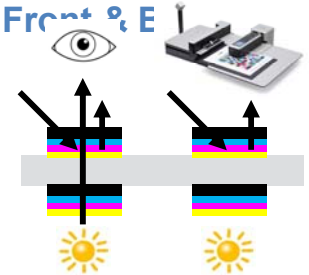


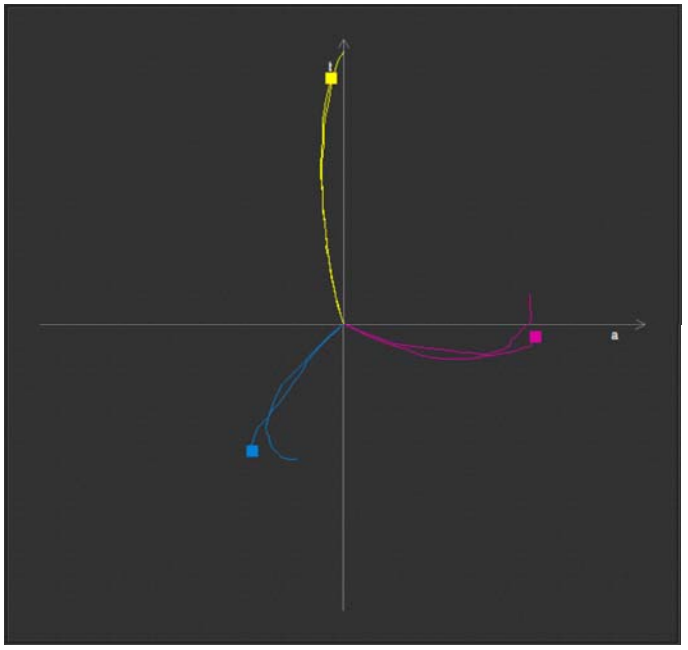
B – Backlit Frontside as transmissive setup (adjustment, calibration, characterization and profiling)





C – Dual sided Frontside/Backside as reflective setup (adjustment, calibration, characterization and profiling), identical Front & E





COLOUR MANAGEMENT METHOD

- **The CIE h° is consistent between A, B and C cases, allowing potentially a reasonable match in the following scenario**
  - The A case becomes the base for the colour management – proper setup for reflection (backlight off), reflectance measurement
  - The B case becomes the reference (aim) for the combined response of Frontside and Backside – aim setup for transmission (backlight on), transmittance measurement
  - Backside is calculated as a function of the Frontside – resulting setup for the combined Frontside/Backside for transmission (backlight on), from above transmittance measurements
- **The combined result can simply be described as:**

$$CS = Front_{tx} \times Back_{tx}$$

CS is the theoretical combined transmittance aiming to match the reference Backlit Frontside setup;
$Front_{tx}$ is the media-relative transmittance of Frontside setup only;
$Back_{tx}$ is the media-relative transmittance of Backside derived from Frontside setup

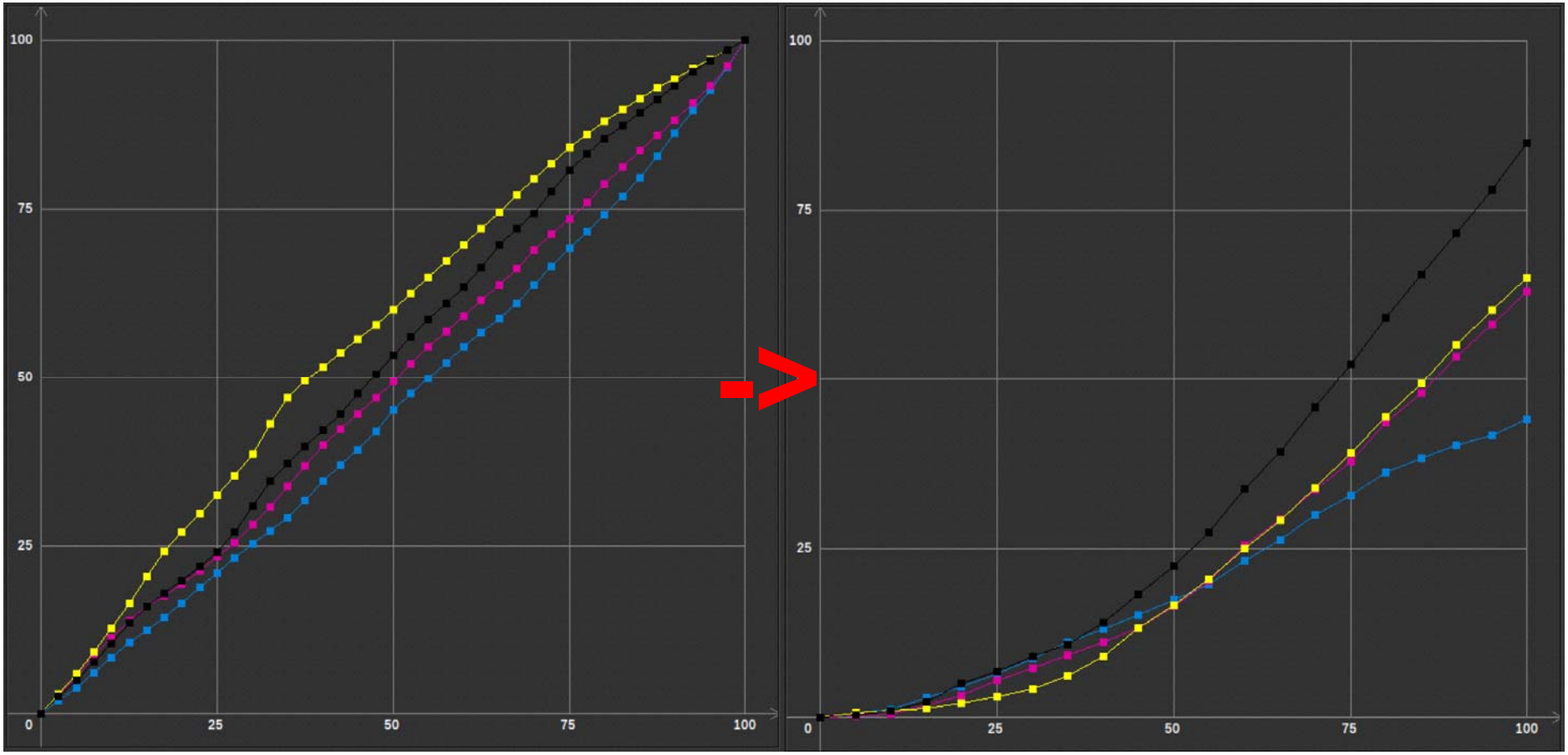
- **The formula to calculate the Backside derived from Frontside is still work in progress, but the results looks promising**
  - It provides media-relative transmittance spectral data for the CMYK primaries

PRACTICAL IMPLEMENTATION

- **Easiest is to modify the gradation of printing system primary colours e.g. CMYK on the Backside, similar with the current approach for Backside content where ink is printed as a fixed % of the frontside**
  - Frontside is fixed and can't be adjusted anymore after the initial setup
  - Initial Backside is just a duplicate of the Frontside (ICC profile included)
- **Two measurements are needed**
  - Fixed part – Frontside gradation used for Reflective setup (case A) but measured as transmission this time
  - Aim part – Frontside gradation used for Transmissive setup (case B)
- **Adjustment curve is calculated for the Backside from the resulted media-relative transmittance spectral data according to the tone value formula implementation of the used printing workflow (e.g. ISO Status density, colorimetrical TVI, spectral density)**
- **The original Backside curve (initially same as Frontside) is replaced with the adjusted Backside curve (original ICC profile is maintained)**

RESULTS FROM A CITYLIGHT PAPER DUAL SIDED PRINTING COMBINATION

⇨ **Backside adjustment curve calculated for a typical printing workflow**

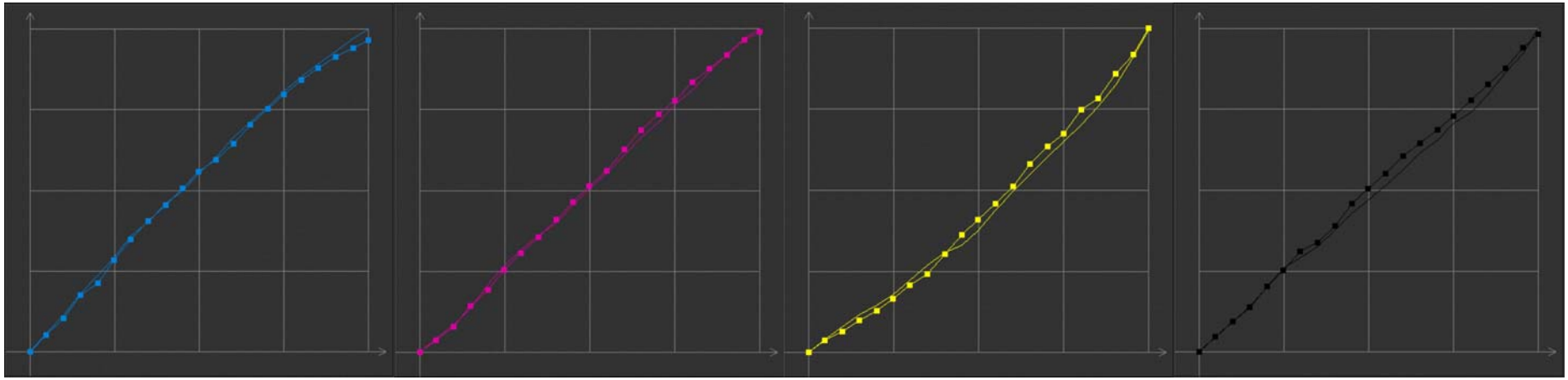


Initial Frontside / Backside TVI Curves

Backside TVI Curves

RESULTS FROM A CITYLIGHT PAPER DUAL SIDED PRINTING COMBINATION

- The match between the Frontside Backlight gradations used as aim for the Transmission setup and the resulted combined Frontside/Backside gradations used for dual sided day night printing combination



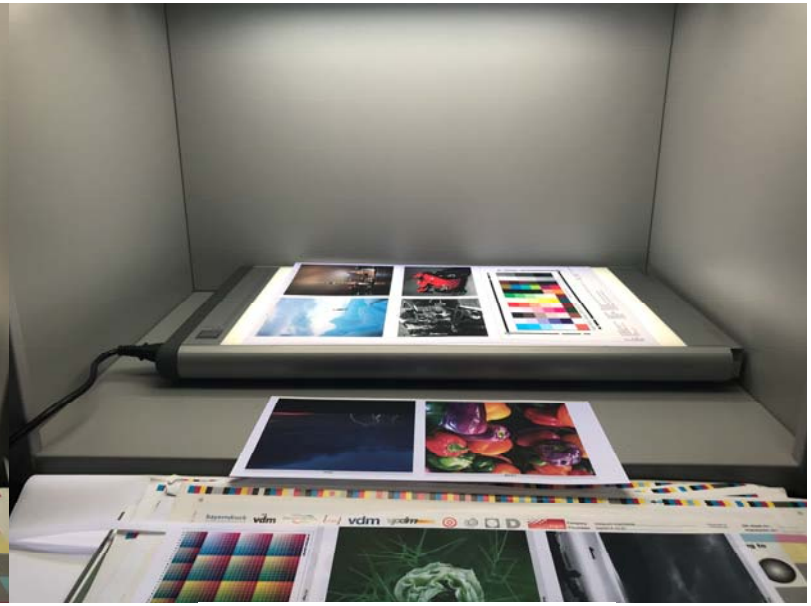
- Current formula for media-relative transmittance spectral data measurements of 1680 CMYK combinations (Universal LFP chart) – Avg. 2,5 ΔE^*_{00} /Max. 6,0 ΔE^*_{00}

MORE TO DO

- **Further study of the methods and their combined results**
  - Finding more printing combinations suitable for testing, especially for dual sided printing with functional registration system for Frontside/Backside
  - Improving the formulas
  - Evaluation of OBA's influence for both reflection and transmission in mixed light environments

Backlight/Reflection On

Low UV in Reflection



Backlight/Reflection On

High UV in Reflection

THANK YOU FOR YOUR ATTENTION

Q & A

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