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How to create characterization data for a printing standard (let's make FOGRA51!)

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TAGA
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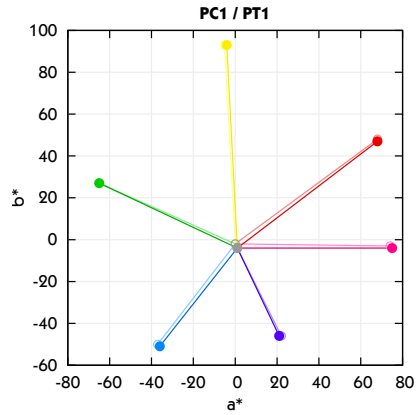
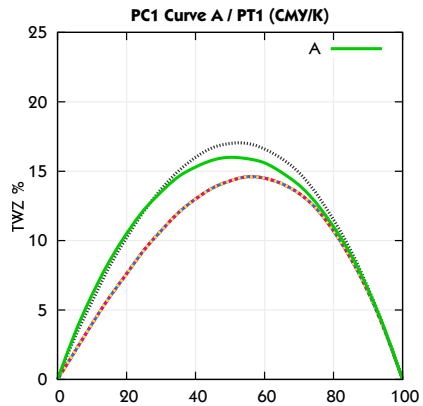
Why a New Data Set?

- ISO 12647-2: one way of process calibration
- CIELAB aim values for solid inks
- No aim values for other overprints or gray, but. . .
- Tone value curves per ink

- 2013 revision changed: M1 mode, solids, curves
- We need new reference data
- Top priority: PC1 (woodfree coated offset paper)



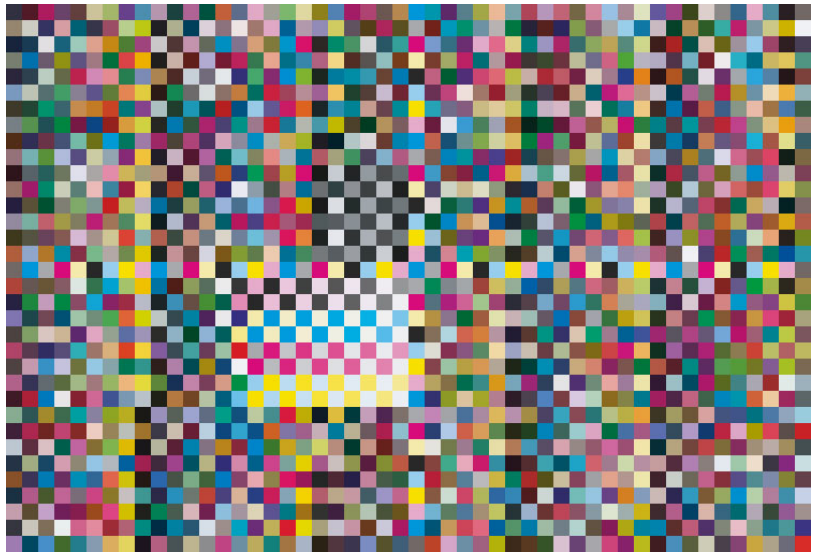


Characterization

- ISO 12642-2:2006 defines a set of CMYK patches known as IT8.7-4 test chart
- We need the corresponding CIELAB values

- Variant from GMG
  uses internal print control strips
  and is suitable for scan mode

  "ISO 12642 Plus"



Traditional Approach: Fingerprinting

- Choose paper and ink set
- Determine wet ink densities

  which lead to the best CIELAB match when dried
- Calibrate dot gain via plate setter curves
- Print test form
- Measure dry chart with spectrophotometer

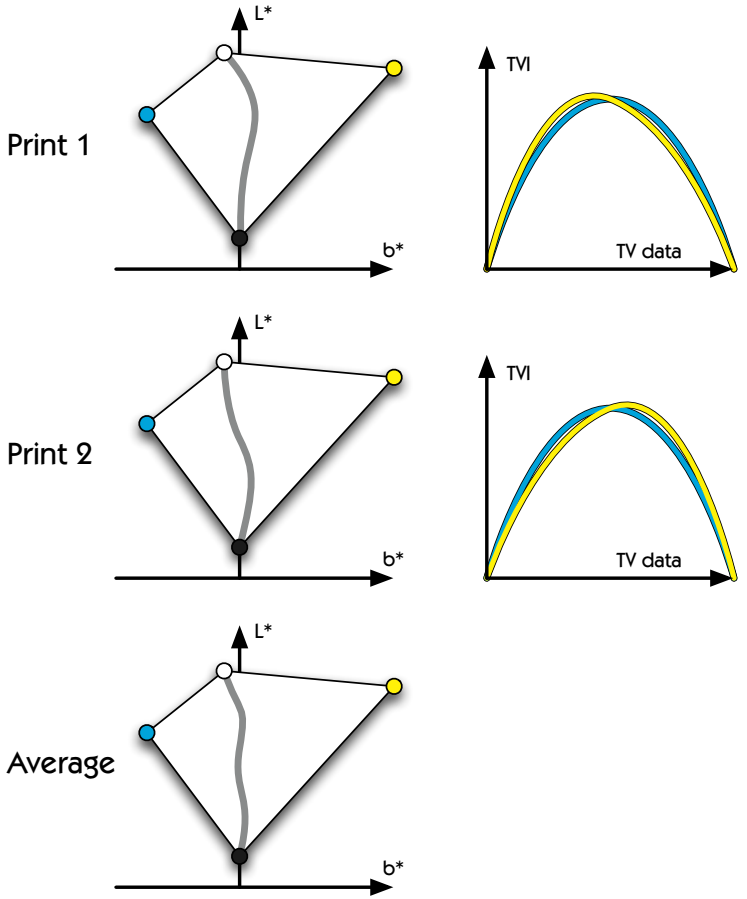
But for a Reference Data Set…

- People expect perfect standard conformity
- Representativeness: use "more than just one" of
  paper, ink set, printing machine, measurement device

- Multiple fingerprints needed to cover variation in materials and technology
- How to combine them?

How to Combine Measurements?

- Printers produce different prints
  (example: gray balance due to TVI)
- Averaging can cause problems →
  (mixes different characteristics)
- Better to idealize first:
  Adjust data to same paper
  Adjust inks to same color
  Adjust TVI to standard curve



Novel Approach: Process-based Modeling

- Describe the mosaic of overprinting dots deposited on a substrate, with ink trapping
- Model details depend on process (like offset)
- Model parameters have a physical correspondence

- Simple example: YNSN type of model
- Usually spectral

Novel Approach: Process-based Modeling

- GMG OpenColor technology is used to "explain" the different measurements in terms of parameters and then compensate those differences
- General method to create a characterization data set from one or more test charts
- This paper describes roughly how FOGRA51 was built

  (the recently published reference data set for woodfree coated paper)

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ECI / Fogra / bvdm Test Prints

Real Data

- 6 printing houses
- 4 types of paper, 4 KCMY ink sets
- ISO 12642 Plus test chart
- Test images, repeated control elements

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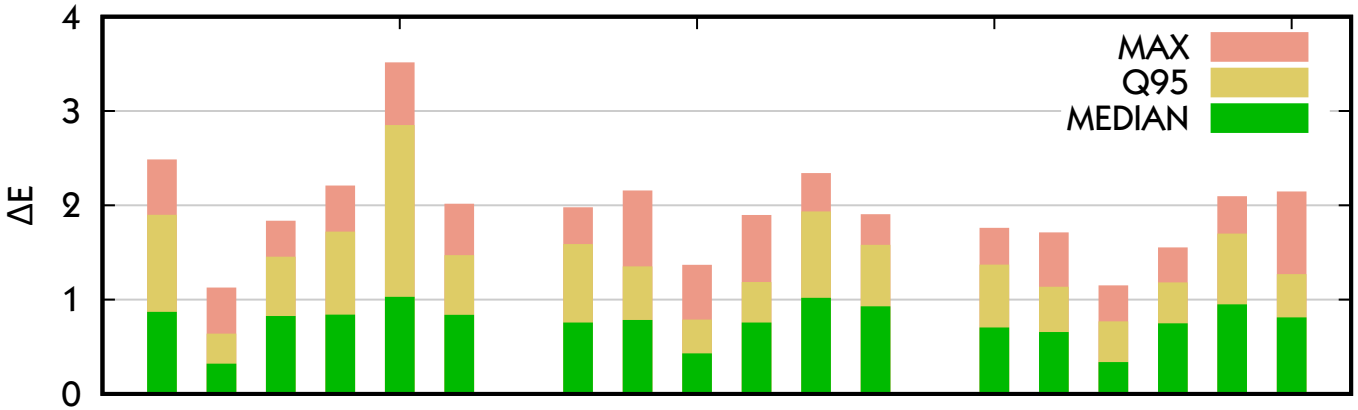
M1 Measurements

Real Data

- Automation with ColorScout A+ xy table
- Multiple sheets: outliers re-measured or dropped
- Averaged to 24 spectral "real data" sets (6×4)
- Good agreement across devices (median ΔE<1)

(shown here: 3 out of 6 prints)



Six pairings of 4 M1 devices, shown for three prints (n=1617 patches)

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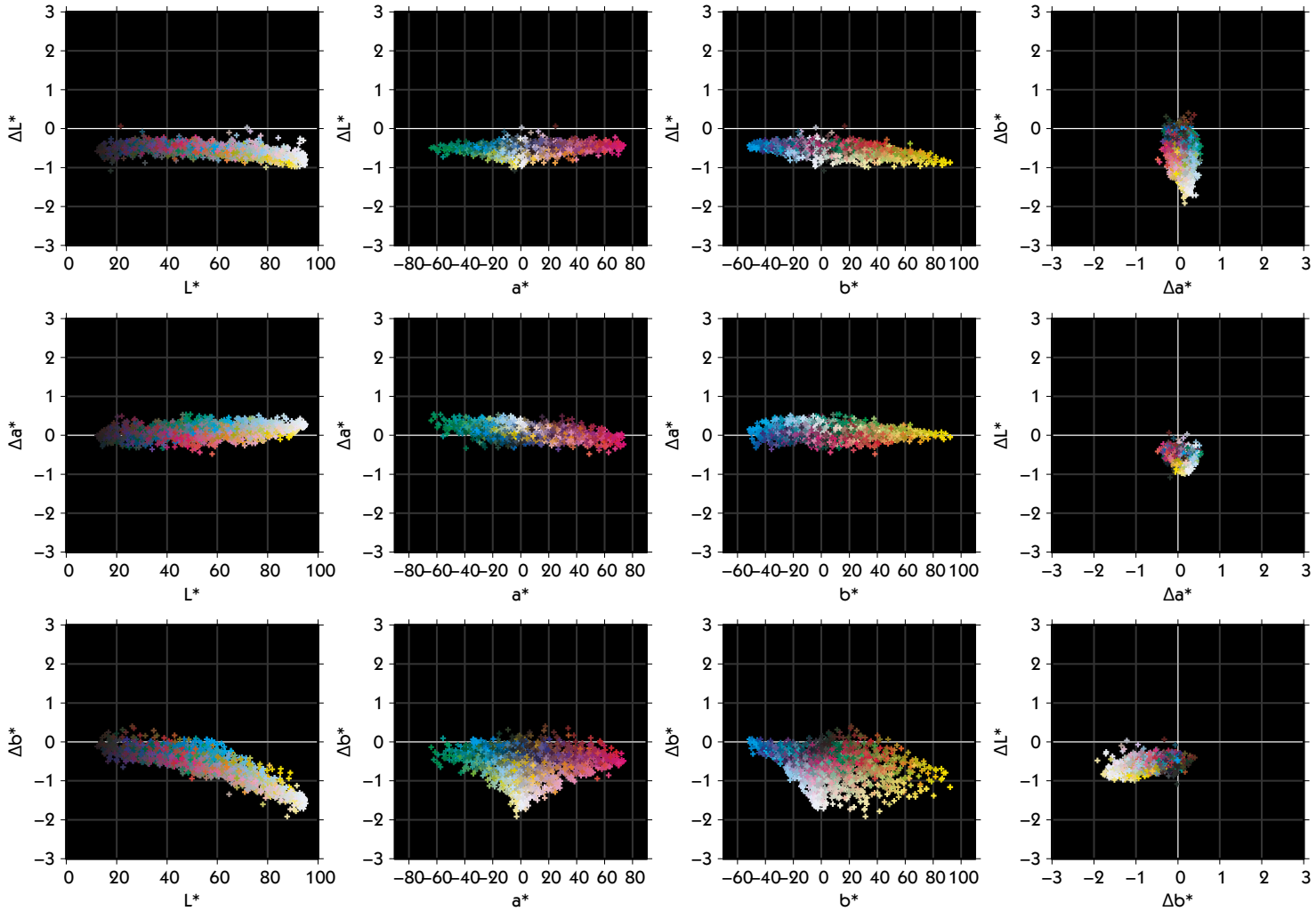
M1 Measurements: Example, eXact / FD-7

Real Data



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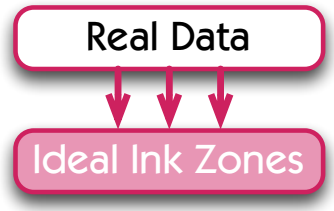
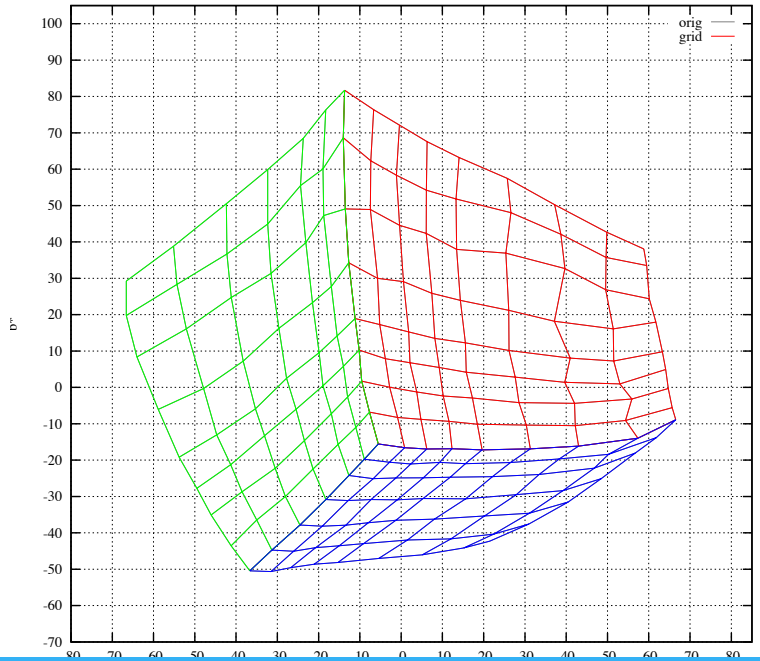
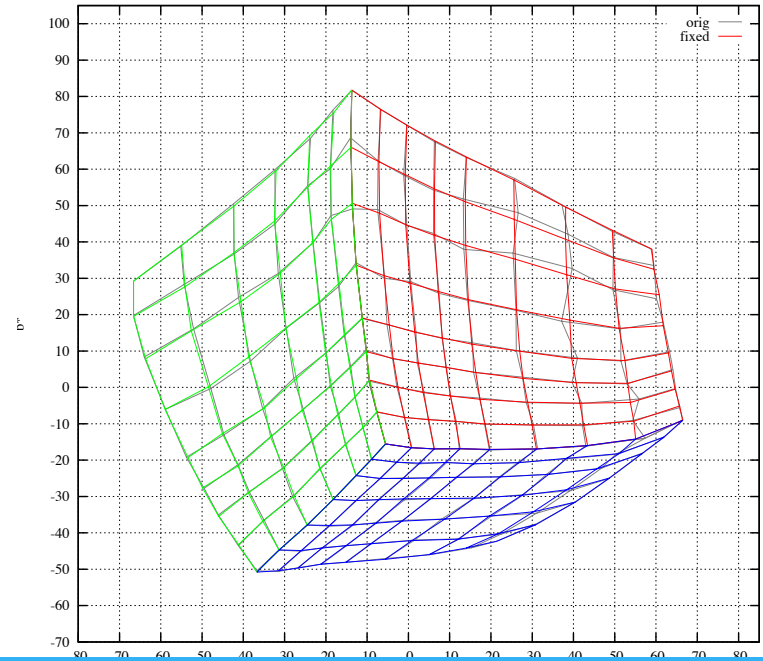
Idealization of Ink Zones



- Use embedded control strips and model to detect and remove inking variations across the test chart area
- Result: perfect ink zones, smoother data.





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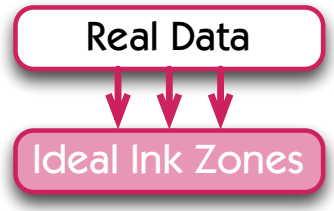

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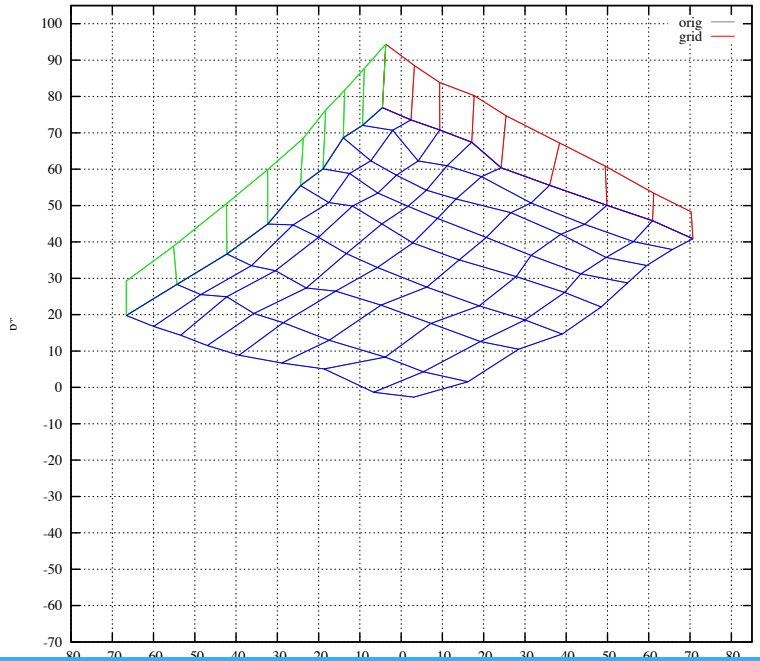

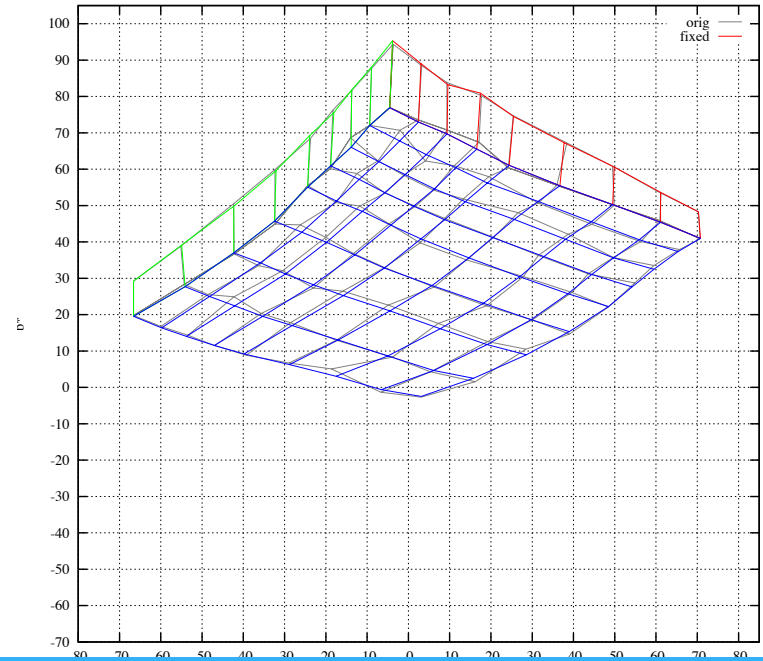

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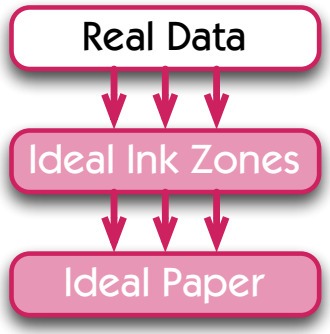
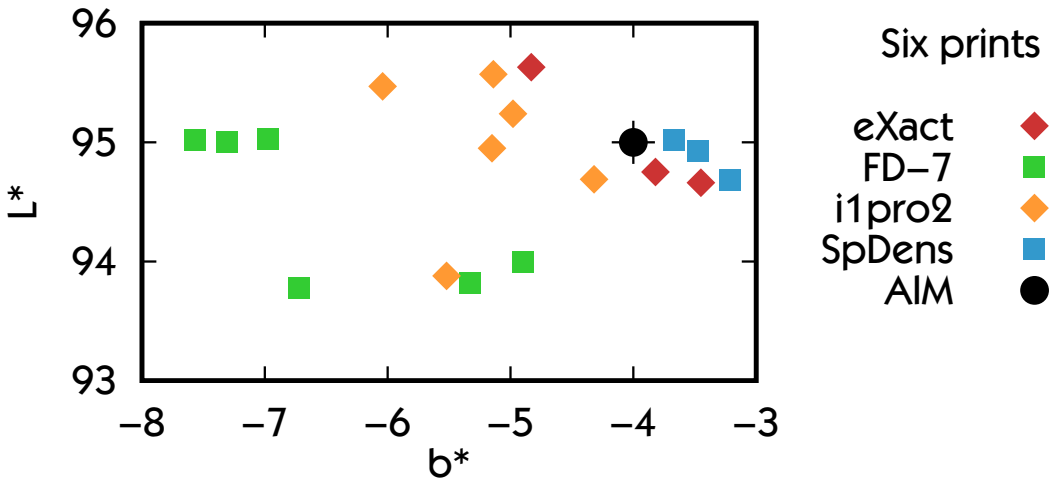
Idealization of Paper



- Modify spectrum of paper to CIELAB aim value
- Substitute paper spectrum in model
- This shifts all colors
- As if we used an ideal paper instead of the real ones

  (in terms of color)



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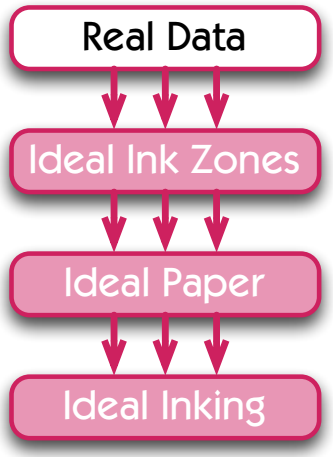
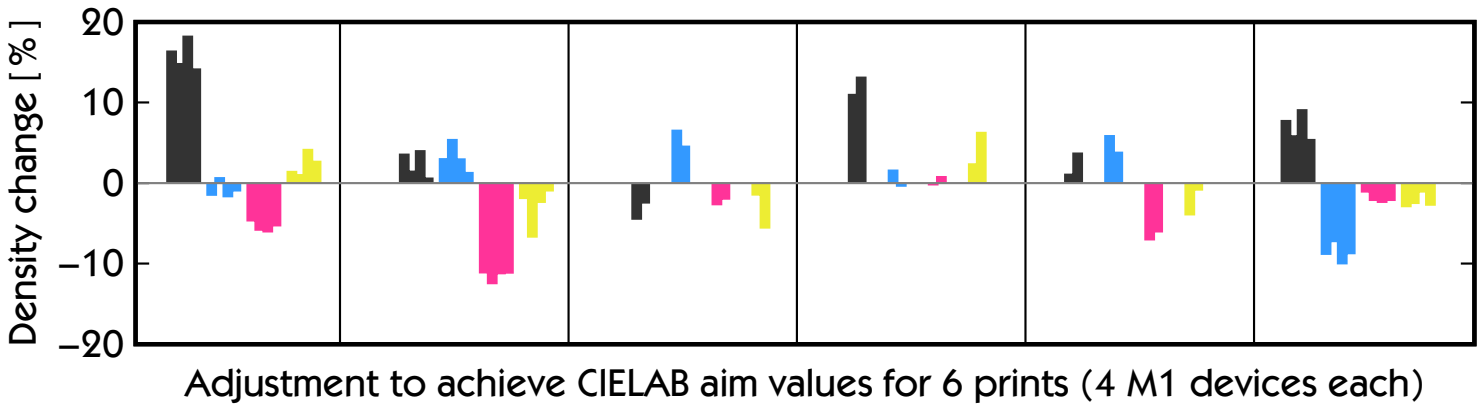
Idealization of Inks by Density



- Adjust ink layer thicknesses virtually to get close to CIELAB aim values for the primaries
- As if the printer adjusts ink zones for optimal density
- The model shifts all colors (via the screen mosaic)



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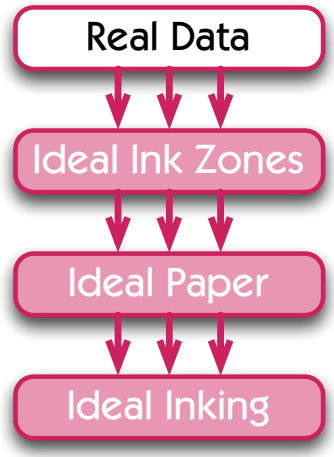
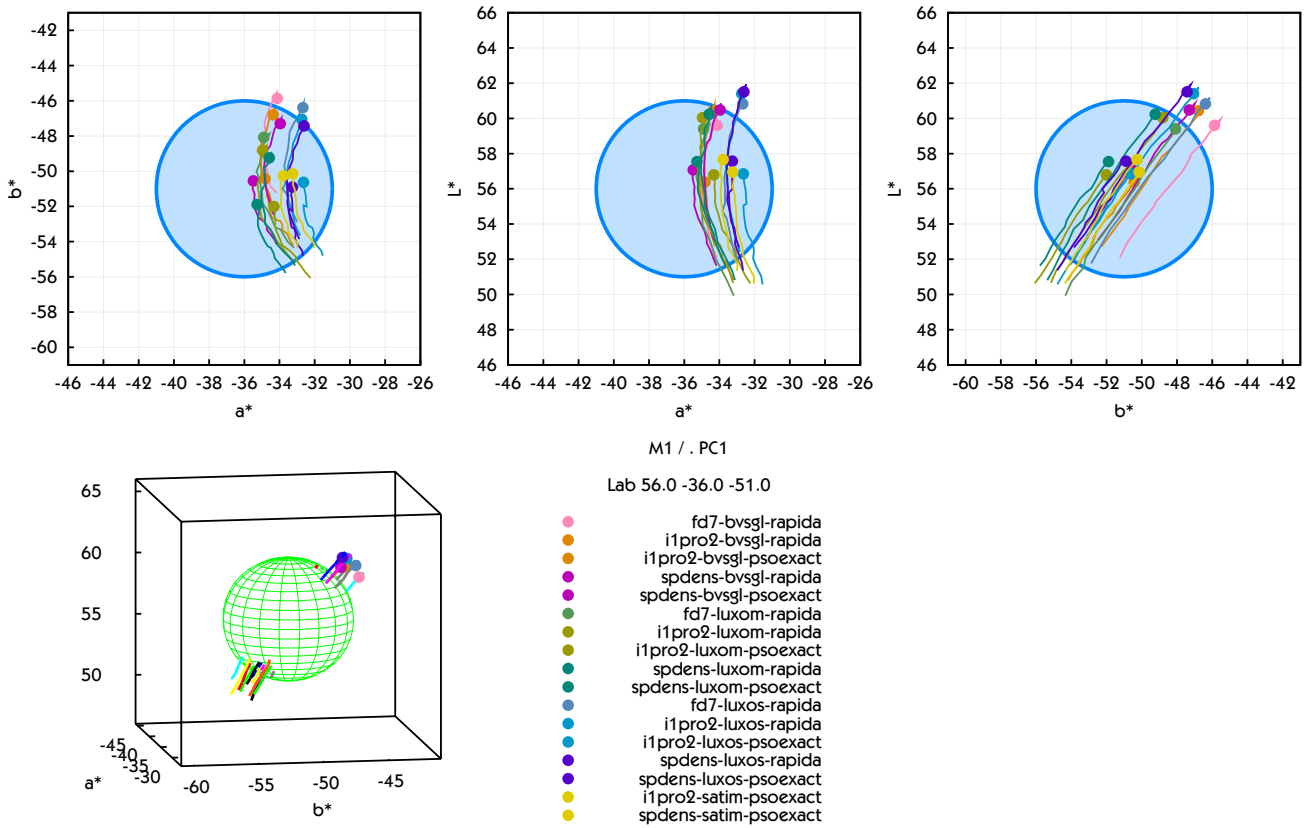


- Real-world example: solid cyan



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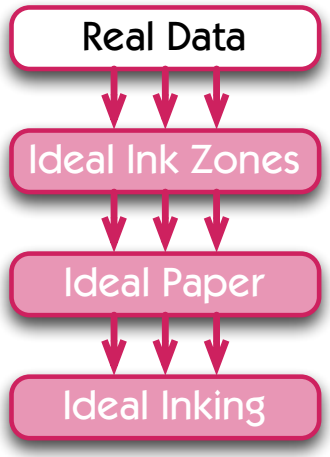
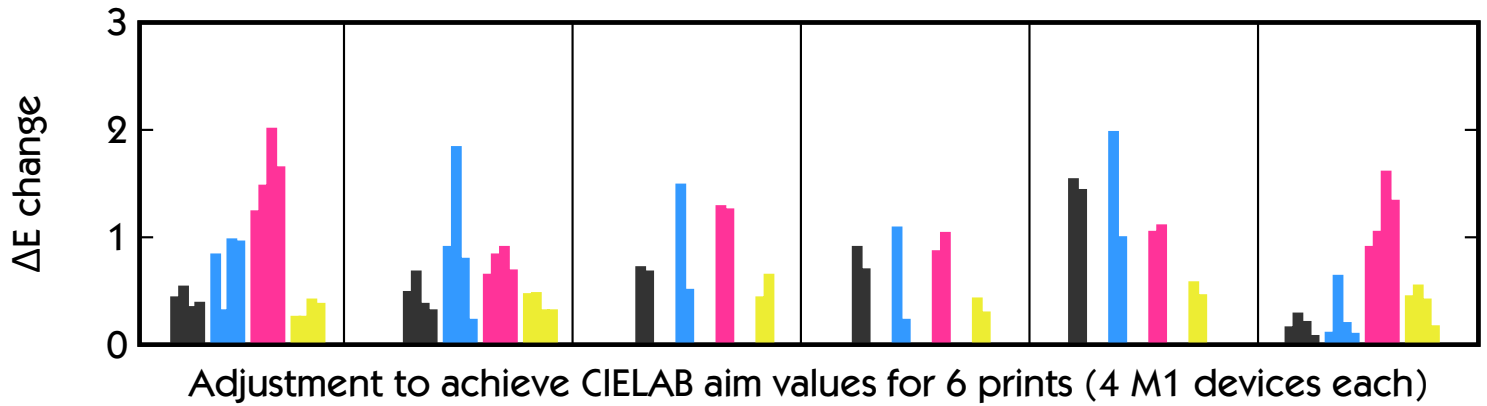
Optional: Spectral Tuning of Inks



- For each of the 24 data sets:
  small spectral modification of the primaries
  to match the exact CIELAB aim values
- The goal is to find plausible spectra
  (not an arbitrary shape change)



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Perfect Gradation

- TVI tolerances ±3 % can combine to >3 ΔE
- Adjust gradation to match Status E tone value aim
- As if we had perfect plate curves

- Reduces gray balance differences by a factor of 2

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Result of Virtual Standard Process

- Normalized data from different prints
  (from various substrates, ink sets, and printers)
- Checked with proofs: for the 6 printers,
  we used i1pro2 data sets and i1pro2 inkjet gamut
- Original prints still recognizable

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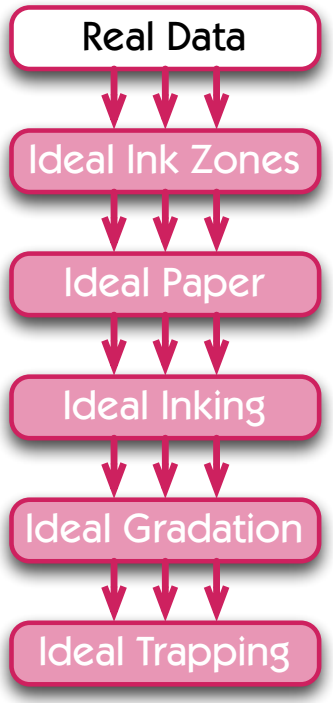
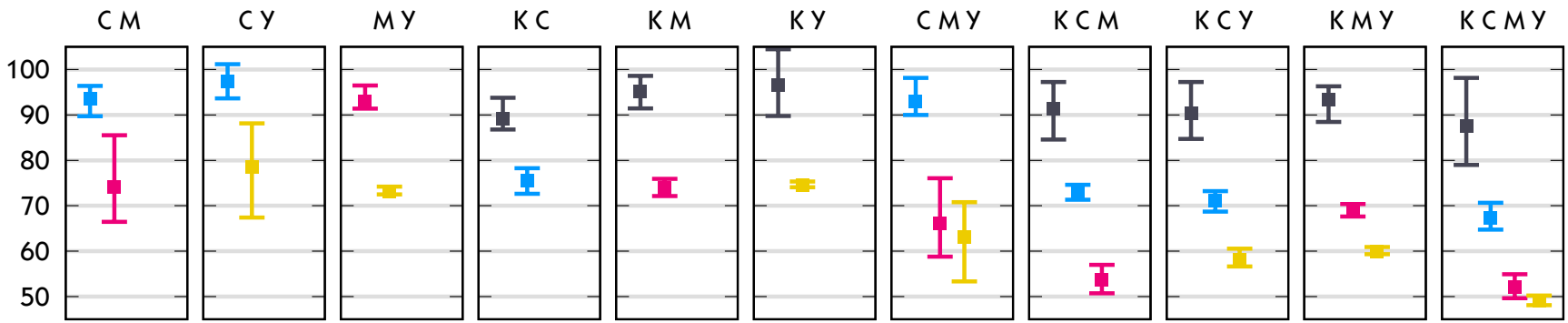
Average Trapping



- Observation: effective ink trapping remains stable
- Calculate trapping from much more print samples (selected data sets from Fogra's data base)
- For all 24 models, change to averaged trapping
- Much more representative



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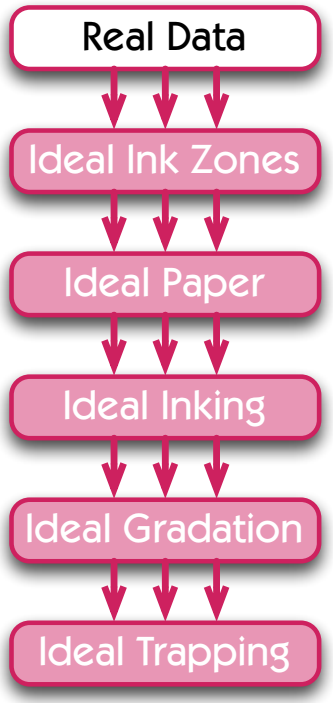
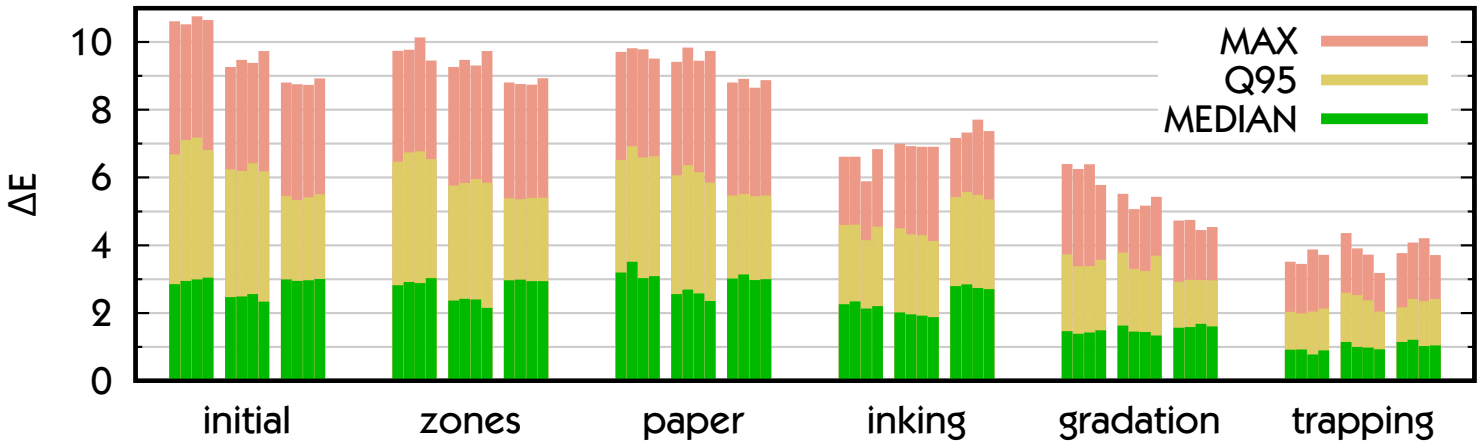
Increasing Similarity



- Each step reduces differences between the prints
- Compare pairs of prints (here: 3 out of 6 prints):



Idealization steps for 3 pairings of 3 prints (4 M1 devices each)

- Final agreement across prints: median ≈ 1ΔE

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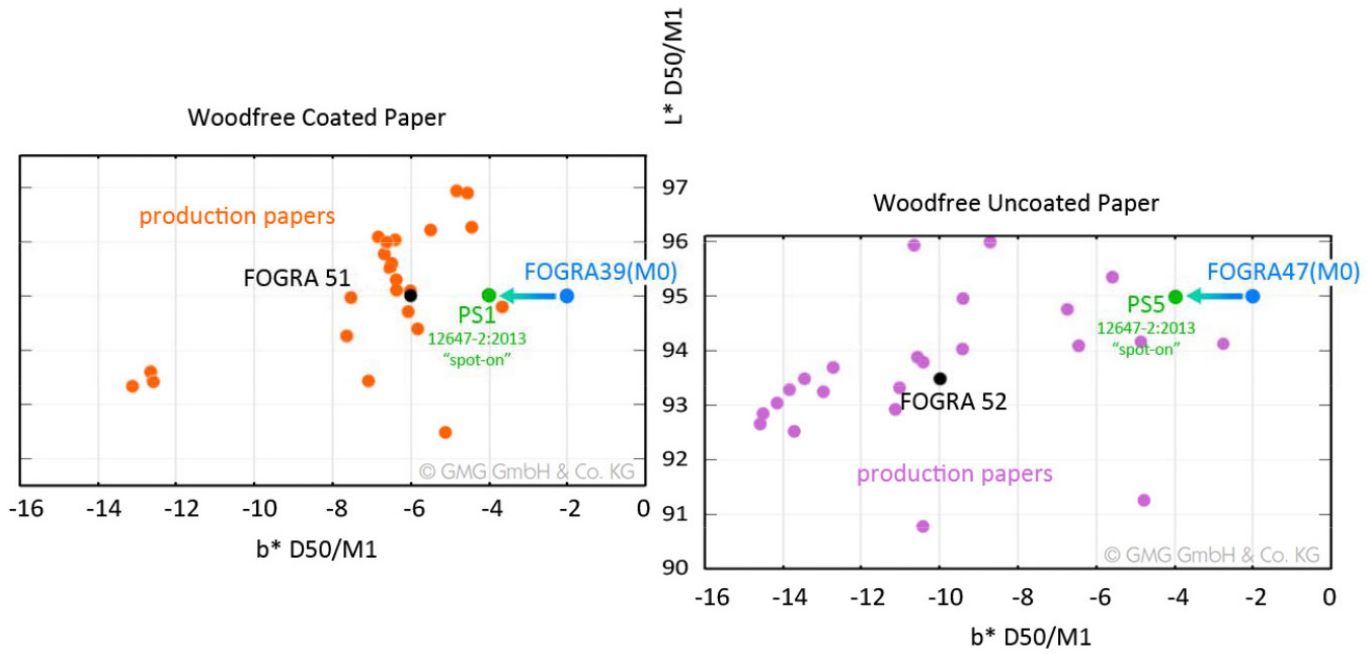
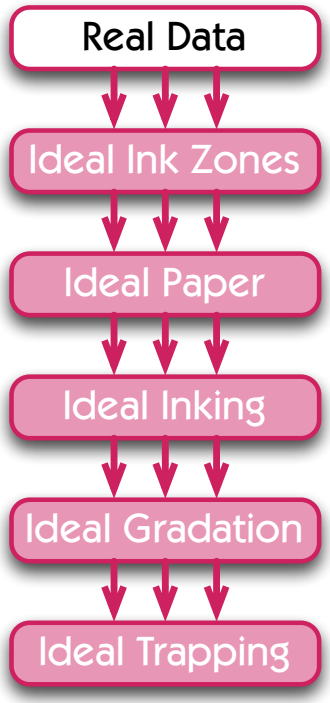
FOGRA51: Shifting the Paper again

- CIELAB value for the PC1 paper not representative
- We decided to shift to bluer color 95 +1.5 −6

  As shown below; much stronger shift needed for FOGRA52





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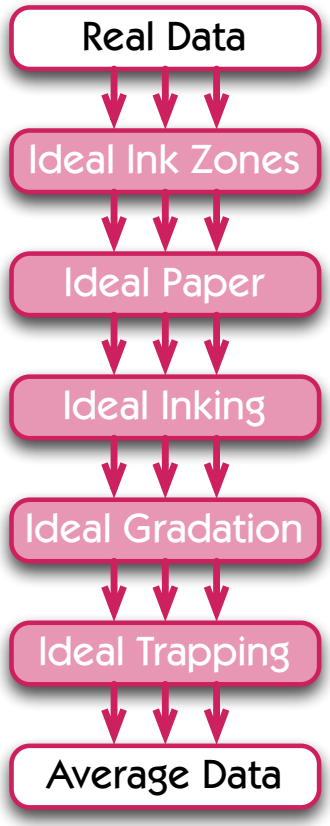
Final Averaging

- Remaining differences cannot be explained by the GMG OpenColor model
- Average the 24 sets spectrally
- Last model run to get rid of small shifts:
  Nudge solid inks to CIELAB and tone curves to aim
- Calculate CIELAB values, done!



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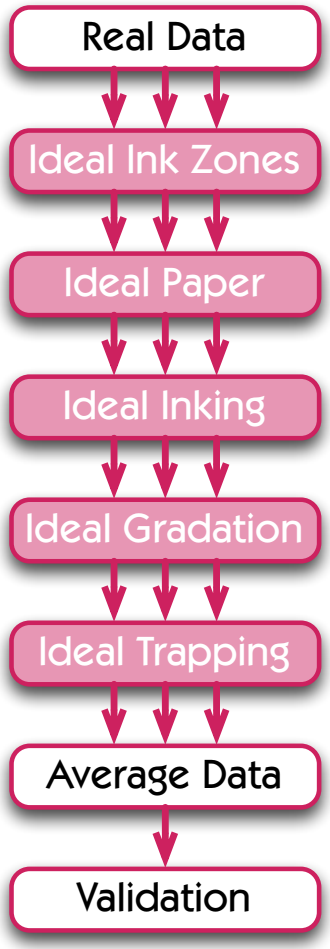
Validation

- ECI created an ICC profile and separated test images
- Two successful test print runs
- Used successfully in end-to-end production workflow with large print buyer
- Release of FOGRA51 and PSOcoated_v3.icc on September 30, 2015.



Summary

- We have selected suitable test prints close to PC1
- We have measured the ISO 12642 Plus targets with four different M1 devices on the ColorScout xy table.
- Measured data were idealized via process parameters (as a printer would do it) using GMG OpenColor technology.
- Ink sets were generalized to an average trapping
- Successful validation

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Outlook

- Could also be done with a G7 process calibration
- Main difference: adjust gradation per channel for a well-defined grayscale appearance, the neutral print density curve.

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Acknowledgments: For FOGRA51, thanks to...

- Florian Süßl (ECI) assembled the test form
- Karl Michael Meinecke (bvdm) organized the print runs
- Roland von Oeynhausen (ECI) supported all runs on-site
- Michael Hansen (Heidelberger) provided the spectral tuning of the primaries
- Many printers who donated their time and equipment
- Paper manufacturers who donated paper
- My colleagues in Ulm and Tübingen who helped with the measurements

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Thanks for your attention.

we know color