Channel Density Solver — TRIFORCE Case Study

Abstract. This report documents the composite density attribution method applied to the TRIFORCE_V4 calibration set. We fuse the measured L* ramp with the corresponding .quad ink draws to estimate the effective density each channel contributes across the tone scale. The resulting weights inform the composite redistribution solver so that highlight inks are not over-credited and the shadow anchor retains control of maximum density.

1. Introduction

Multichannel linearization requires reconciling per-channel ink usage with a single measured tone response. The channel density solver addresses this by pairing the LAB measurement ladder with the source .quad file. By inspecting which channel dominates each input step, we bound the density each ink can plausibly deliver and prevent weak highlight channels from inflating the composite correction when they reappear alongside stronger inks.

2. Materials and Methods

The TRIFORCE_V4 dataset comprises 25 LAB samples spanning 0–100% input and a multi-channel .quad describing the draw ratios for K, C, and LK (all other channels disabled). For each step we calculate the L* decrement relative to the previous sample (ΔL*) and the fractional ink contribution per channel. Highlight intervals where a single channel exceeds a 90% share are treated as dominance windows that establish the channel's solo density ceiling. Subsequent mixed intervals distribute ΔL* in proportion to the measured shares while respecting the established ceilings.

3. Results

Region	Input (%)	ΔL*	LK Share	C Share	K Share
Highlight	7.5	3.64	97.5%	2.5%	0.0%
Midtone	35.0	6.09	63.1%	34.1%	2.8%
Shadow	90.0	1.41	24.3%	2.3%	73.5%

Integrated across the tone scale, the solver attributes 7.7% of the darkening to LK, 76.9% to K, and 15.4% to C. These weights align with the visual plot: LK alone drives the highlights, K assumes control past 70% input, and C acts as a midtone supporting ink.

4. Density Constant Calibration Concept

To tighten attribution we calibrate a density constant for each ink: the fraction of the total darkening it can produce when acting alone. For TRIFORCE, LK demonstrates roughly 7.7% of the total density on its own; subtracting that ceiling leaves about 15.4% for C in the midtones. The remainder (≈76.9%) is credited to K, which anchors the shadows. At runtime the app exposes `getCompositeDensityProfile(inputPercent)` so operators can inspect the per-channel shares baked into each input step.

Channel	Estimated Density Constant
LK	0.077
C	0.154
K	0.769

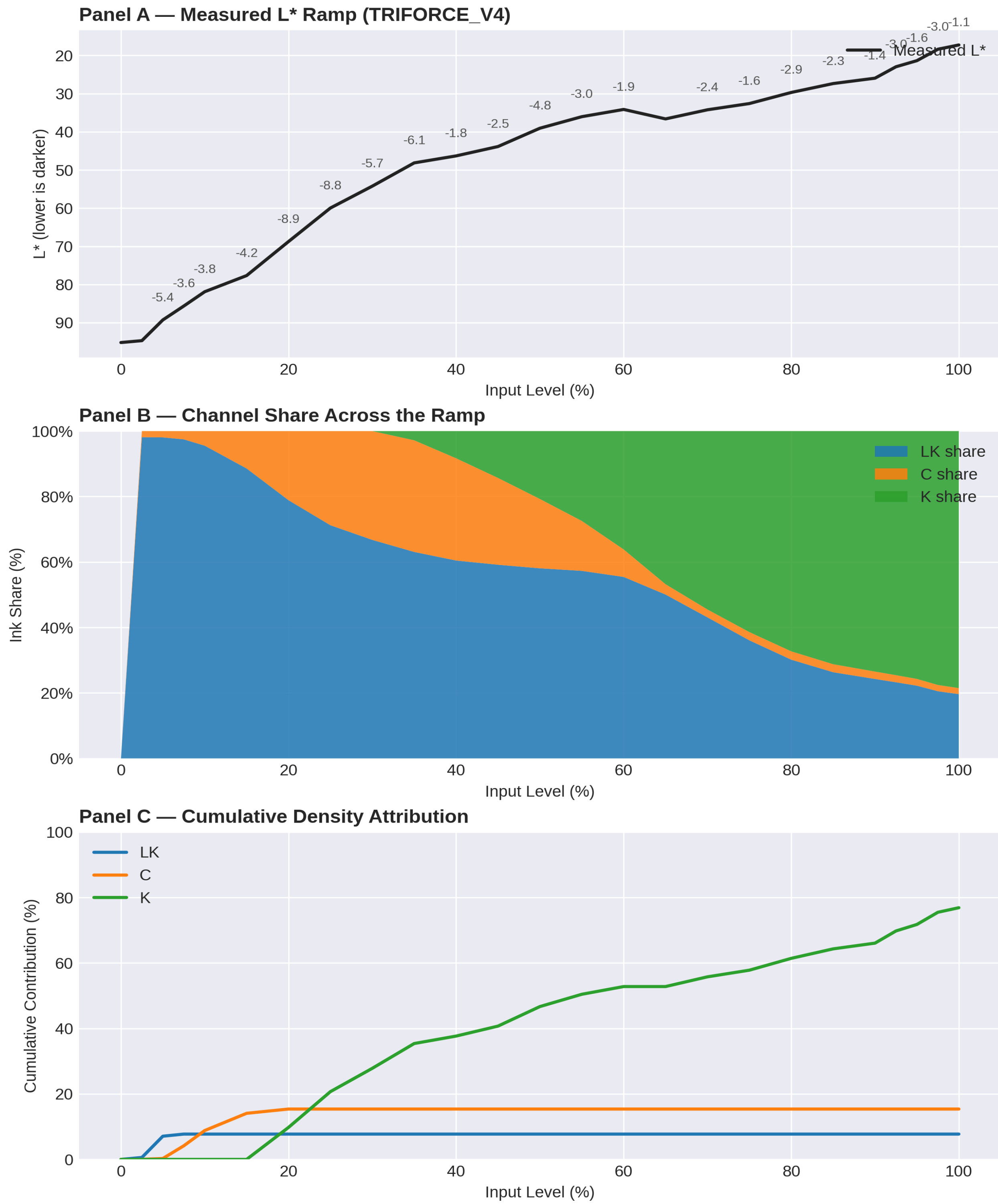
5. Discussion

The TRIFORCE case study demonstrates why equal weighting distorts multichannel redistribution. When the solver honours dominance windows, the composite curve preserves the legacy amplitude while preventing highlight inks from saturating the headroom. Future work will evaluate adaptive thresholds for dominance detection and extend the analysis to datasets where more than three channels are active simultaneously.

Figure 1

Composite visualisation of the TRIFORCE_V4 density analysis. Panel A shows the measured L* curve with annotated ΔL*. Panel B stackplots the fractional ink share for LK, C, and K. Panel C integrates the contributions to yield cumulative density weights.

Channel Density Analysis — TRIFORCE_V4 Dataset



Appendix A — Numerical Summary

Channel	Cumulative ΔL*	Contribution (%)
LK	6.22	7.7%
C	12.37	15.4%
K	61.84	76.9%