GIS | GLOBAL INKJET SYSTEMS

A NANODIMENSION DIVISION

Image quality challenges and workflow software solutions for digital decor printing

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Product Champion

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Company Overview

- Leading provider of technology solutions to industrial inkjet systems builders
- Supported printhead manufacturers
  - Fujifilm Dimatix, Konica Minolta, Epson, Kyocera, Ricoh, Toshiba Tec, Xaar, Seiko
- Founded November 2006
- Based in Cambridge, UK
- Employees 70+
- Supplier & partner to over **130** customers worldwide
- Part of the **Nano Dimensions** group of companies

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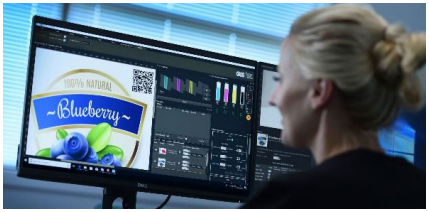
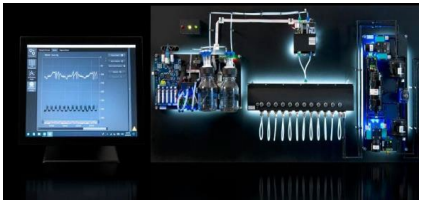
Complete CONTROL from DIGITAL pixel to PHYSICAL drop





We work with world leading companies from R&D, Prototype Development - through to Production

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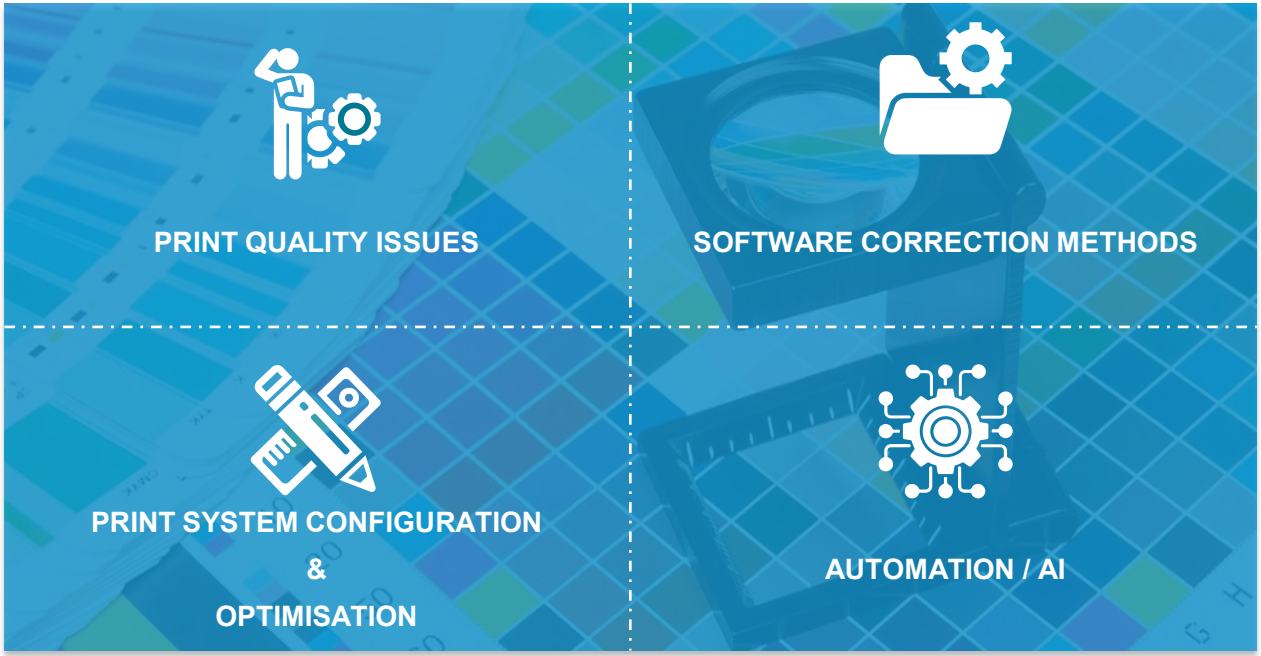
Nothing is perfect and digital printing is no exception

However, software configuration and image compensation can improve machine imperfections



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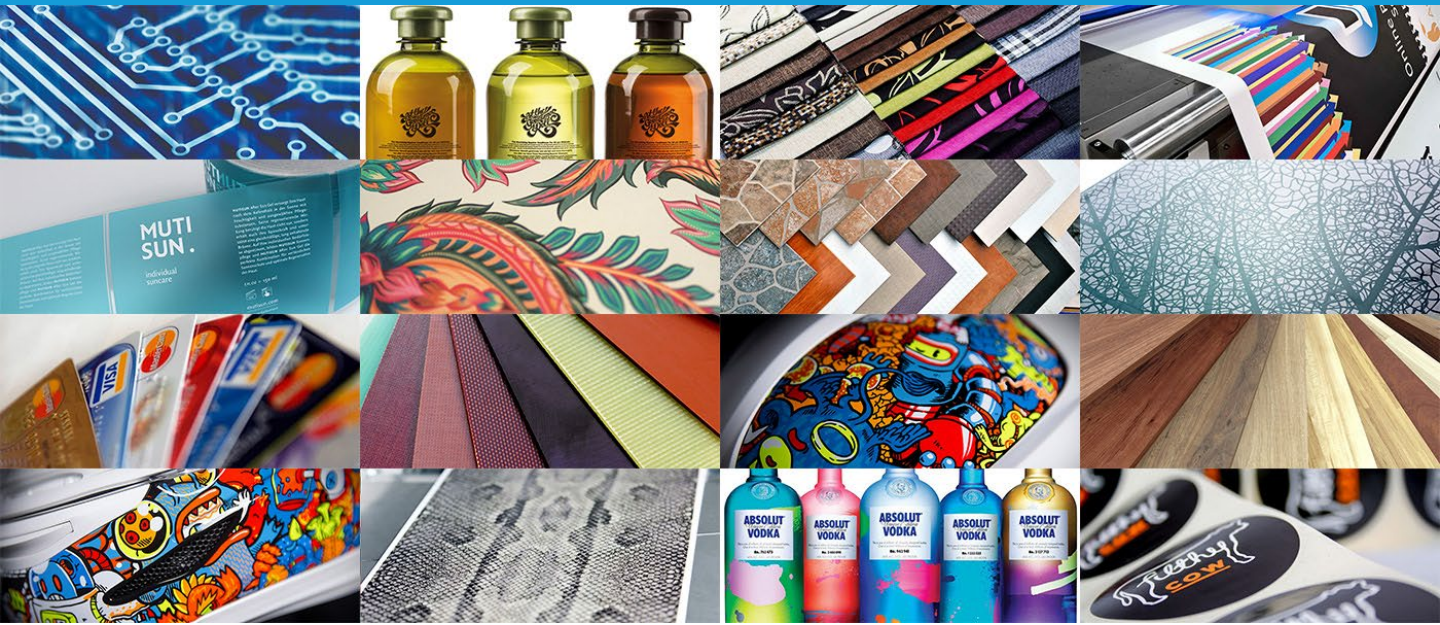

Print Quality Issues

Factors effecting print quality

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Print quality issues in the field

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01	Printhead misalignment and jet straightness
02	Encoder jitter and related issues
03	Mechanical control of print media
04	Complexities of multi-pass and printhead stitching
05	Colour management
06	Encoder location and position issues
07	Ink gamut limitations and control
08	Screening implementation, grey level mapping and ink limiting
09	Printhead and colour channel linearisation
10	Ink system control
11	Printhead print height
12	Pre and post substrate treatment
13	Print and process resolution
14	Encoder resolution
15	Source image formats adequate for print processing
16	Build up of static and management of electrical noise
17	Substrate white point for colour management

Printhead alignment and stitching

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Why is a good stitch important?

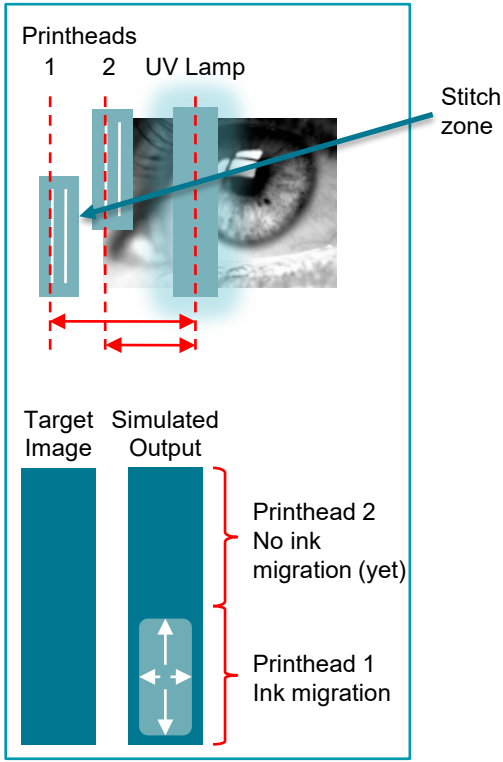
- The human eye is very good at spotting discontinuities especially in areas of flat colour

What needs to be controlled?

- Printhead alignment: Typically positioned to within <20% of the diameter of a drop
- Printhead calibration: Drop size conformity
- Ink substrate interaction: Ink spread creating visible artefacts – ink migration control

Stitched printheads do not all jet in the same place at the same time

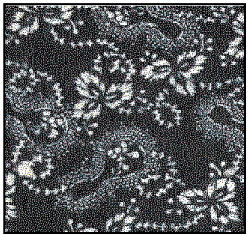
Some will be printing *wet on dry* while others will print *wet on / near wet*



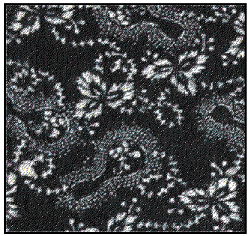
Colour registration

- Colour registration can affect output colour and detail
- Typically there is a reduction in colour gamut and darkening of the image

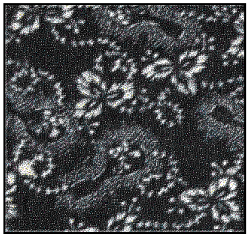
X & Y nudge



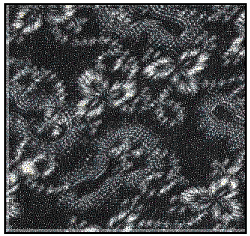
Perfect Alignment



+1,+1 Pixel Nudge

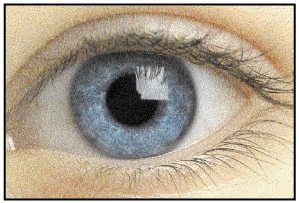


+2,+2 Pixel Nudge

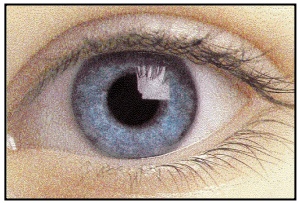


+4,+4 Pixel Nudge

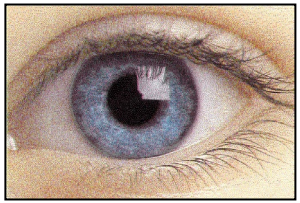
X only nudge



Perfect Alignment



+2,0 Pixel Nudge



+4,0 Pixel Nudge

Printhead-to-printhead and Nozzle-to-nozzle variations

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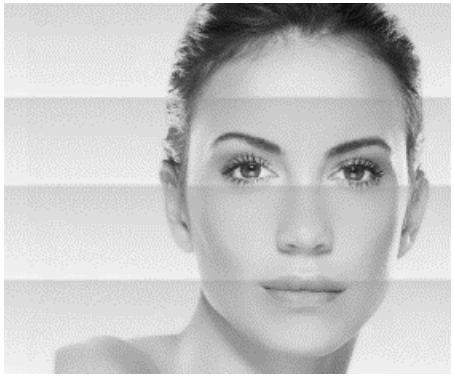
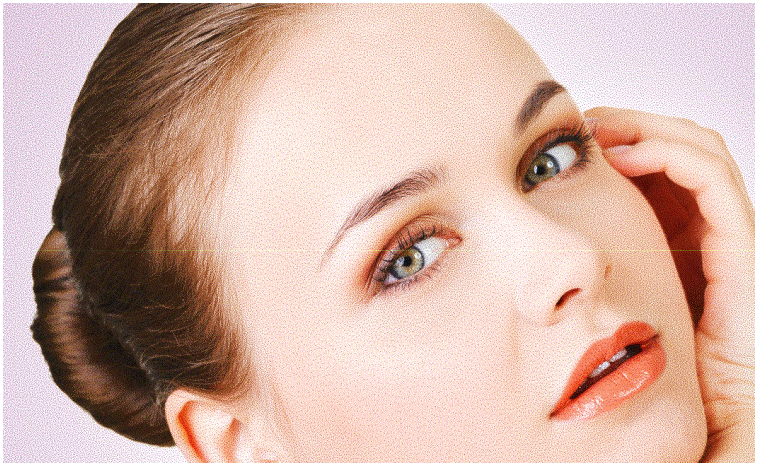
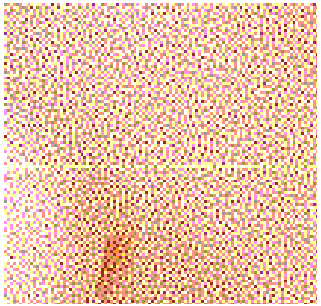
Printhead banding



Nozzle density variations

Missing nozzles





Ink flow between print passes

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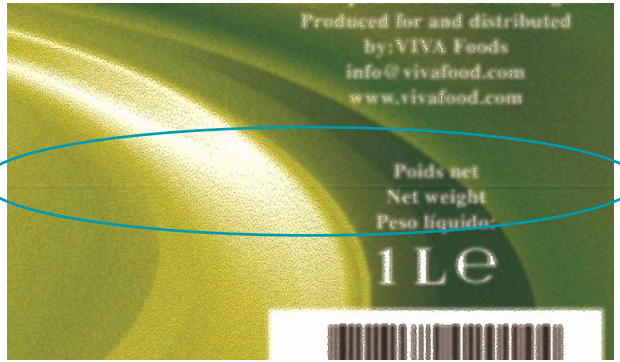

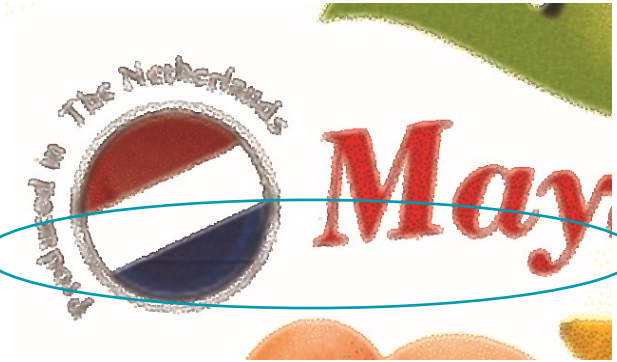

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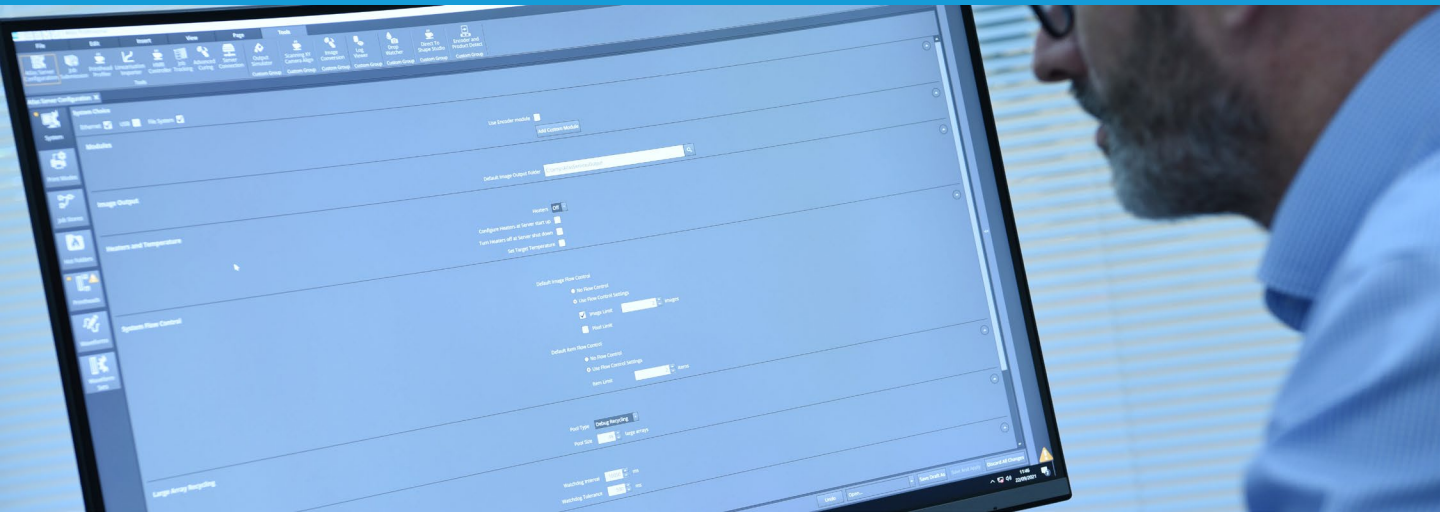
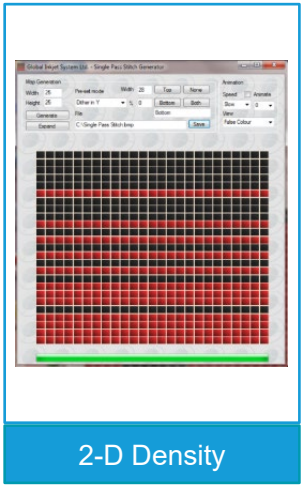


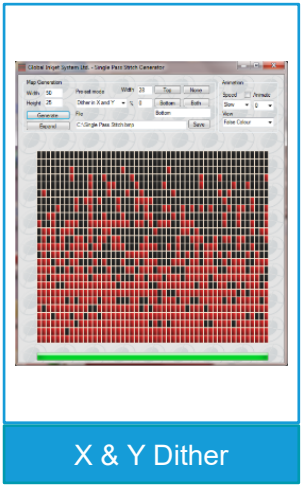
Print system configuration & optimisation

Hard stitching – binary printing

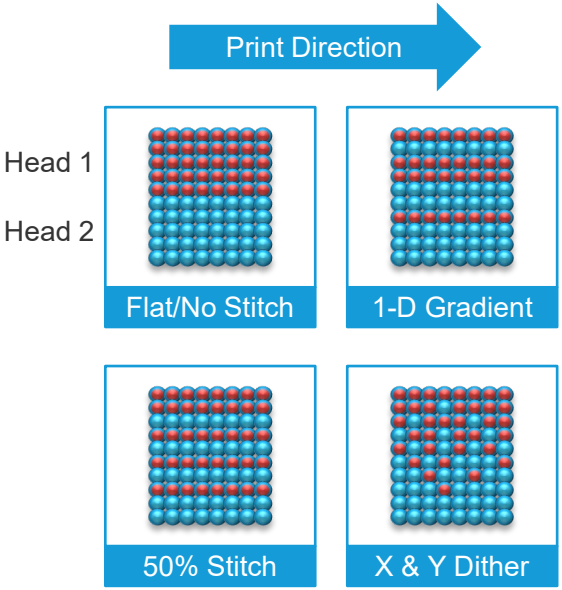
- **Masking (Hard Stitching)**
  - Nozzle on/nozzle off
  - Wide variety of options
- **Stitches can massively improve output quality & different applications benefit from different strategies**



2-D Density



X & Y Dither



Soft Stitching – grey scale stitching

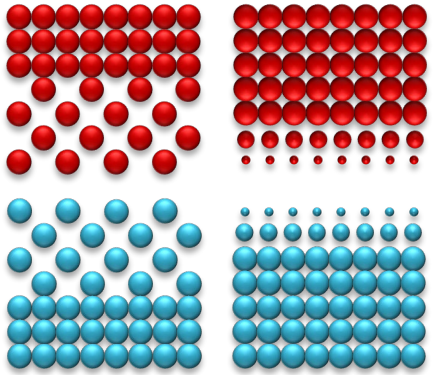
- **Greyscale stitching makes full use of the greyscale capabilities of the head**

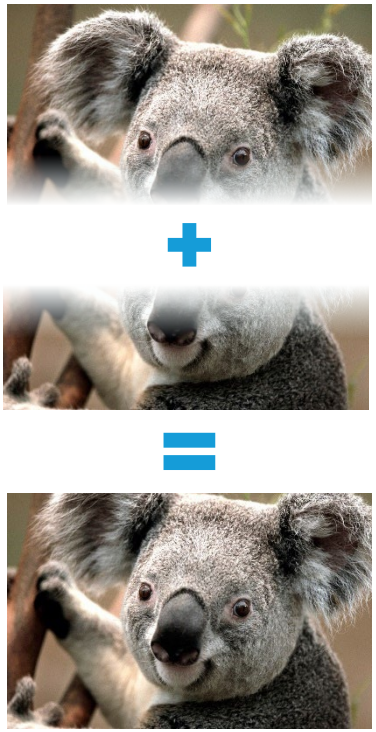
  Slowly reduces the density of the image printed by one printhead while increasing the density printed by the next printhead

- **Only adds value over masking in areas where the density of the image is greater than the smallest drop size**

Printhead 1

Printhead 2



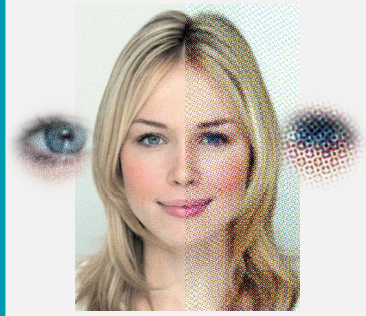


Screeners

- Error Diffusion (ED) and Ordered Dither (OD) Screeners
- Comparison is difficult without controlled viewing conditions
- ED shows slightly less grain in skin tones and better fine detail
- Differences become smaller at higher resolution
- OD significantly faster to compute than ED

Error Diffusion

Ordered Dither

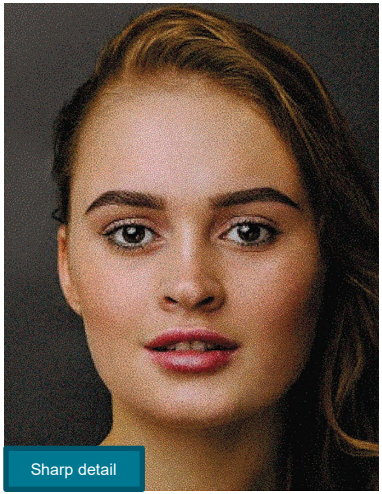


Frequency Modulated (Floyd Steinberg)

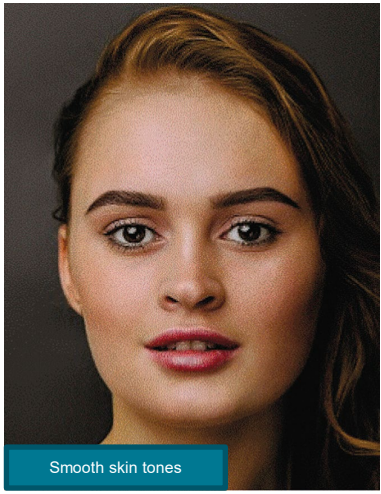
Amplitude Modulated

Screener effects

- Ultra-fast binary and greyscale screeners are crucial to achieving the best image reproduction for the type of image being printed
- Allow the best image quality conversion of contone images to produce smooth grey-level transitions while maintaining sharp line detail
- Once the screener type has been selected, the screener is optimized to achieve a smooth contone to grey-level mapping, full greyscale dynamic range and ink limiting

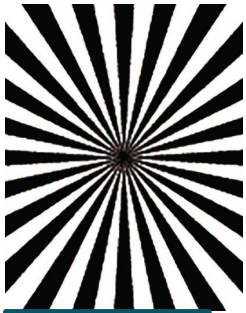


Sharp detail



Smooth skin tones

No anti-aliasing



With anti-aliasing

Grey levels selection – how many grey levels?

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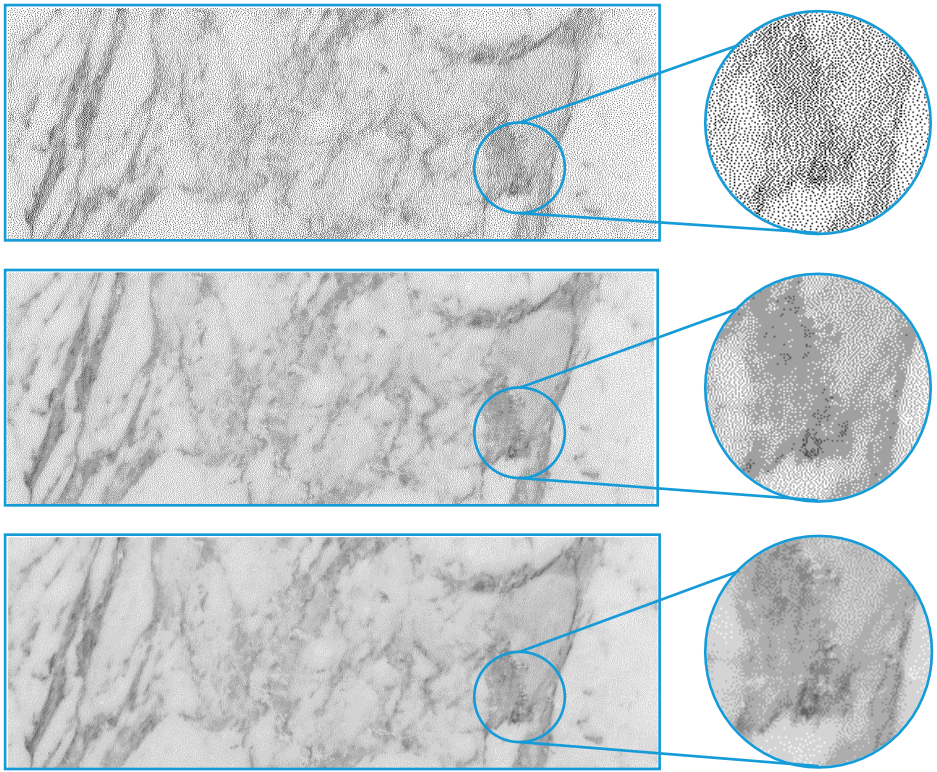


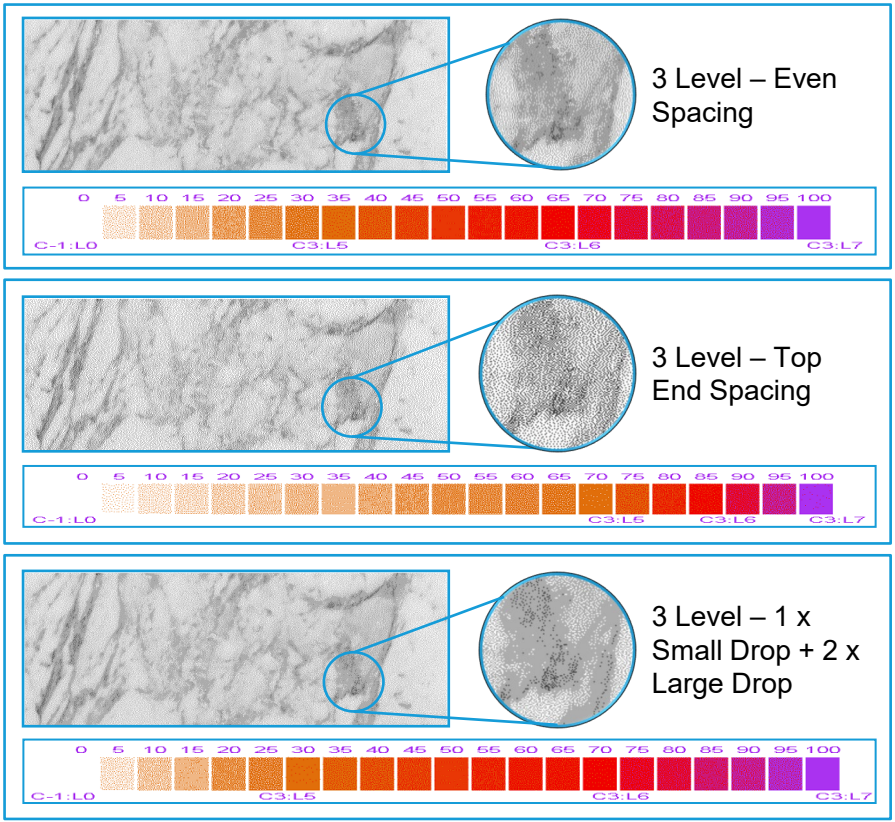
1 Level (Binary)

3 Level – Even Spacing

7 Level – Even Spacing

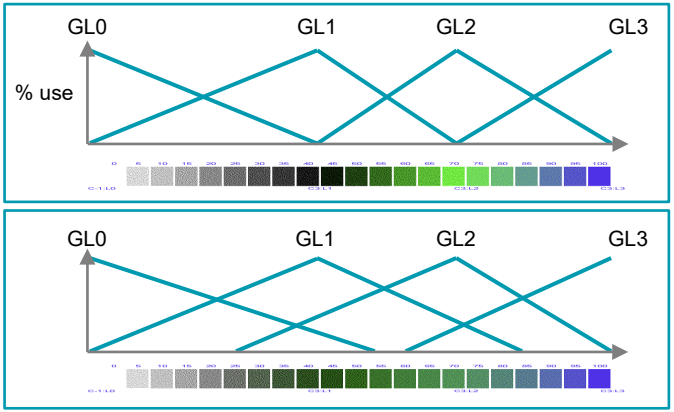
Grey level drop size – drop size distribution

- A key starting point for maximising image quality is to chose your drop sizes carefully
- The smallest drop will often dictate the perceived graininess of the image
- Try to ‘spread out’ the grey levels over the contone range by selecting the appropriate printhead, ink and waveform



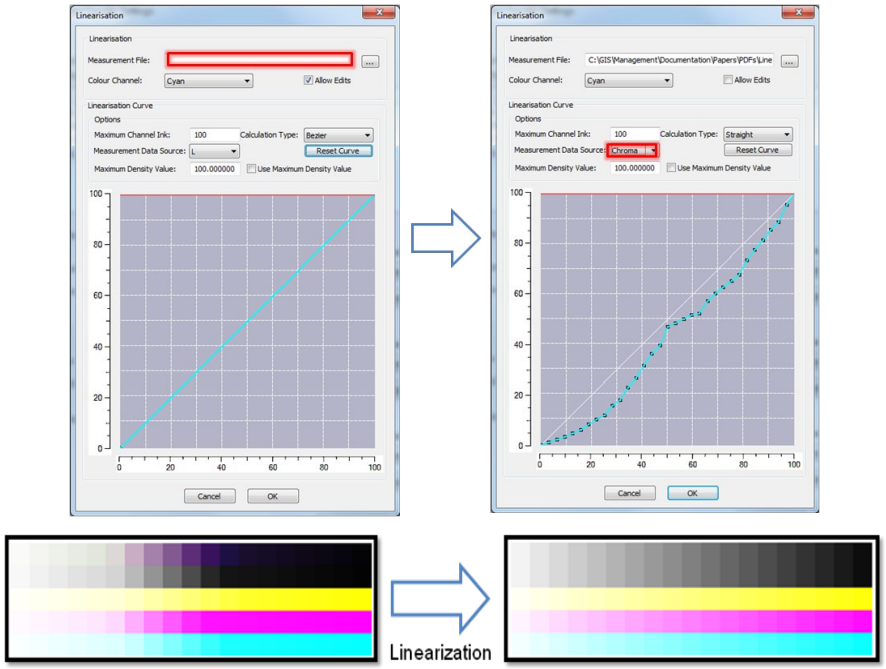
Grey level mapping optimisation

- RIP technologies often allow the user to specify the locations where grey levels overlap and how they overlap
- This can improve image quality especially on systems where the ink can have a gloss finish as it avoids areas of density where only a single drop size is used
- This technique is only applicable to systems printing with multiple grey levels



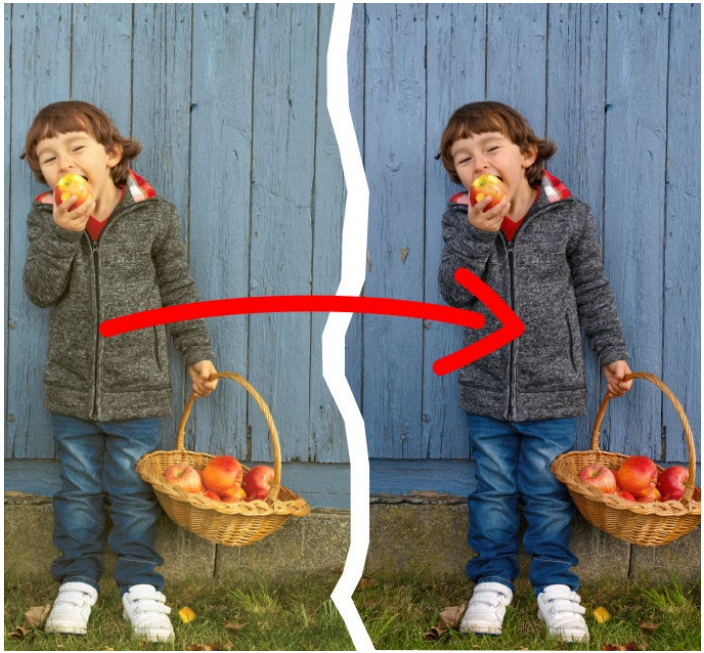
Colour channel linearisation

- Channel linearization needs to be performed on each process colour channel
- This is achieved by printing individual channel linearization test charts, measuring the printed charts with a densitometer resulting in the linearization correction such as CGATS
- Each print mode will need its own linearization and colour profile



Colour management

- Poor colour management results in the printed colour output not matching the desired colours of the original image
- This is the result of poor mapping of continuous colour tones into process colours and poor colour "mixing"
- Resolve by implementing a colour mapping process to produce a colour mapping profile (ICC)



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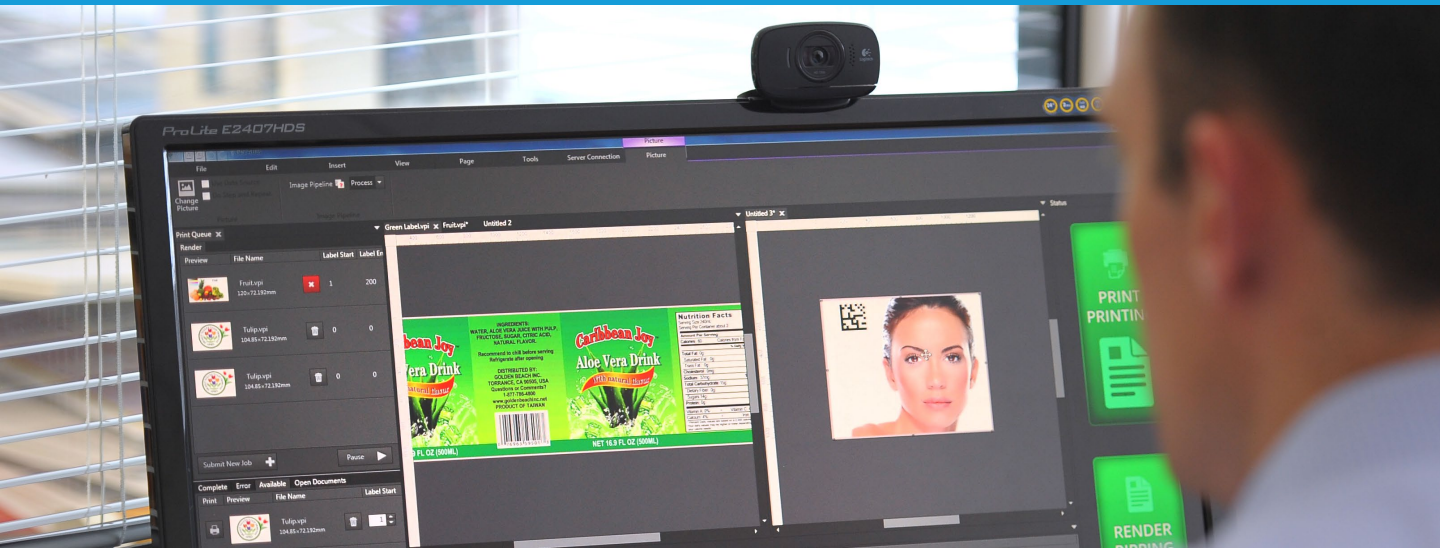

Software correction methods

Software optimisations and compensations

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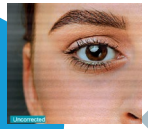
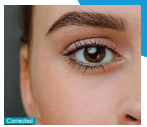
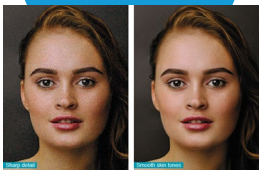
Nozzle Density Compensation



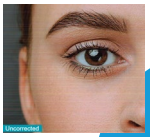


Channel linearisation

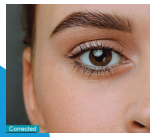
Print Mode and Screeners



Colour Correction



Missing Nozzle Compensation



Screened Image Processing

Printhead and Nozzle density compensation

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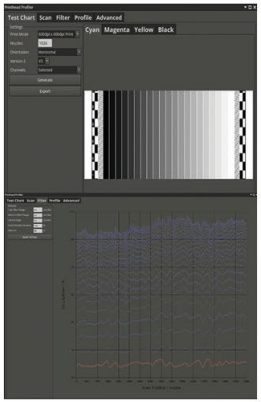
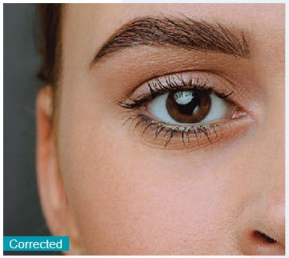
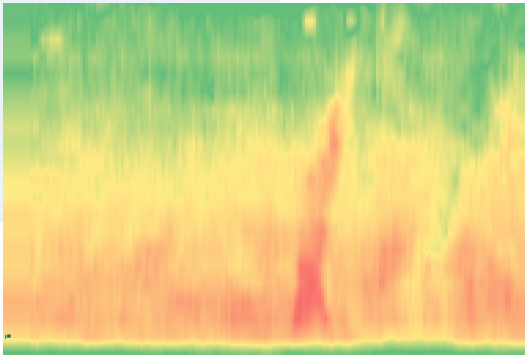




Nozzle Density Compensation

Nozzle Density Compensation adjusts every pixel in the original image with the aim of producing the same output print density for the same input density of the original image for every nozzle.

The application of the GIS Printhead Profiler image correction software can be tightly integrated with the screener software to achieve the fastest correction possible and maintain the highest possible performance of the datapath from original image file to printed output.



Output stability / instability heatmap

Printhead and Nozzle density compensation

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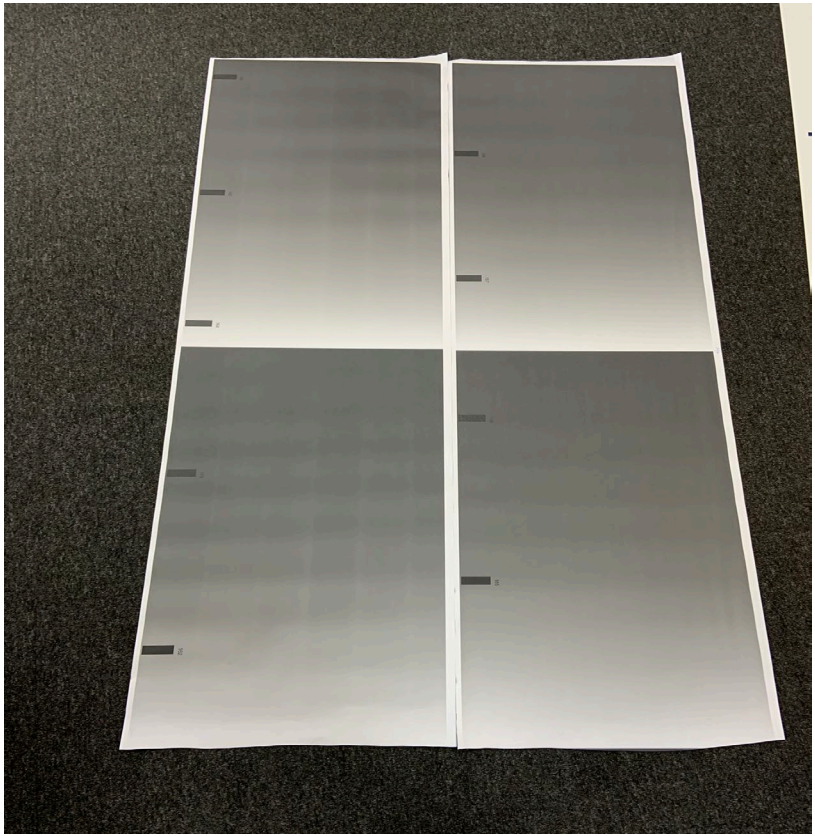

Printhead and Nozzle density compensation

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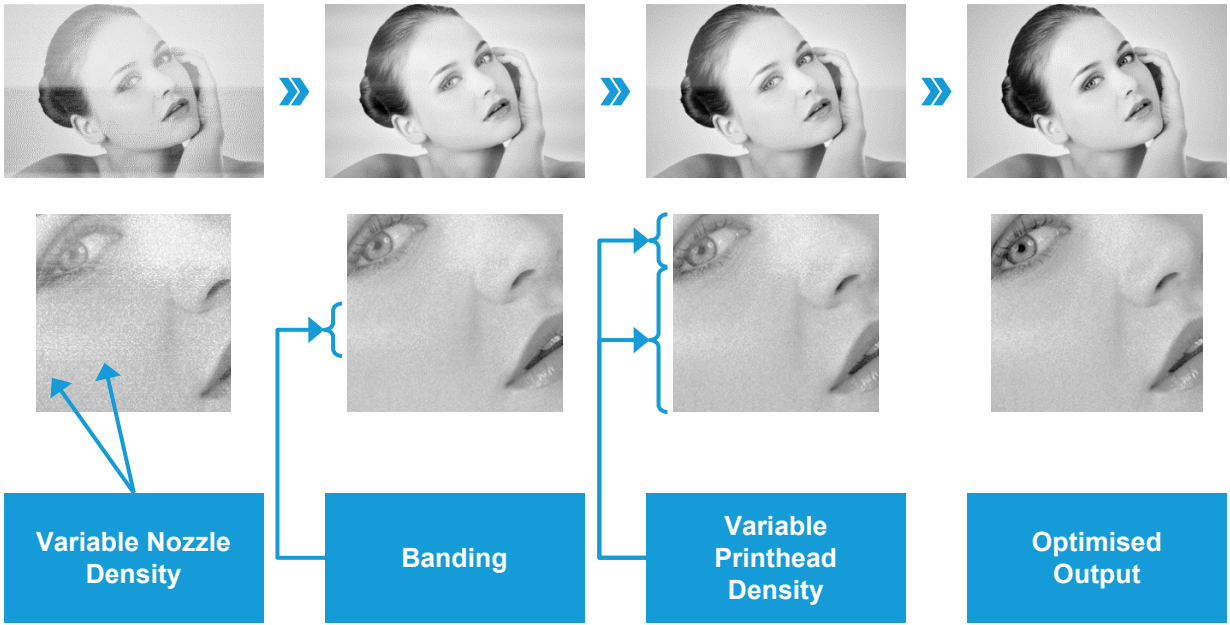
Able to correct density mismatches **per printhead, per bank of nozzles and per nozzle**



Missing nozzle compensation

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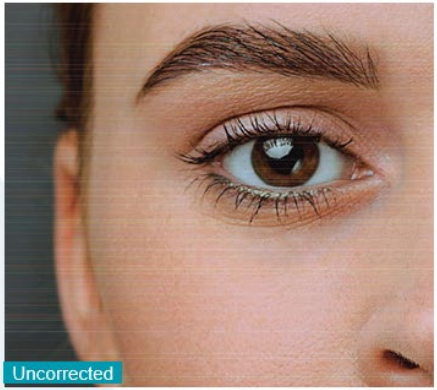
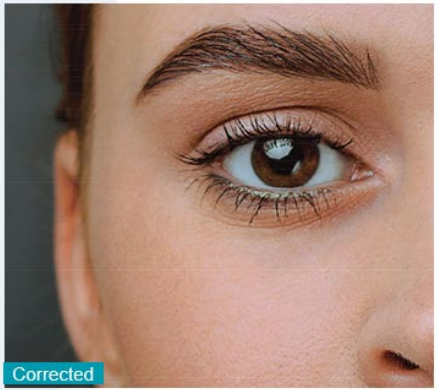
Missing Nozzle Compensation

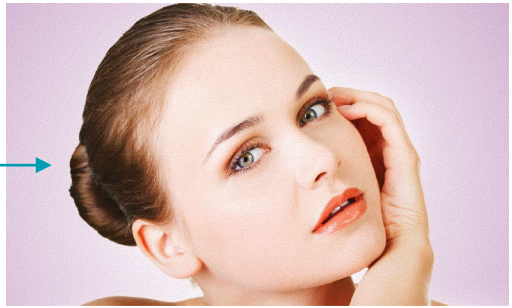
Missing Nozzle Compensation reduces the visibility of missing nozzles. It is tightly integrated with the screeners to maintain optimal performance. In an ideal world all printhead nozzles would be perfect; however, due the size and number within a printhead this is often not the case. Misalignment of or even blocked or damaged nozzles can be masked by software, thereby removing the tell-tale faint lines or missing lines in the final printed image.

Missing Nozzle Compensation allows for neighbouring nozzles to be adjusted to compensate for those issues, thus significantly reducing the visibility of these artifacts and giving the impression that all nozzles are active.

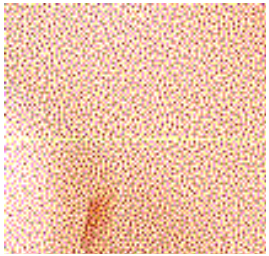




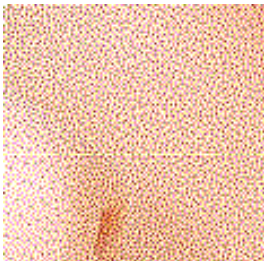
Missing nozzle compensation



4 Level CMYK Magenta missing nozzle on line 511



Uncorrected



Single Channel Corrected

Missing nozzle compensation

Ink flow compensation

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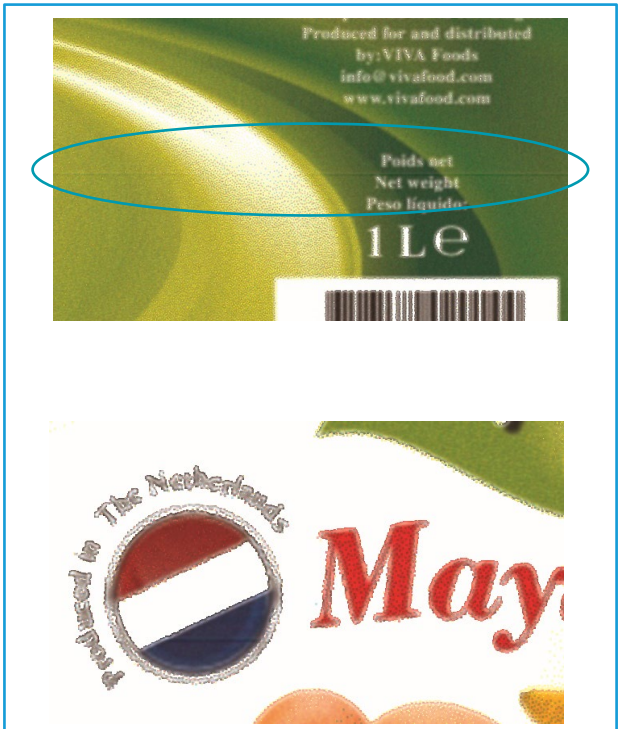

Uncorrected

Corrected

Ink flow compensation

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Not Corrected

Corrected

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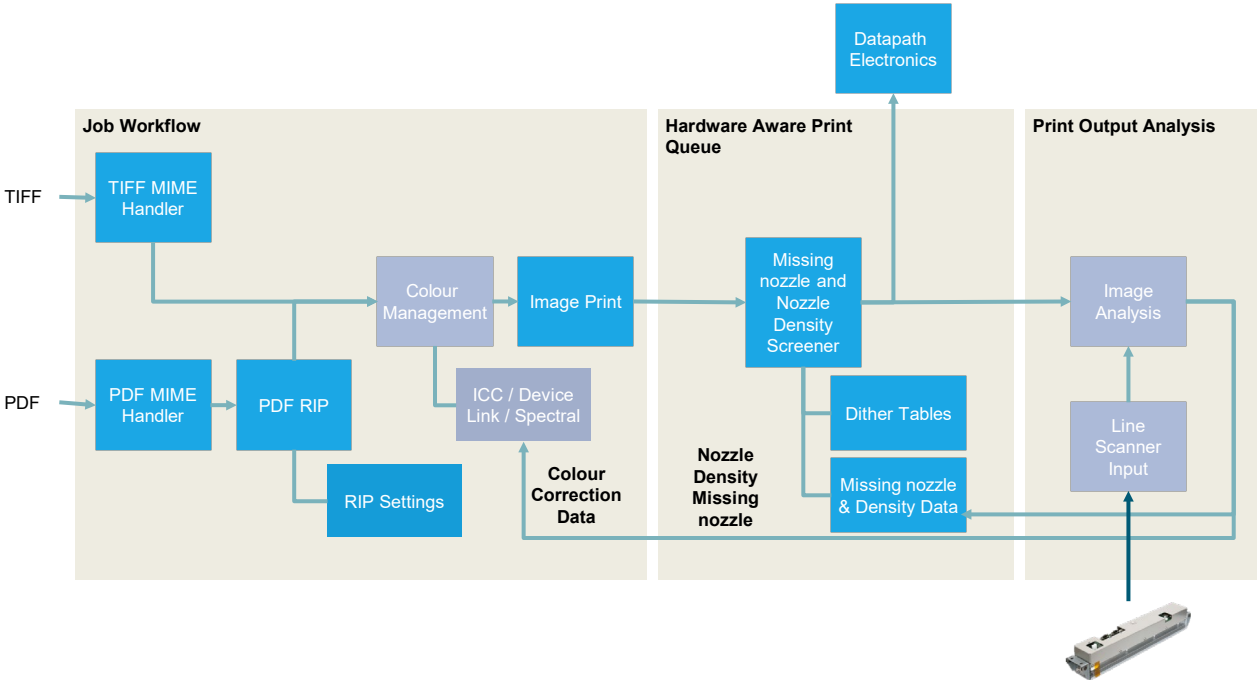
The future is automation

Closed loop compensations

Closed loop nozzle, density and colour compensations



Process corrections

Rotation correction

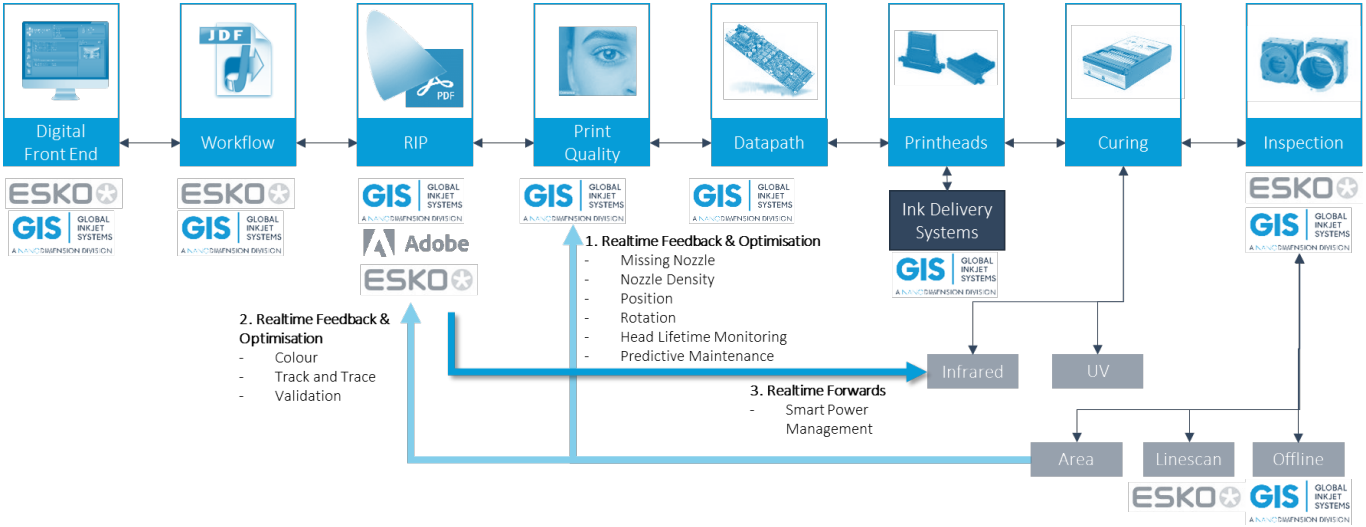
Job Store Entry

PDF → PDF MIME Handler → PDF RIP → Camera Driver → Rotation → Screener → Image Print → Print Queue

Rotation Detection

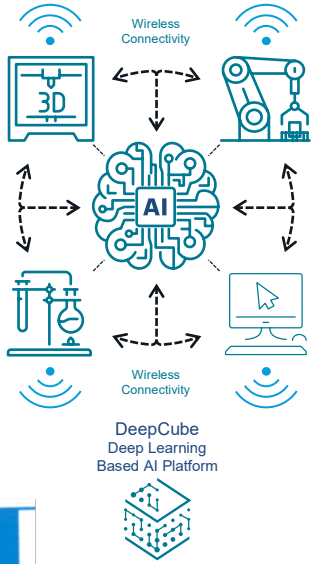
Printhead Array

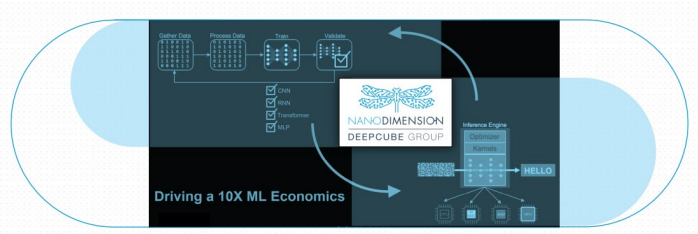
The complete workflow solution

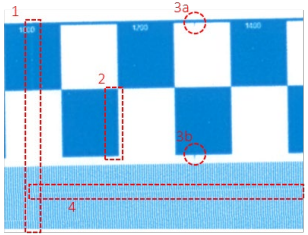


AI Software Deep Learning Technology that Connects into a Robotic Brain

- DeepCube — Nano Dimension's AI platform is **at the center**
- The deep learning-based AI platform **drives self-improving capabilities across the product portfolio**, which delivers:
  - **Better design**
  - **Higher throughput**
  - **Improved yield**







Print Defect Analysts with DeepCube

Summary

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Software compensation can significantly improve image performance for system inaccuracies and errors

The order in which compensations are applied within the workflow can impact the effectiveness and efficiency of the overall data path

Some corrections can be carried out at irregular intervals, others require real-time correction

Human observation shouldn't be dismissed to correct for initial setup and invariant system errors, however ultimately closed loop automated correction is better