GIS | GLOBAL INKJET SYSTEMS

Image Quality: Optimisation and Correction Software

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Inkjet Business Conference

GIS – Company Overview

GIS | GLOBAL INKJET SYSTEMS

- Leading provider of technology solutions to industrial inkjet systems builders
- Founded November 2006
  - Privately owned
- Based in Cambridge, UK
  - Technical support in UK, China & Japan
- Employees ~60
- Patent protected technology
- Supplier & partner to over 130 customers worldwide
- Many applications - including labels, textile, 3D, packaging, product decoration, coatings

GIS Products

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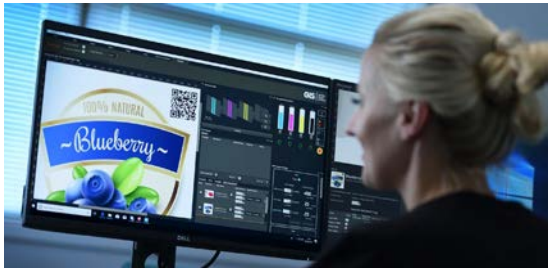
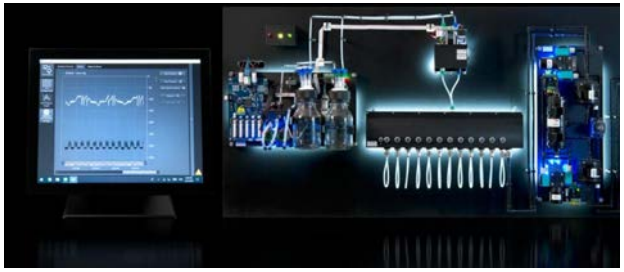
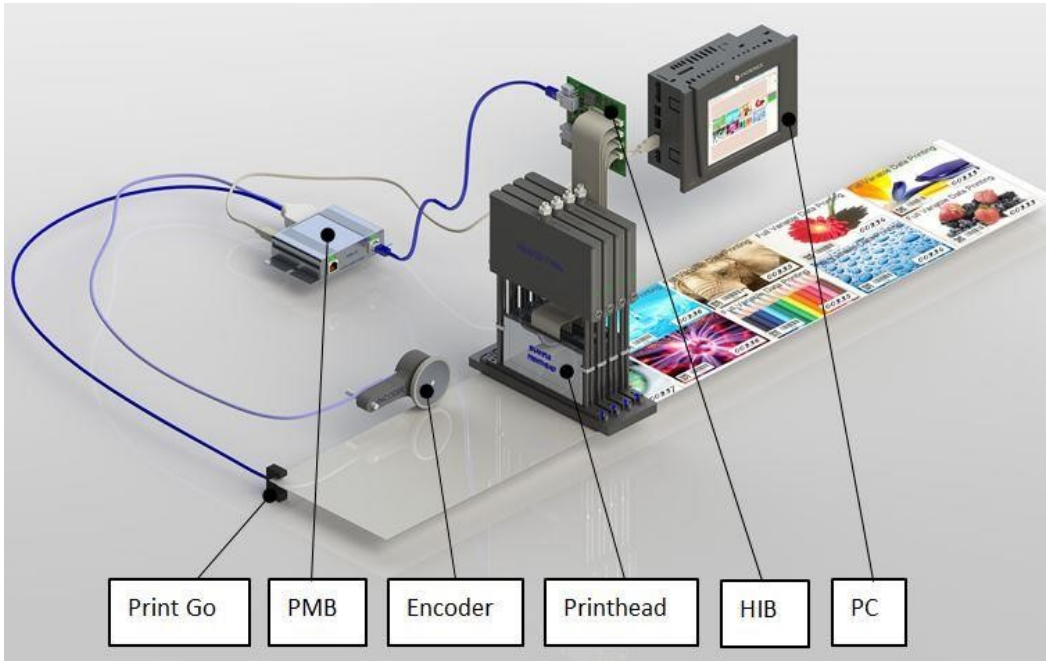
Complete image management from pixel to drop



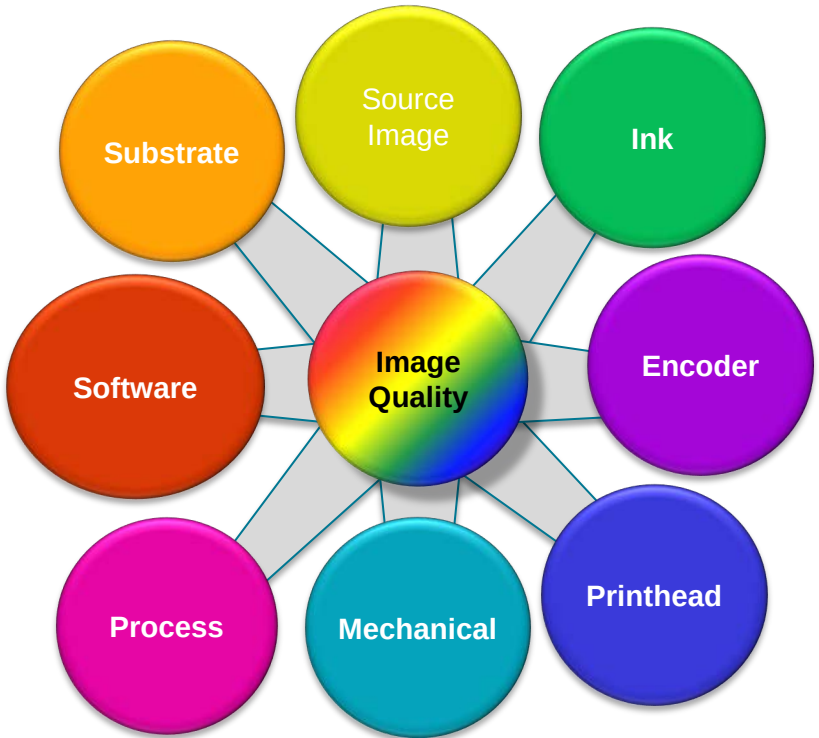


GIS customers - system builders, OEMs, integrators, large end users and fluid developers worldwide - in many different applications and markets

Deceptively Simple….



But, many factors affect image quality……



Factors Affecting Image Quality

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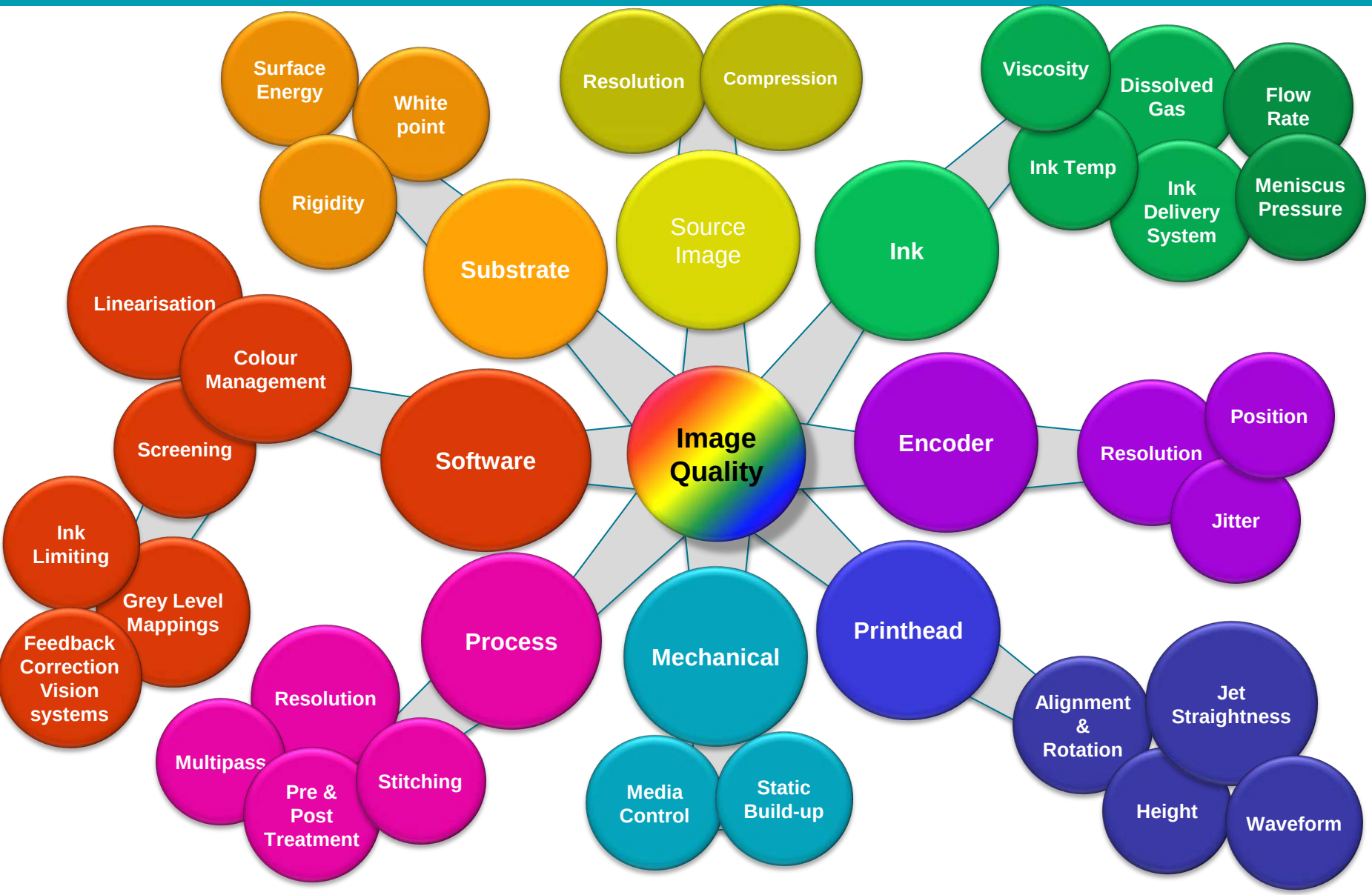

Quality Issues…(Just a Few Examples)

- Jetting errors
- Image artefacts
- Poor edge definition
- Grainy images
- Nozzle density issues
- Missing nozzles
- Banding
- Poor registration
- Texture/unevenness in solid colour areas
- Colour not stable
- Colour bleed
- Ink supply issues
- Lack of thermal control
- Reticulation

- Inkjet printing systems have interacting & co-dependent parts
  - Many components must work together in harmony
- As inkjet enters more demanding applications – print quality requirements increase

Different Applications - Same Challenges

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Graphics	Wide format Textiles Packaging Labels Ceramics Glass Laminates Varnish	**Need to achieve:-** • Flat colours • Uniform coatings • Invisible stitch zones • Colour consistency • Colour accuracy • Edge definition • Accurate drop placement • Registration **Need to correct:-** • Uneven nozzle density • Visible stitch areas • Missing nozzles • Rotation / skew
Materials Deposition	Functional coatings Encapsulation layers OLED display	

Software Correction Technologies

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Software can compensate for many system imperfections

- Stitching
- Missing Nozzle Compensation
- Nozzle Normalisation / Density Correction
- Screeners

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Stitching

Printhead Alignment & Stitching

Why is a good stitch important?

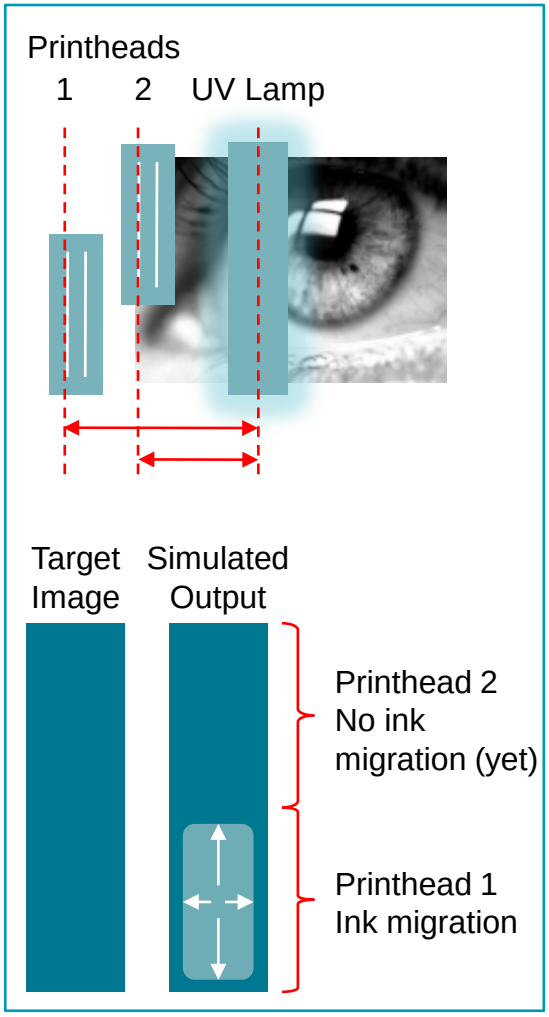
- The human eye is very good at spotting discontinuities especially in areas of flat colour

What needs to be controlled?

- Printhead alignment: Typically positioned to within <20% of the diameter of a drop
- Printhead calibration: Printheads ideally need to be tuned for jet straightness and drop size conformity
- Ink substrate interaction: Ink moves over time creating visible artefacts – ink migration control

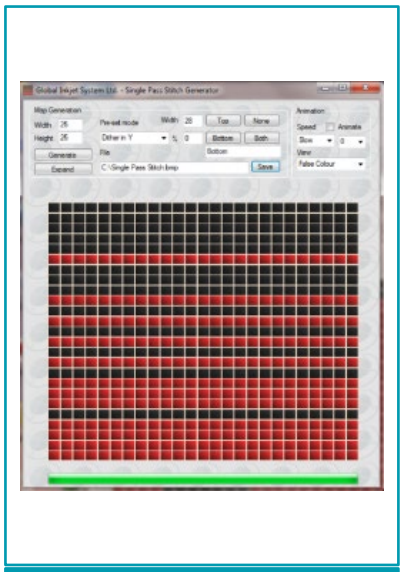
Stitched printheads do not all jet in the same place at the same time

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

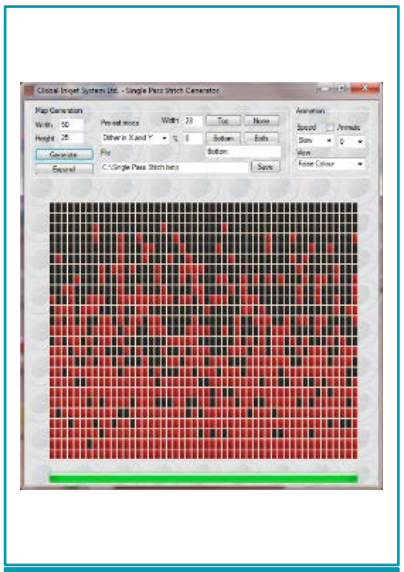


Hard Stitching / Masking

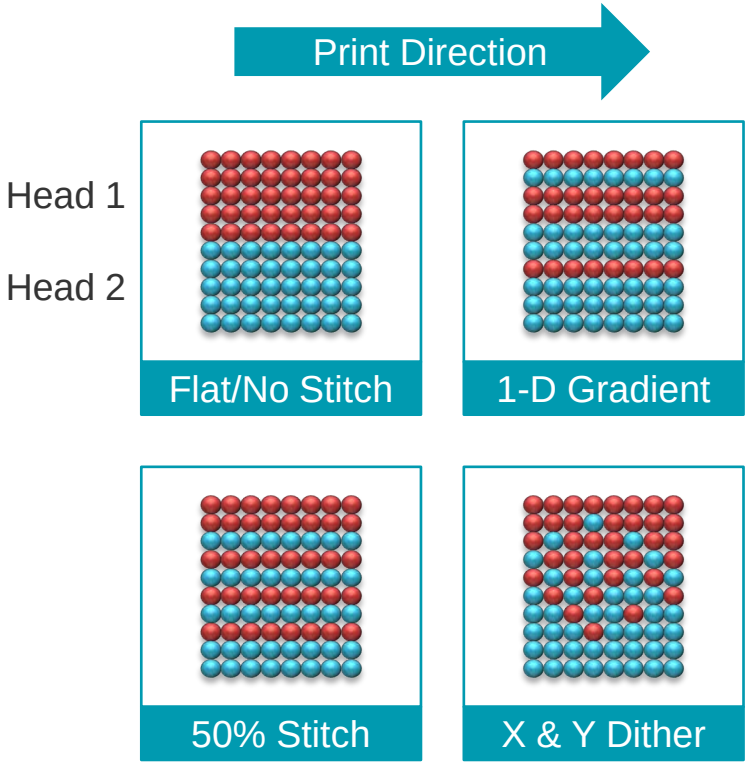
- **Masking (Hard Stitching)**
  - Nozzle on/nozzle off (binary)
  - Wide variety of options
- **Stitches can massively improve output quality & different applications benefit from different strategies**



2-D Density



X & Y Dither



Stitching Examples

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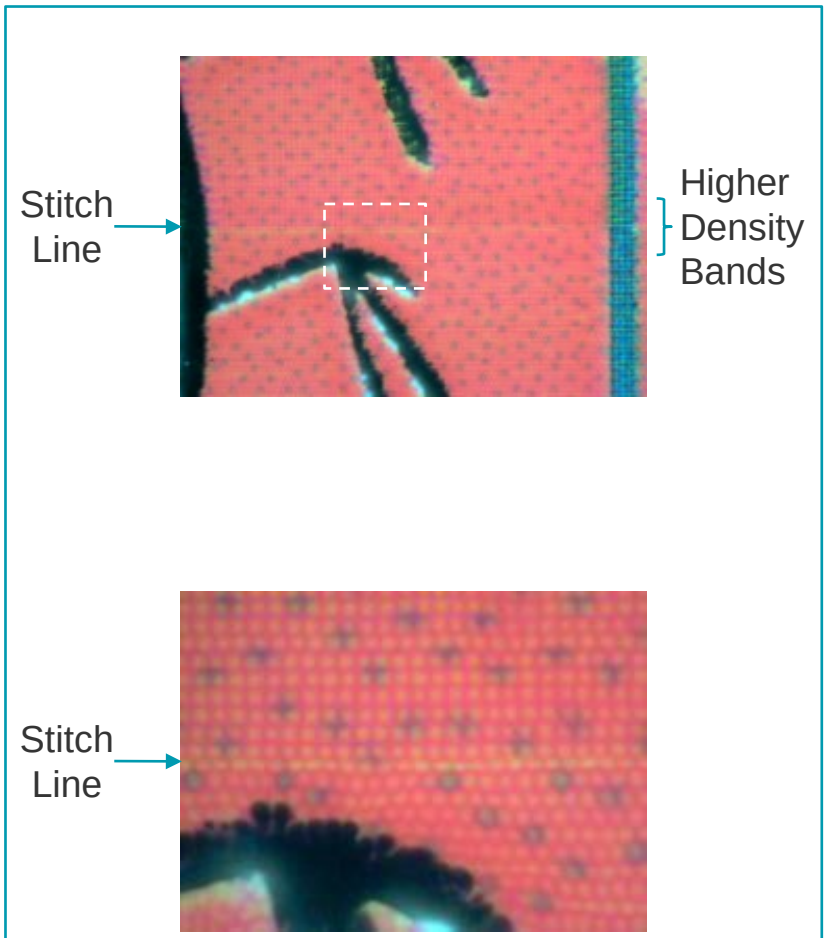
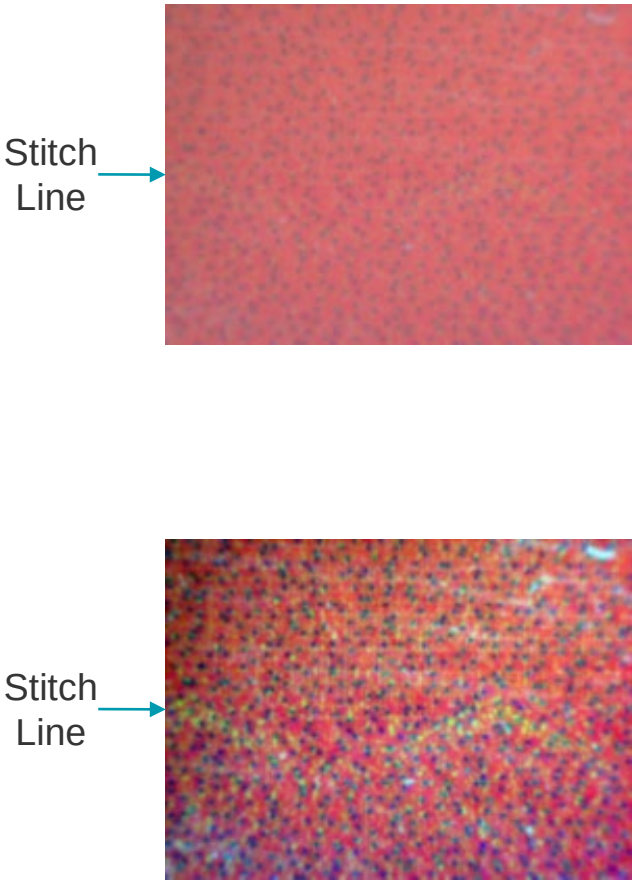


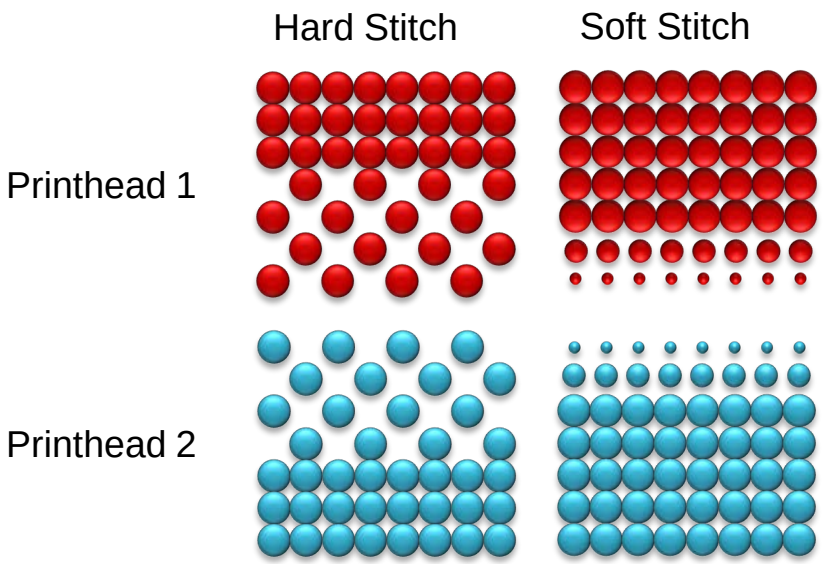
“Flat” or “No” Stitch across flat colour

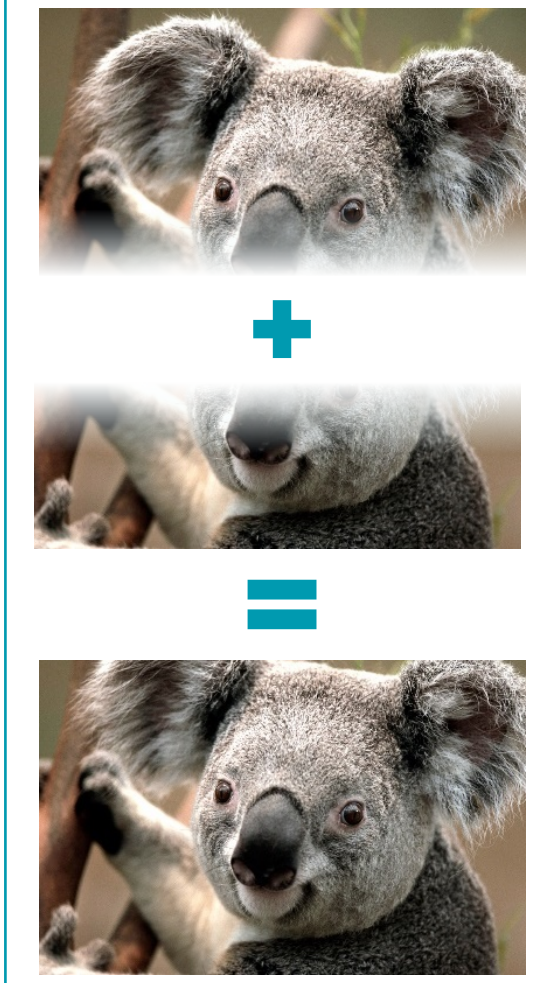


‘Moving Stitch’ across flat colour

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**





Missing Nozzles

Missing Nozzles

Nozzle sizes are getting smaller

- More easily blocked or deflected

Large print bar arrays

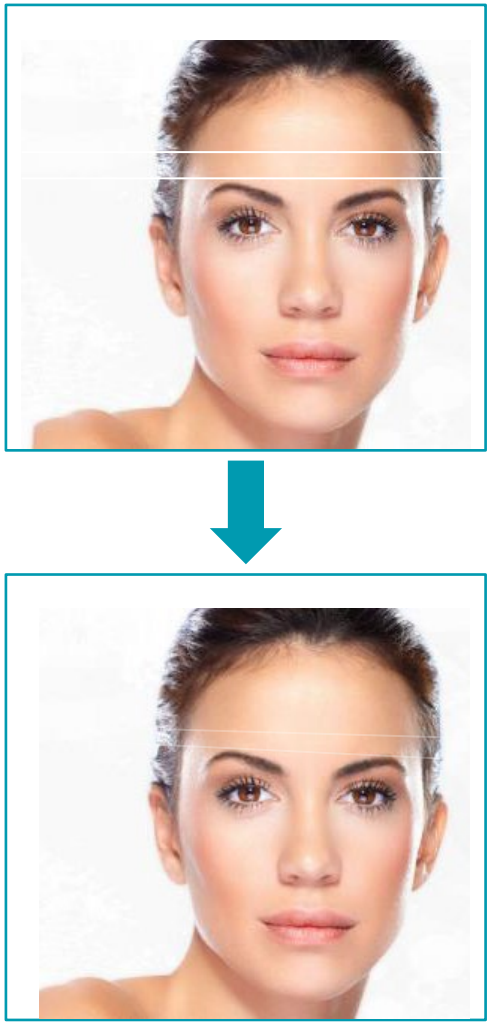
- Many more nozzles
- Higher probability of issues and lower MTBF
- Need coping strategies

Strategy 1: Redundancy

- Add second row of printheads per colour so when one nozzle fails another can be used
  - Expensive

Strategy 2: Hide the problem

- Identify where a nozzle is faulty and spread the jetting responsibility to neighbouring nozzles and/or colours



Missing Nozzle Compensation

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Isolated nozzles work best

- Clusters of nozzles much more difficult to hide
- Technology works best where there is some substrate bleed/drop overlap

Many different strategies exist using neighbouring nozzles

- Correction in contone or screened data
  - Hide error in same colour plane to neighbouring nozzles
  - Hide error in other inks - in multi-ink backgrounds
    - If Cyan nozzle fails - could add a little black to hide white space
    - If Black fails – use composite (CMY) black
- Increase the density of neighbouring nozzles
  - For binary printing this is achieved by enabling neighbors which would have typically been off
  - For grey level printing this is achieved by increase the grey level of the neighboring nozzles
    - To achieve the most accurate correction, reserve the maximum grey level for nozzle correction, and tune the system performance to match

Strategies work best in mid & light mid tones

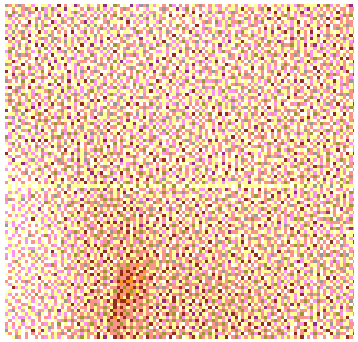
- Also improves dark tones

Helps disguise/makes the missing nozzle less visible

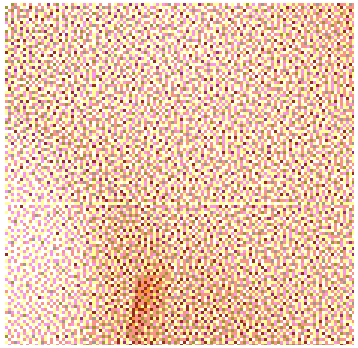
- Less white space

Missing Nozzle Compensation

4 Level CMYK
Magenta nozzle
out on line 511



Uncorrected



Single Channel Corrected

Missing Nozzle Compensation

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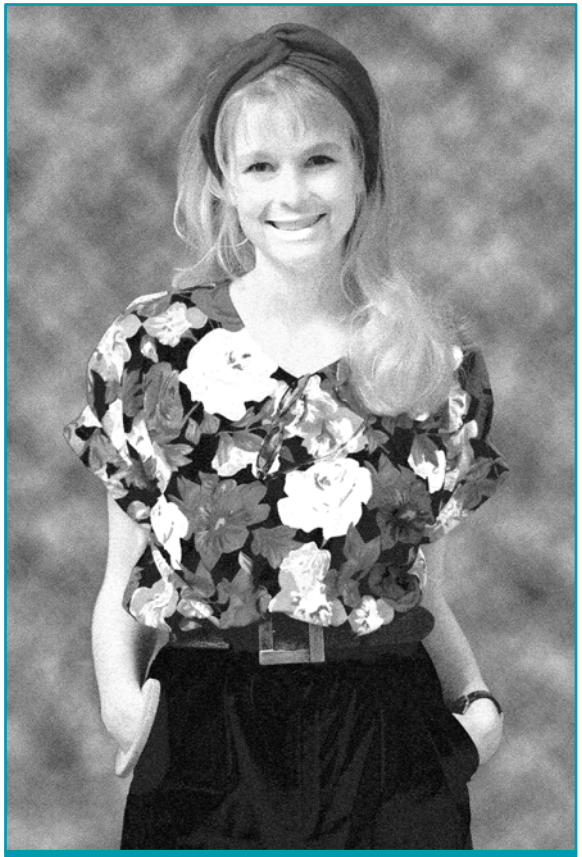
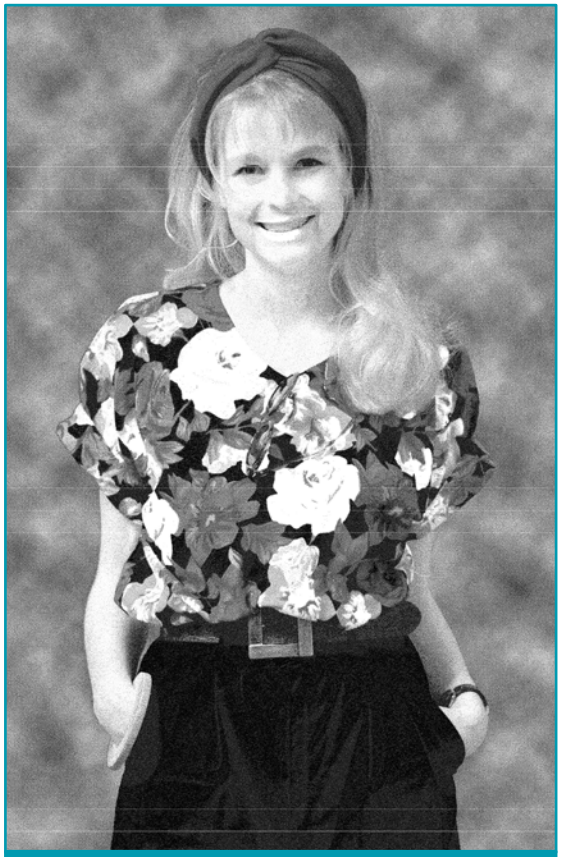
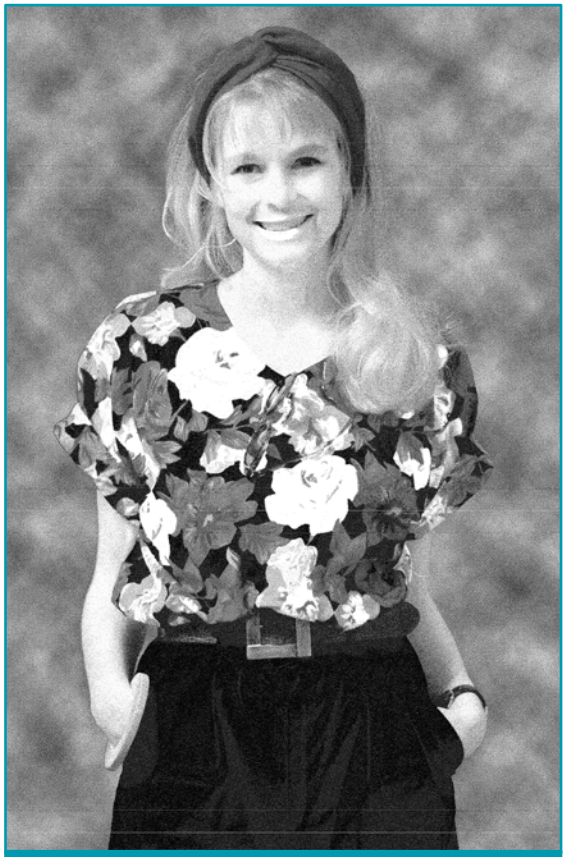


Original Image



Missing Nozzles



Missing Nozzle Compensation

Nozzle Density / Nozzle Normalisation

Nozzle Density / Nozzle Normalisation

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Drop volumes not always consistent across printhead

- More apparent the more heads you have in an array
- There can be a “non-linearity” in drop volume
- Even small difference can affect final print – particularly areas of solid colour
- We want uniformity - flat colours

Many reasons why this can happen:-

- Printhead manufacturing issue - drop ejection may not be consistent
- Temperature variation in ink system - affects ink viscosity
- Piezo activity - heavy use of some sections of printhead creates warm areas
- Electronics - uncalibrated/low quality electronics may affect drop volume

Typical Example - Uncorrected

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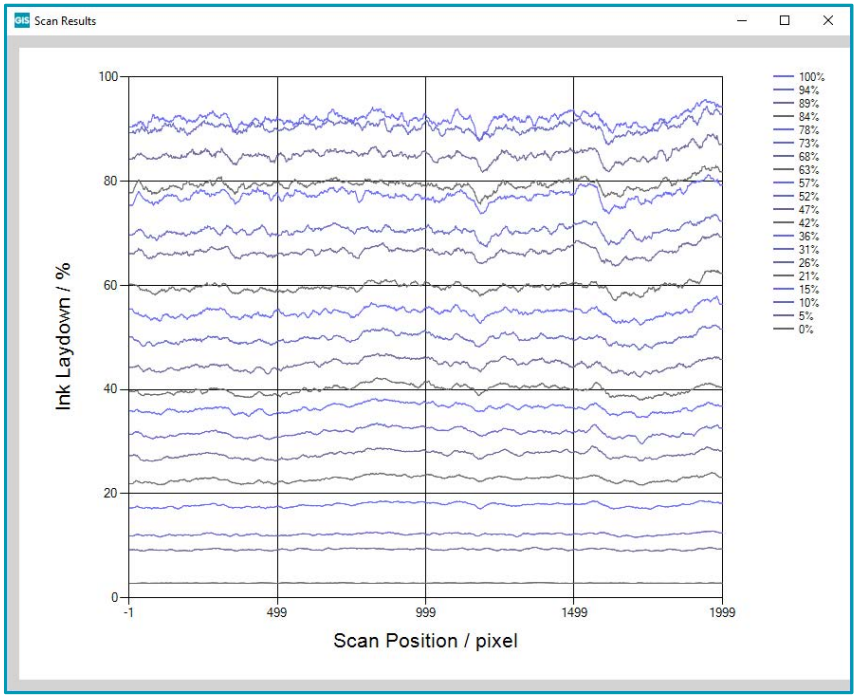
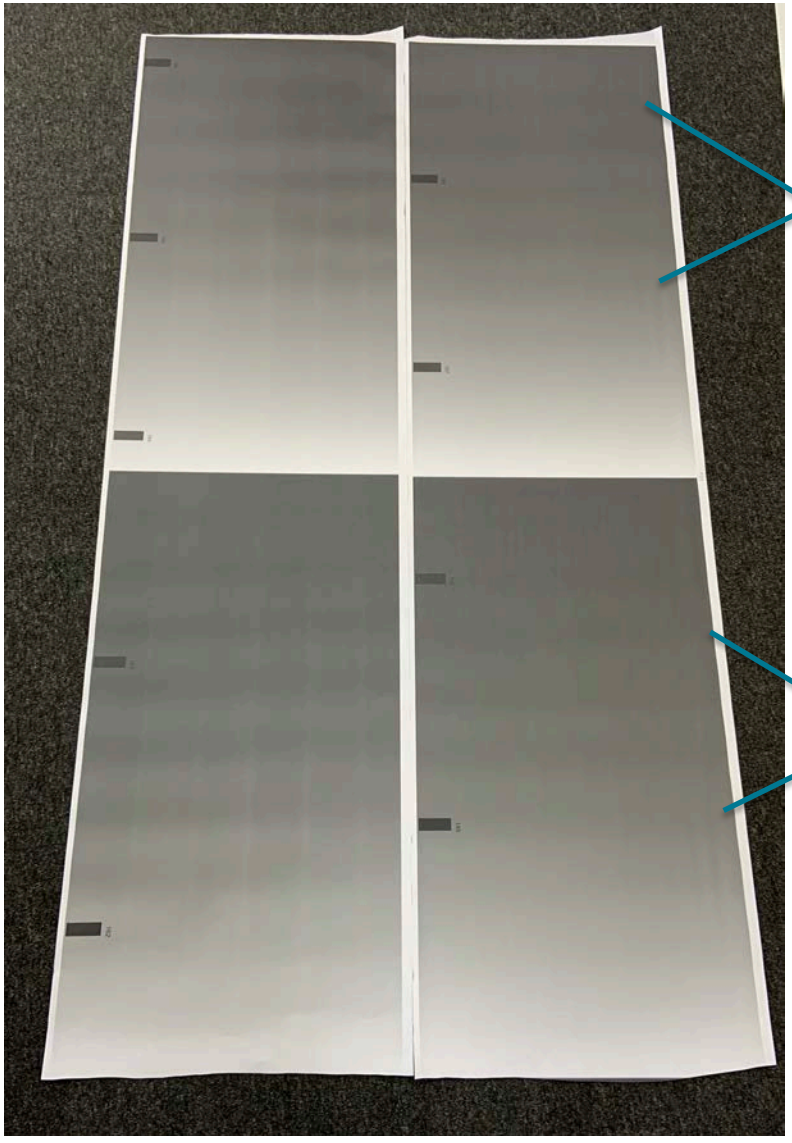
Nozzle Density Correction

Nozzle Density Correction – for Flat Colours / Uniform Coatings

- Aim is to achieve even density across a full printhead array for each grey level
- **Offline solution:** Print greyscale test pattern for each colour channel and measure the density across the printhead array at a range of grey levels
- **Inline solution:** closed loop with line scanner
- Adjust the grey level mapping at intervals across the printhead array



Uncorrected Corrected



Uncorrected Corrected

Uncorrected Corrected

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Uncorrected

Corrected

Uncorrected

Corrected

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Screeners

Screeners

- For detailed presentation on Screeners please see https://www.globalinkjetsystems.com/wp-content/uploads/IJC-2019-GIS-Understanding-Optimising-Screeners.pdf by Phil Collins, Director - Advanced R&D at GIS

Example Print Configurations	Screener Considerations
Static pre-RIP'ed	Screen once for best quality. Screener speed usually not as important.
Single-pass low latency	Screener speed dominates, favouring Ordered Dither.
Scanning-XY with density correction	Mechanical stability. Robustness to density / colour shifts.
Direct to Shape with robot transport	Curved surface awareness. Integration with motion control.
Closed Loop	Screener speed must match changing inputs.

Closed Loop Example – GIS & Esko Process Map

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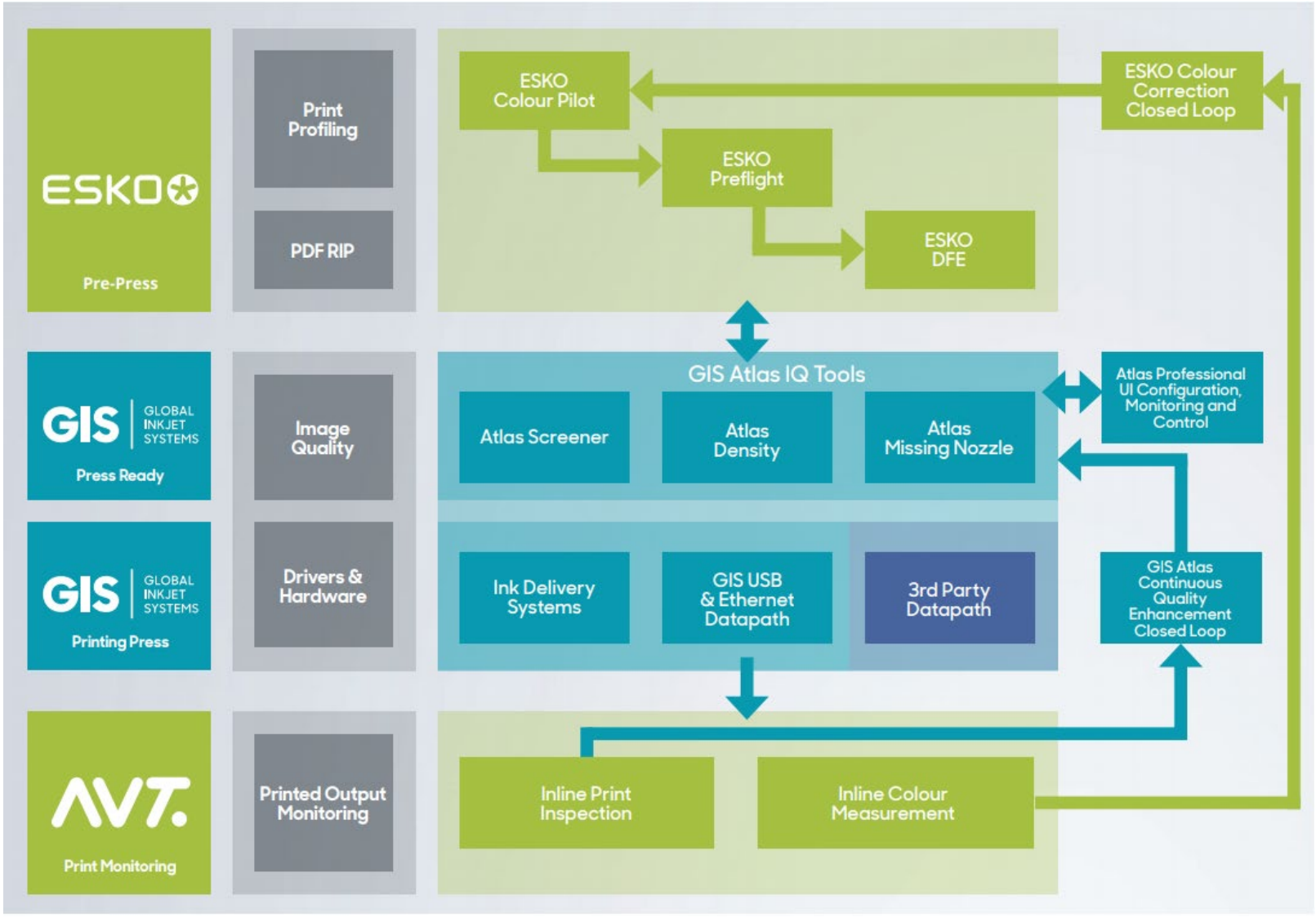

Image Quality Summary

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- Pressures on achieving & maintaining image quality will increase
- Advanced software capabilities and screening techniques are key
- GIS offers full suite of software IQ Tools to OEMs: off-line or in-line implementation

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

Inkjet systems have interacting & co-dependent parts. Multiple print quality strategies required for optimal results

Some corrections can be carried out offline, others require real-time correction with closed loop systems

Innovative software can unlock new applications & opportunities

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