Curved Surface Direct Product Decoration Challenges and Solutions

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Information Management Institute

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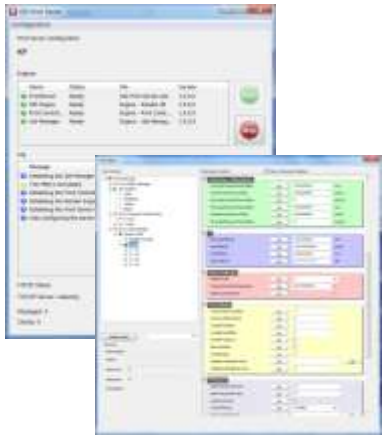
CONTROL | PERFORMANCE | INNOVATION

GIS – Overview

GIS Print Server
RIPs & Utilities



PC

GIS Electronics

Print Manager Boards

Head Interface Boards

Printheads

GIS User Interfaces
3rd Party Control

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GIS Operating System

Layout
Transport
Spit & Drop Watching
Printhead Status
Job Submission & Queue
Colour Management
Ink Cost Calculation

GIS User Interfaces

3dr Party Control

Complete Remote Control
TCP/IP (ASCII / Unicode)
VB/C++/C# Libraries
Example Source Code & Projects

TCP/IP

GIS Print Server

High Speed PDF RIP

Real Time Multipage PDF
Render & Screening

Colour Variable RIP

1D, 2D & Composite Barcodes
Bitmap Support (GIF, PNG, BMP, TIF, JPG)
Shapes (Lines, Rectangles, Circles)
External Data Support

Print Manager Boards

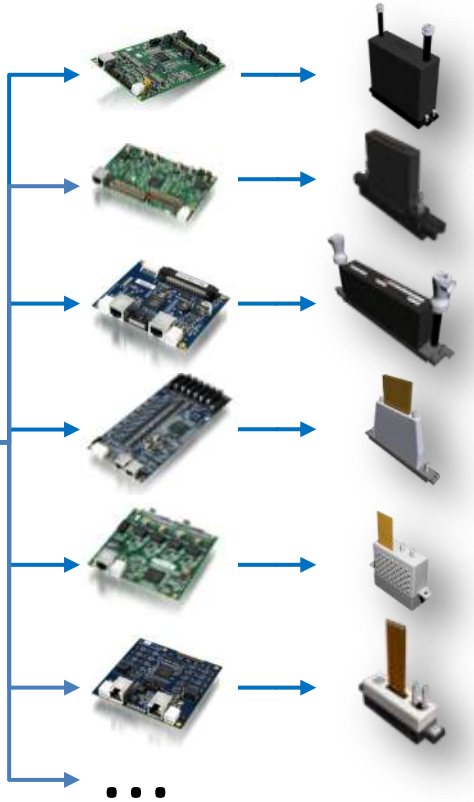
Peripheral Control

Software Motion Control (XY, Single Pass etc.)
Ink System Control
PLC Control

Utilities & Tools

Pattern Generator
Waveform Generator
Multipass Map Generator
Single Pass Stitch Generator
Curved Surface Compensation Generator
Print Server Monitor
Print Manager Board Info
Transport Mechanism Tester

Head Interface Boards



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Agenda

- **Direct production decoration**
  - Snapshot of what's happening now
- **Understanding shapes**
  - Flat is easy; curved is….challenging
- **Printing onto various shapes**
  - Cylinders, cones, bottles
  - Stitching
- **Integration into production lines**
- **Printing onto more complex shapes**
  - GIS curved surface tool

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Direct Product Printing Technologies

Screen printing

Dry offset printing

Pad printing

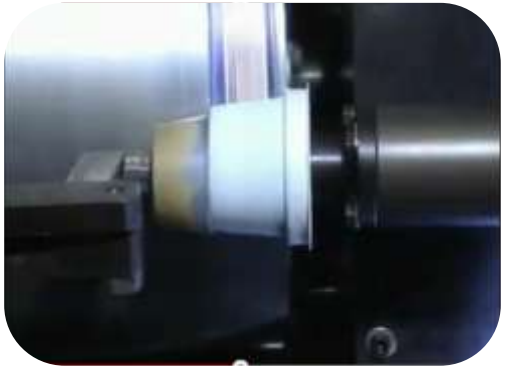

Image sources: Kase Equipment; Ink Cups Now; ITW TransTech

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Product Examples

Four million unique bottles produced by Absolut – screen & spray

Direct printing – screen/dry offset

Cartonboard wrapped around plastic

Shrink sleeve

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Where Digital Adds Value

- Your Heineken
- L'Oreal Toy Story 3 Shampoo
- Sprite (Coca Cola Israel)

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Direct Product Decoration

UNDERSTANDING SHAPES

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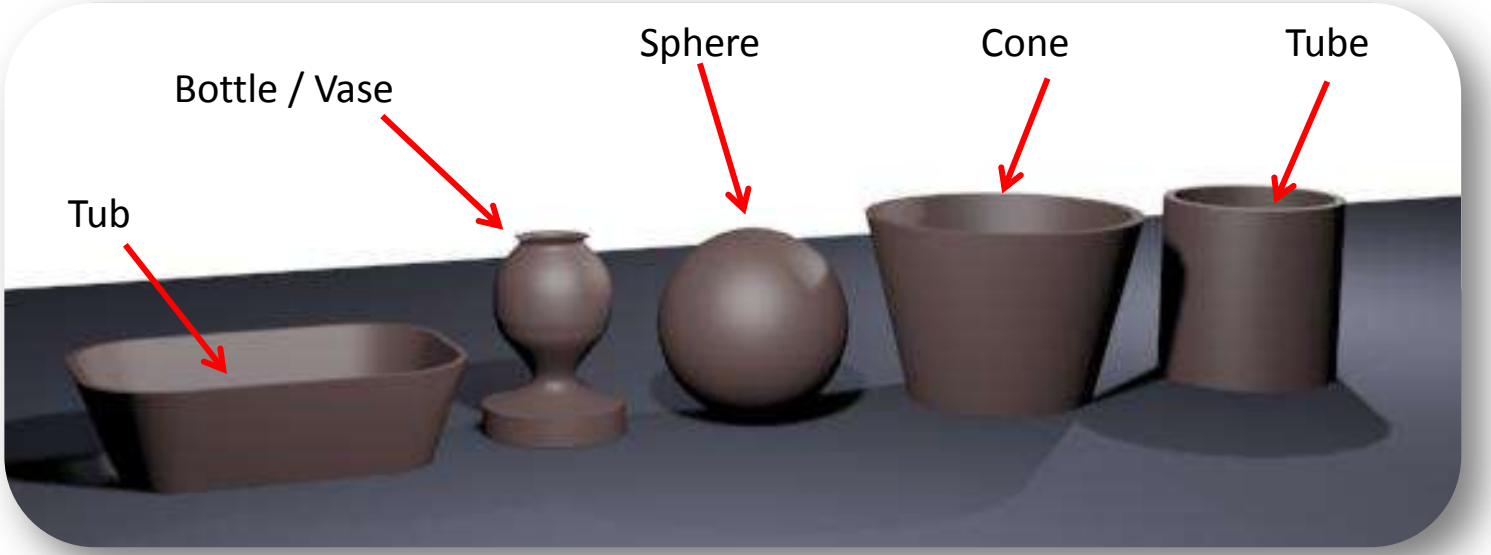
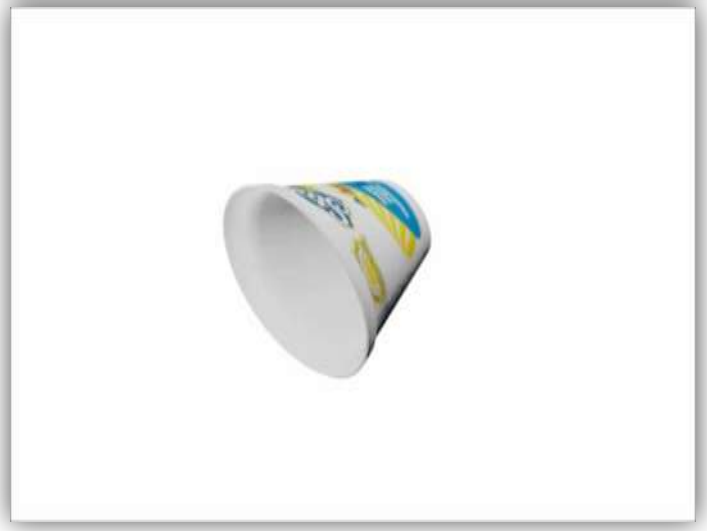
Categories of Shapes

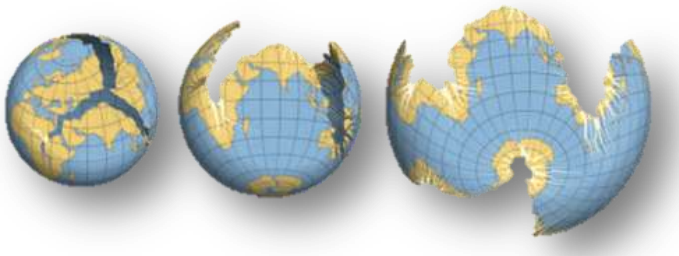


- **The real world is made up of a variety of different shapes**
- **Continuity in direction of print**
- **"Continuous" shapes – curvature remains constant in direction of print**
  - Tube, cone (mixed resolution, but still continuous), bottles etc
- **"Discontinuous" shapes – curvature changes**
  - Tub (mixture of flat edges and curved corners)
  - Correction required keeps changing
  - Discontinuity across the printhead – adds considerable complexity

Unfolding or “Flattening” Shapes

- **Allows us to understand the complexities of printing onto that surface**
  - **Cylinders**
    - Slice a cylinder down one side – unfolds/flattens to a simple rectangle
  - **Cones**
    - Cones unfold into “arced” rectangle
  - **Tubs**
    - Tubs are combinations of cones and cylinders with discontinuities
  - **Bottles & Spheres**
    - Bottles & spheres cannot easily be unfolded
      - Spheres have always presented a problem
      - Bottles often highly complex





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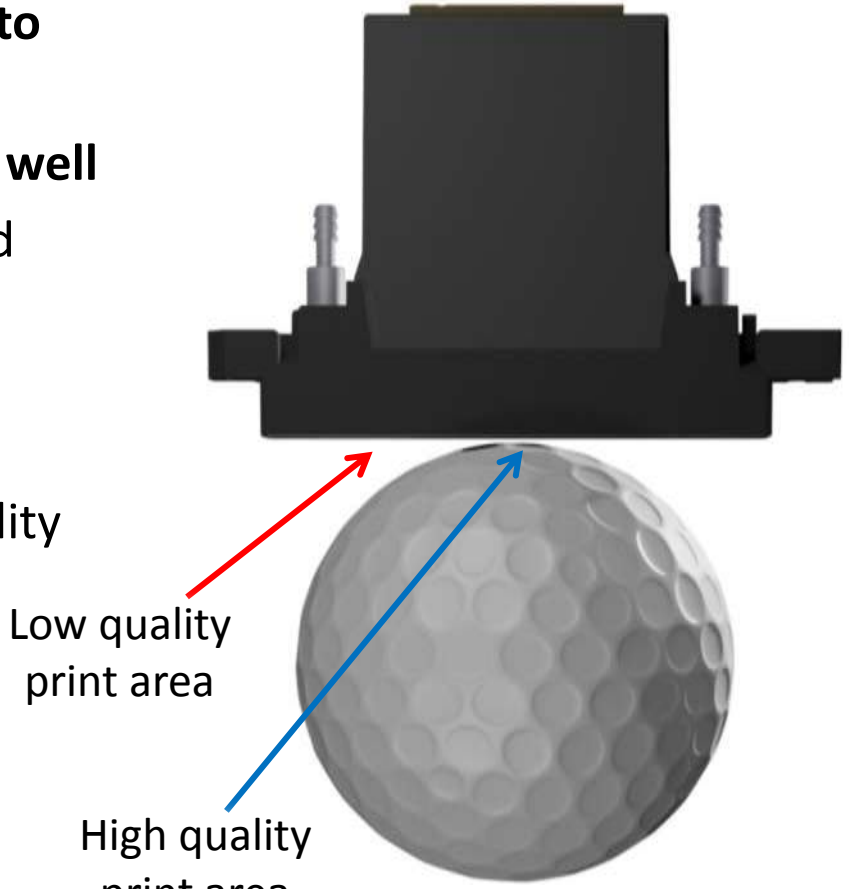
Flat Printheads and Curved Shapes

- **Inkjet printheads have been designed to print well onto flat surfaces**
- **Some shapes are very hard to print on well**
  - Drops only jet a few millimetres and decelerate quickly
  - Jet straightness
  - Larger drops jet further but smaller drops improve graphical image quality
  - Printhead dimensions
    - Reaching the nooks & crannies
- **Golf ball example**
  - Area of print focused in small area
  - Or - many revolutions needed



In an Ideal World….

- **An interesting challenge for the industry!**
- **In the absence of such a product - we have to deal with reality**
  - Physical characteristics of printhead in relation to curved surface
    - Jet straightness
    - Time of flight
    - Distance between nozzle banks
  - Image compensation – where applicable

Product Decoration

CONTINUOUS SHAPES

TUBES, CONES AND BOTTLES

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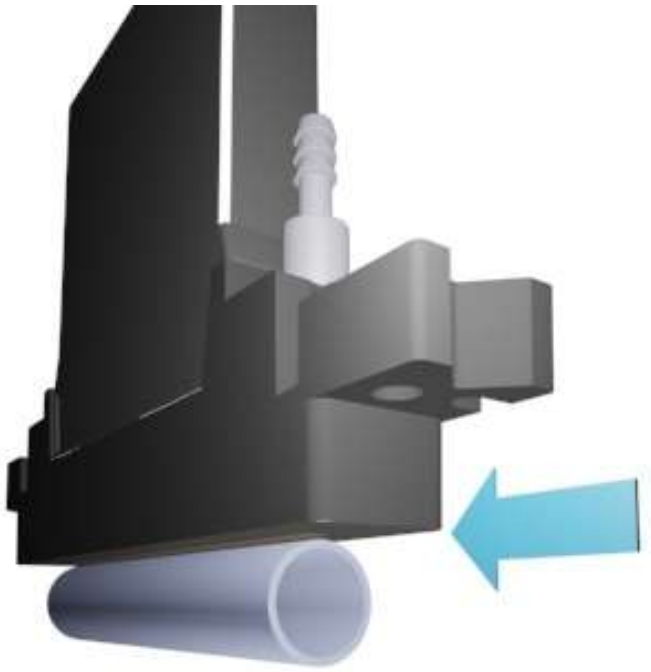
Printhead Orientation

- **Orientation of the object under the printhead to get best possible print**
- **Three key issues**
  - Symmetry
  - Nozzle bank width
    - The narrower the better
  - Number of columns
    - Different times of flights
    - More complex



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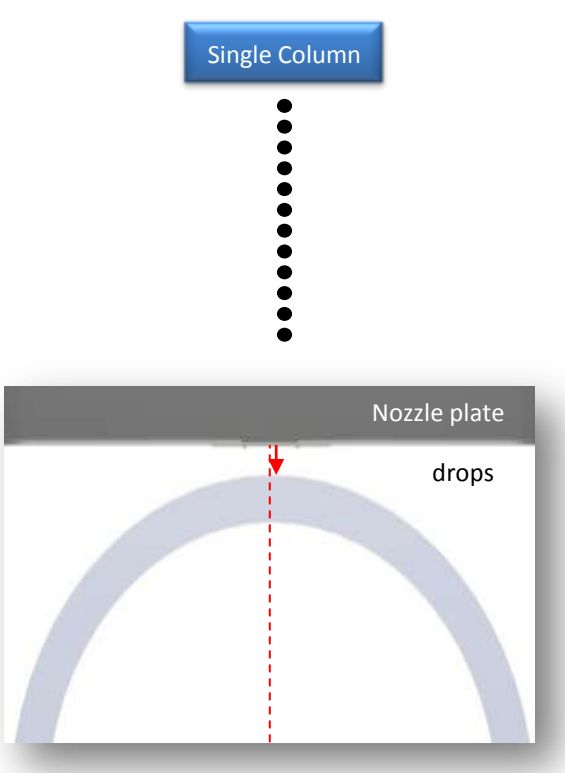
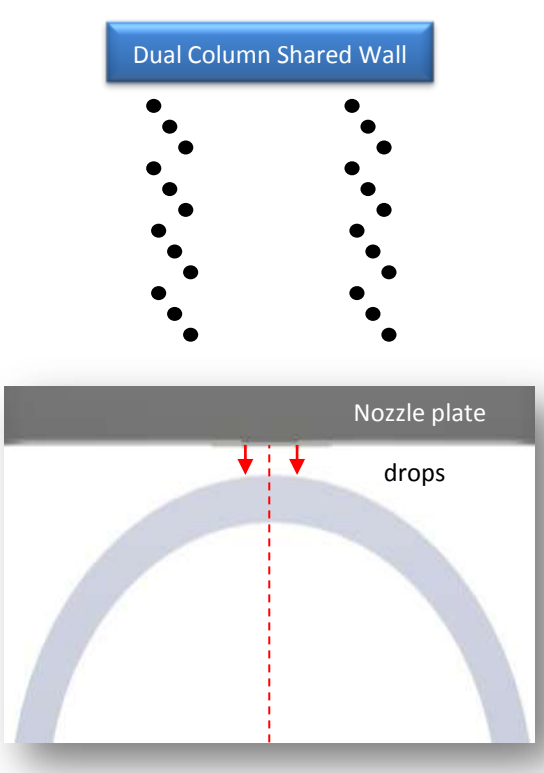
Printhead Geometry



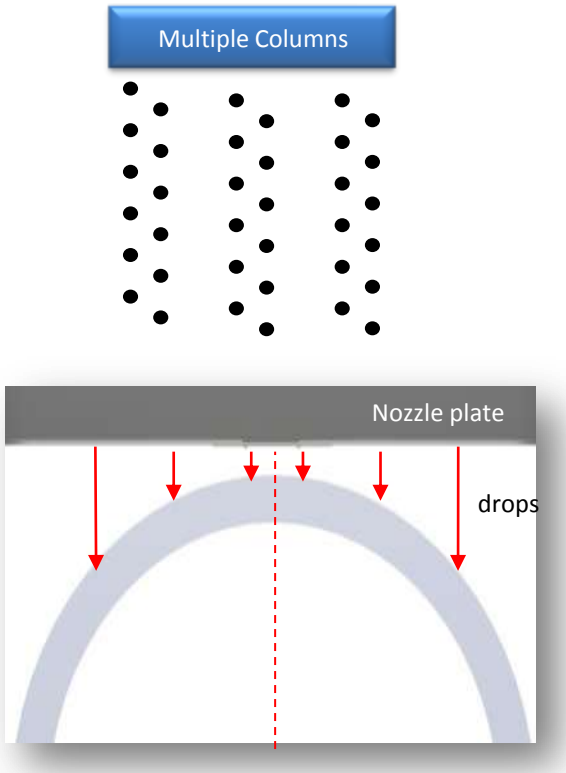
Single column

Easiest, but lower resolution



Dual column shared wall

Symmetrical , narrow is better



Multiple columns

Faster, complex but some printheads have independent fire control, which helps

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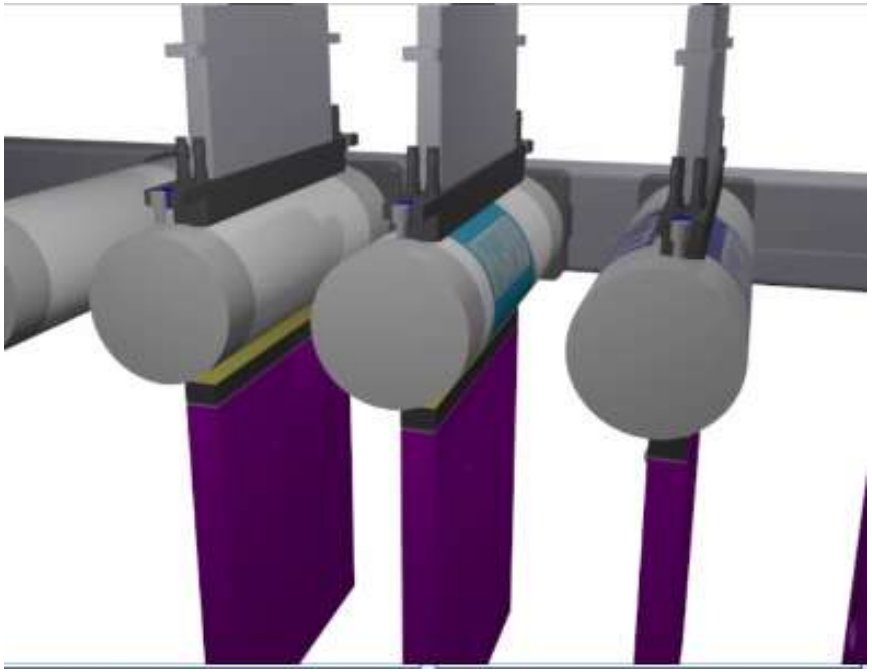
Tube Rotation Under Printhead

- **A “flat” image wrapped around a cylinder**
  - No image compensation required
- **Physical characteristics of the printhead**
  - Geometry
  - Drop ejection
  - Time of flight

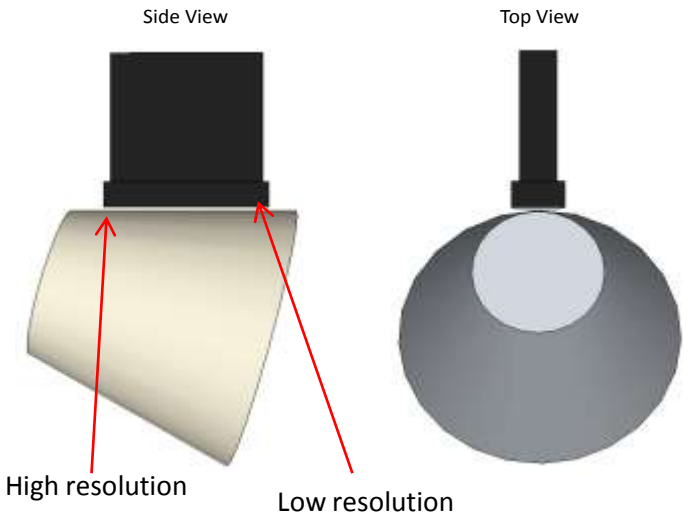
Tube Array



- Open-ended tube on mandrel
- Heads in a fixed array
- Each mandrel can spin/geared
- UV lamps under each print station
- Motion control moves mandrel under 1st printhead - Cyan
- Needs 1.5 revolution per colour to print and then cure
- Whole mechanism moves along and prints each colour in turn
- Example of pipelining

Cones

Cone – continuous shape, but more complicated than a tube



- **Nozzle alignment issues as before**
- **Resolution changes when printing onto curved surfaces**
- **Need to compensate for density increase**
- **Screening more complex**

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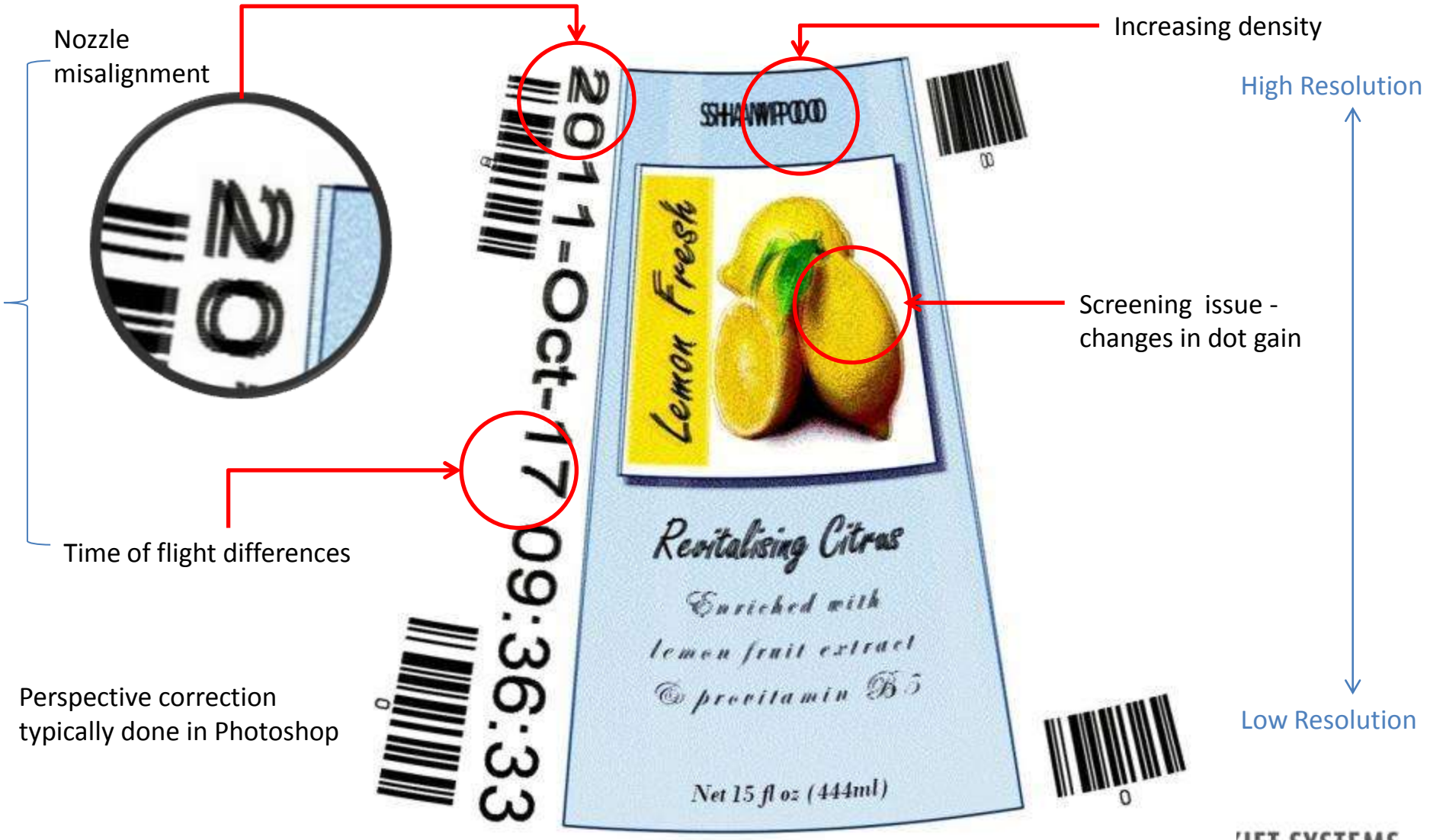
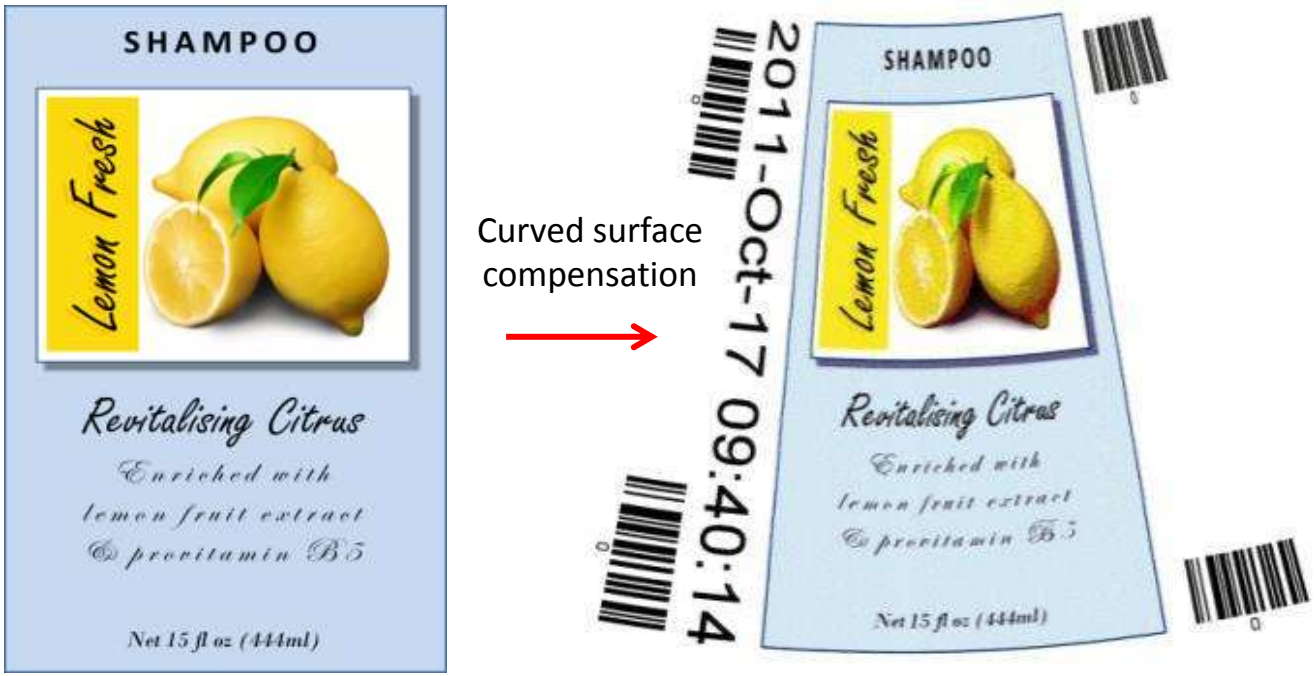
Printing with No Correction



Printing with Correction



- **Correct nozzle alignment**
- **Density correction**
- **No dot gain issues**
- **No screening artefacts**
- **Image distortion - managed in original artwork**

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Printing Onto Bottles

- **Huge range of shapes of bottles**
- **Labels/decoration typically on the tube section**
- **Printing more of the bottle presents new challenges as often different corrections required**
  - Combination of tubes & cones
  - Some have discontinuous shapes e.g. a tub-shaped base
  - Plus ridges etc

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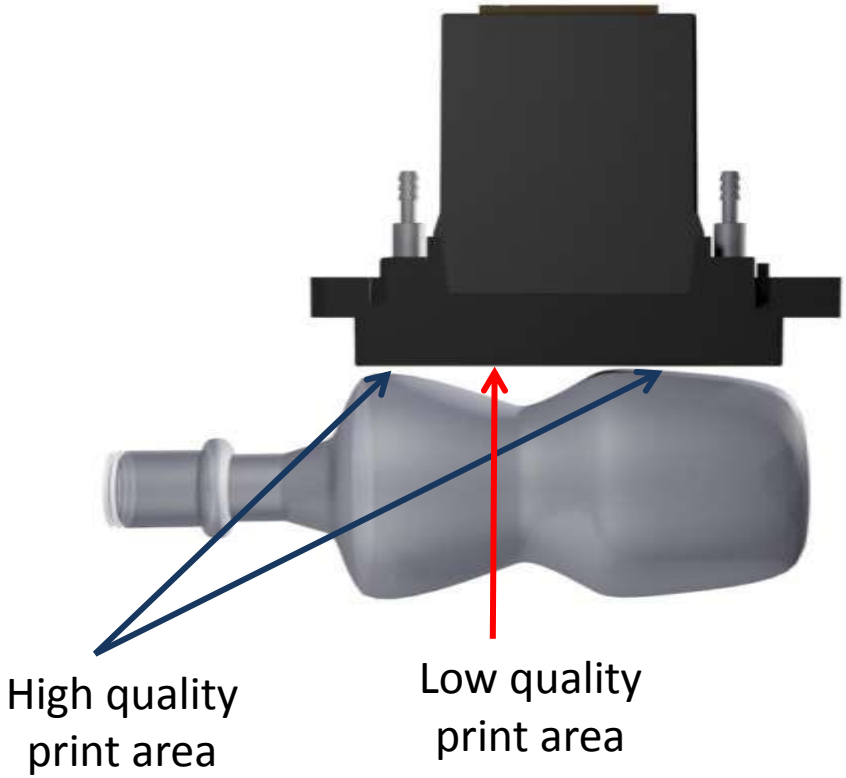
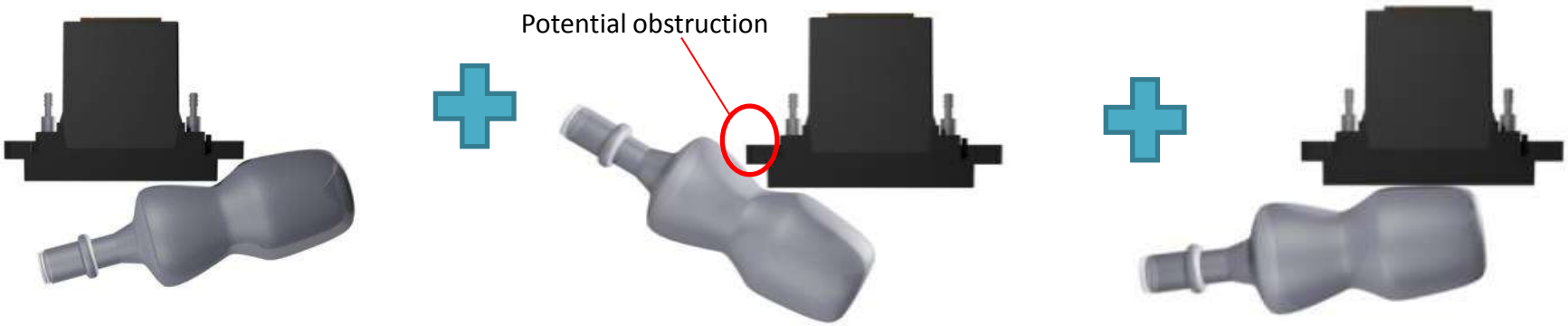
Printing onto Bottles - Complex Shapes



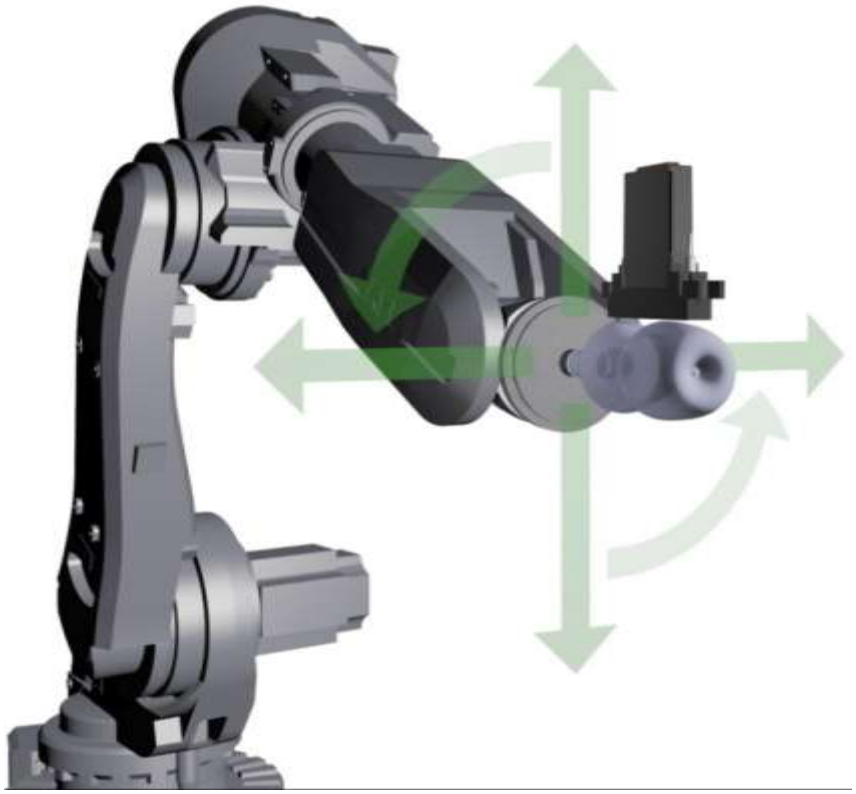
- **Multiple angles may be required to print the entire surface**
  - Neck ridges
  - Narrowing of middle section
  - Some areas almost impossible to reach
- **Simplistic approach shown here**
  - Print quality will vary dramatically – needs large drops for the throw distance

Printing onto Bottles - Complex Shapes



- **Three step process (in this example)**
  - Printhead printing 3 parts of the bottle and stitching image data together at software level
  - Production speed reduced
  - Mechanism needed to orientate the printhead
  - Choice of printhead can be critical
    - Ideally avoid heads with wide mounting points which can cause obstruction. Best to use a printhead with nozzles right up to the edge to get into the print areas
- **Robotics a possible solution (in this example)**

Robotics



- Six degrees Of freedom
- Versatile (works with most objects)
- Potentially low accuracy
- Ok for single pass

Xennia Xanadu 3D product printer

Multiple Heads/Multiple Swathes

- **Decoration – typically wider than one printhead print swathe**
- **Good stitching needs to control:-**
  - **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**

One Printhead – Two Swathes

- **Need to print two swathes with one printhead**
- **Must print in two different locations**
- **Requires additional mechanical movement of printhead or bottle**
- **Requires stitching between revolutions**
  - Wet on dry (may have to cure between sections) – creates more challenges
- **Lower print quality**
  - Can be overcome by advanced stitching techniques
- **Lower throughput**

Two Printheads – Two Swathes

- **Need to print two swathes with two printheads**
- **Printheads correctly located**
- **Requires no additional mechanical movement of printheads or bottle**
- **Still requires stitching between revolutions**
  - No longer wet on dry
- **Higher print quality**
- **Higher throughput**

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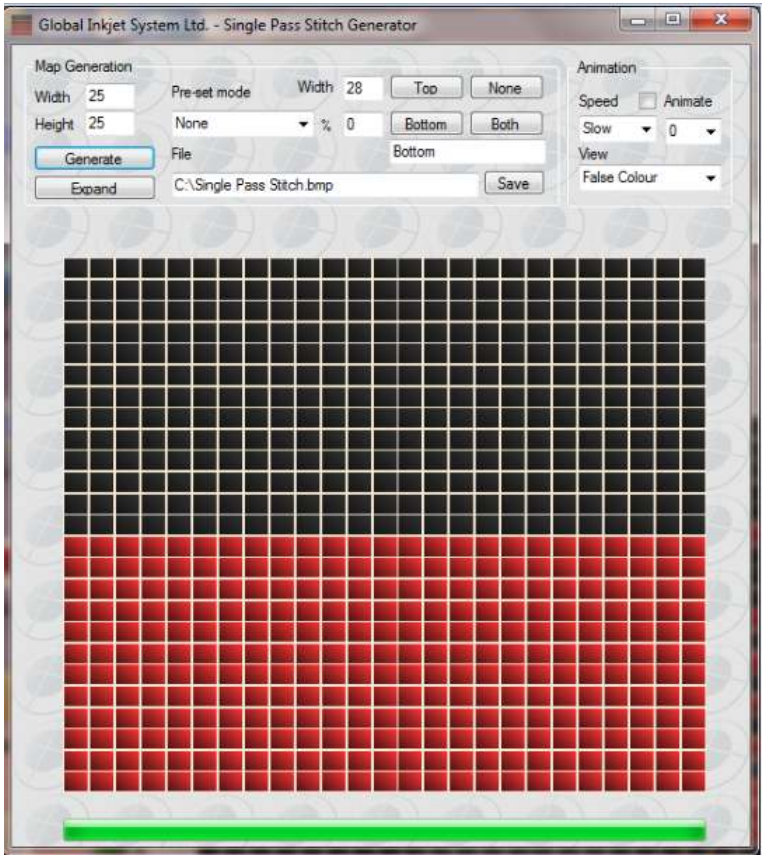
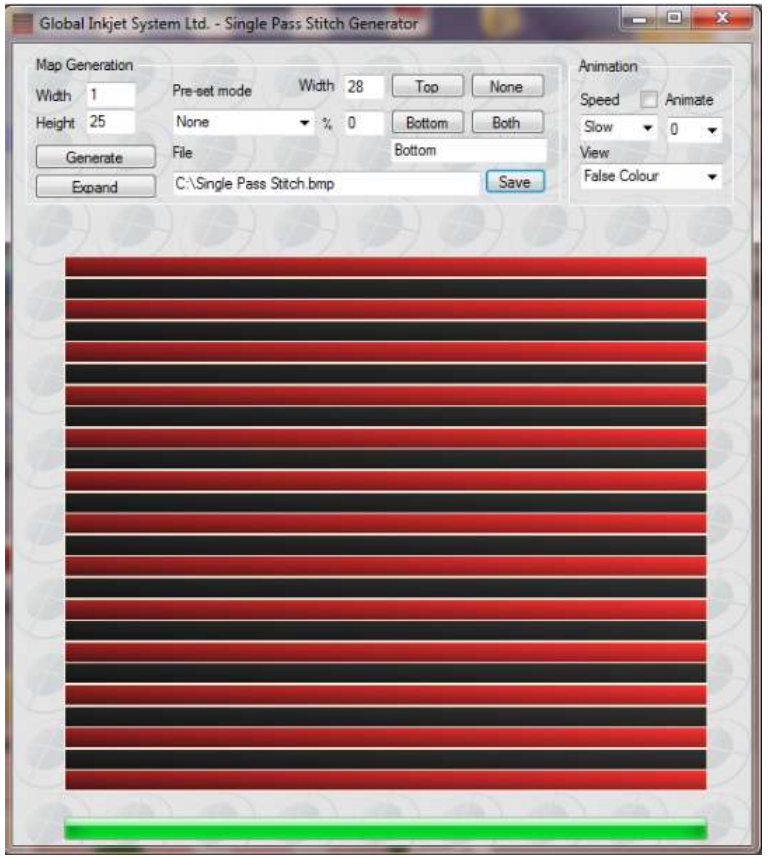
GIS Stitch Generator



No /"Flat" Stitch



50% Stitch – printing with alternating lines from each printhead in the region of overlap. Simple to implement.

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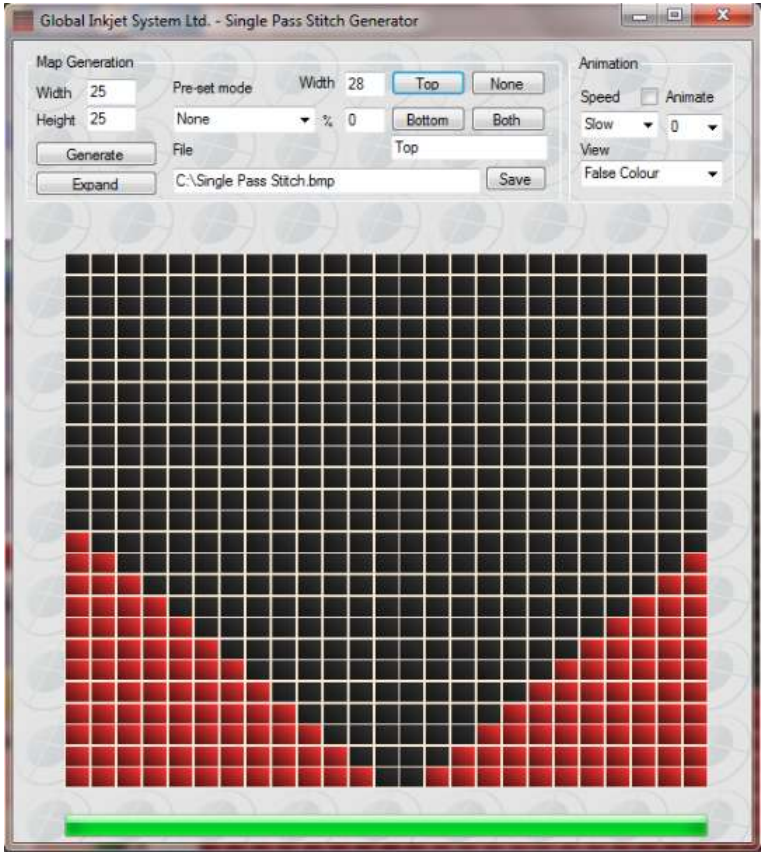
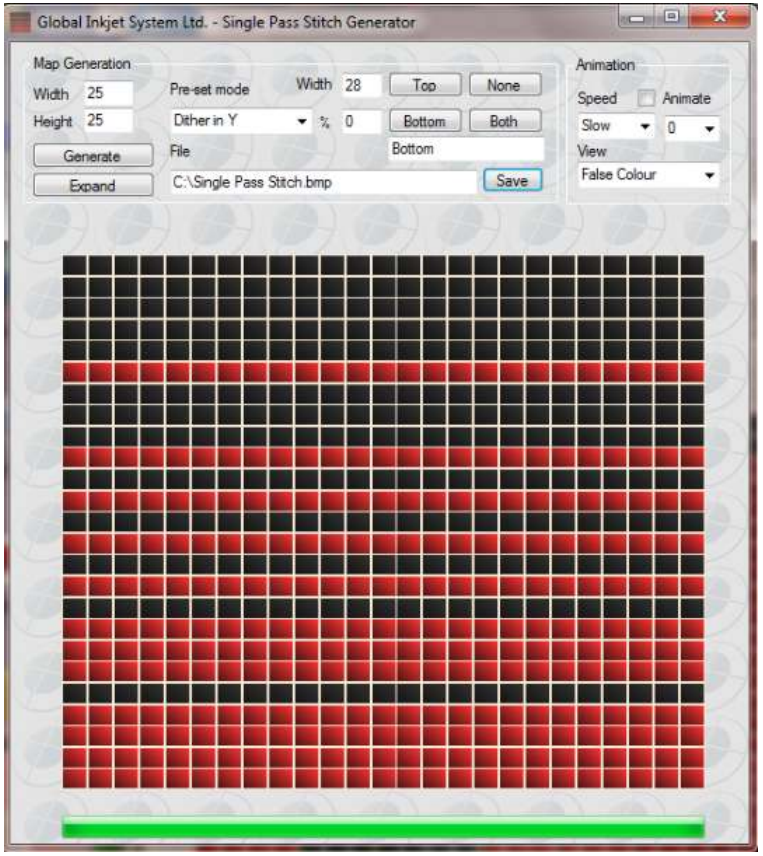
GIS Stitch Generator



Moving Stitch - Typically a saw tooth or sinusoidal stitch that disrupts the visible stitch line. Can be improved by using different frequencies for each ink



2D Stitch - same as 1-D but with dithering in the print direction.

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Curing and Drying

- **UV curing**
  - When, where and if to pin
    - On each colour?
  - When and where to cure
  - Print as quickly as possible
- **Ink properties**
  - Migration
  - Adhesion
  - Gamut
- **Process**
  - **Pre-coat**: primer; white
  - **Colour**: UV: aqueous: solvent: hot melt
  - **Special Inks**: metal effect: security: UV visible
  - **Post-coat**: varnish: lacquer

Direct Product Decoration

INTEGRATION INTO PRODUCTION LINES

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Production Lines

- **Production lines can run faster than inkjet can print today**
- **Bottles/cans in particular – very high speed e.g. 1,800/min**
- **Inkjet must find ways to integrate efficiently – otherwise the chance of adoption will be low**
- **Many projects underway/already installed**

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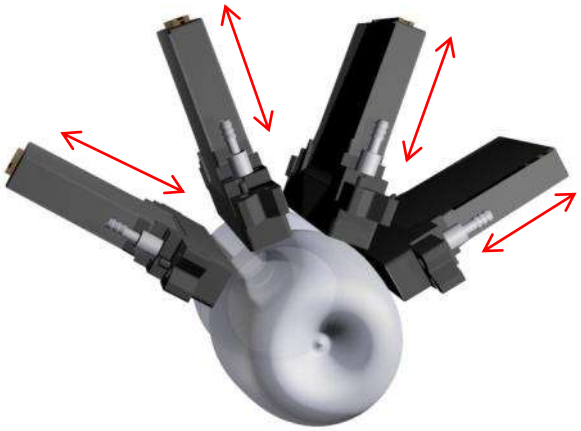
Increasing the Number of Printheads



Large diameter

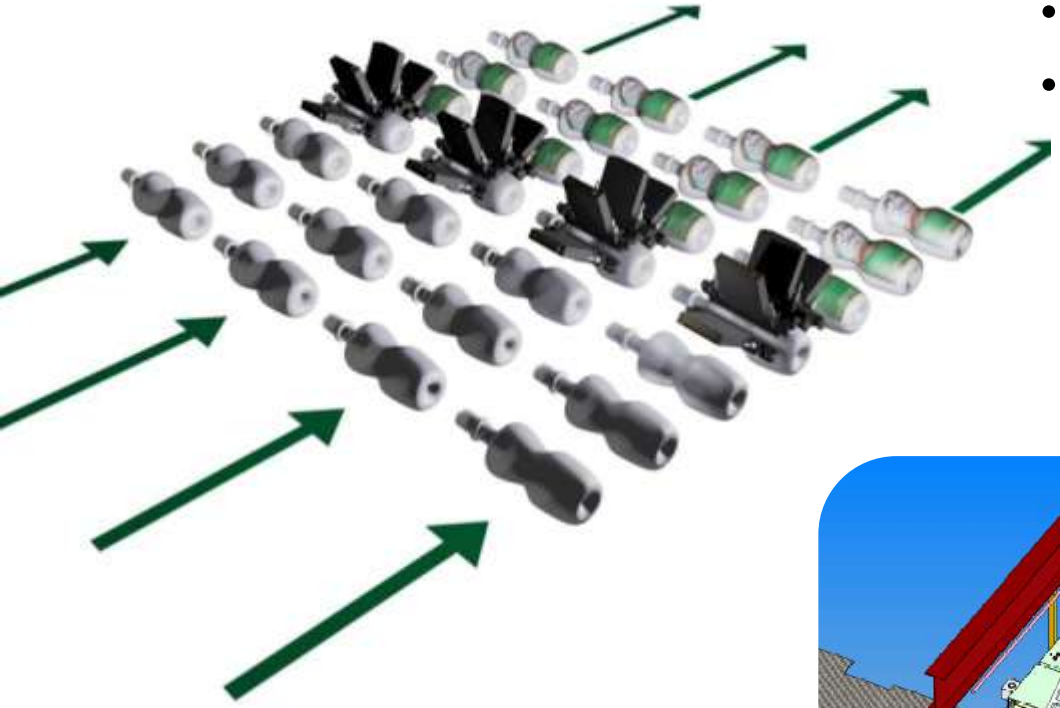
Medium diameter

Small diameter

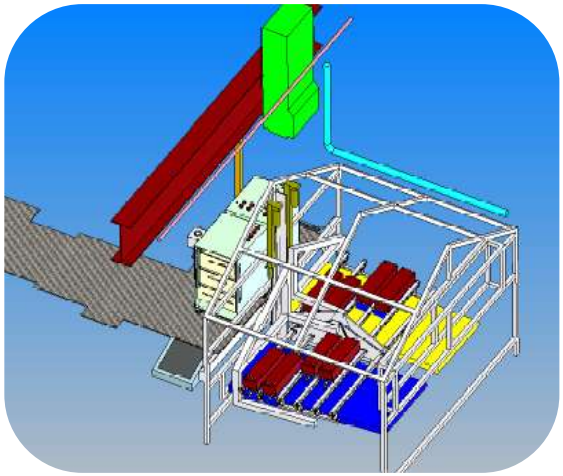
Printing with multiple printheads

- Productivity increased
- Difficulty printing onto very small objects – moving printheads in and out as required
- Printheads are rotated
- Stitching difficult
- Faster than printing one colour at a time
- Removes the need to pin/cure after each colour

Parallelisation



- **Simple built in redundancy**
- **Can “match” production line speeds**
  - Multiple print stations – then rejoin main production line



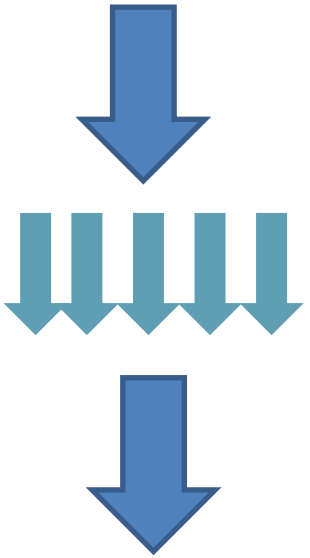


Image courtesy Fujifilm Dimatix

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Pipelining

- Redundancy more difficult
- Easily scalable to add more inks
- Needs pinning/curing between colours

- Ideal system probably has both parallelisation and pipelining

Direct Product Decoration

DISCONTINUOUS SHAPES

(COMPLEX) BOTTLES AND TUBS

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Discontinuous Shapes

- **All issues previously discussed apply – but on discontinuous shapes the required corrections change during the print (often from pixel to pixel)**

- **GIS has developed a multi-dimensional nozzle, density and screener correction technology that can be adjusted to each surface type and associated application process**

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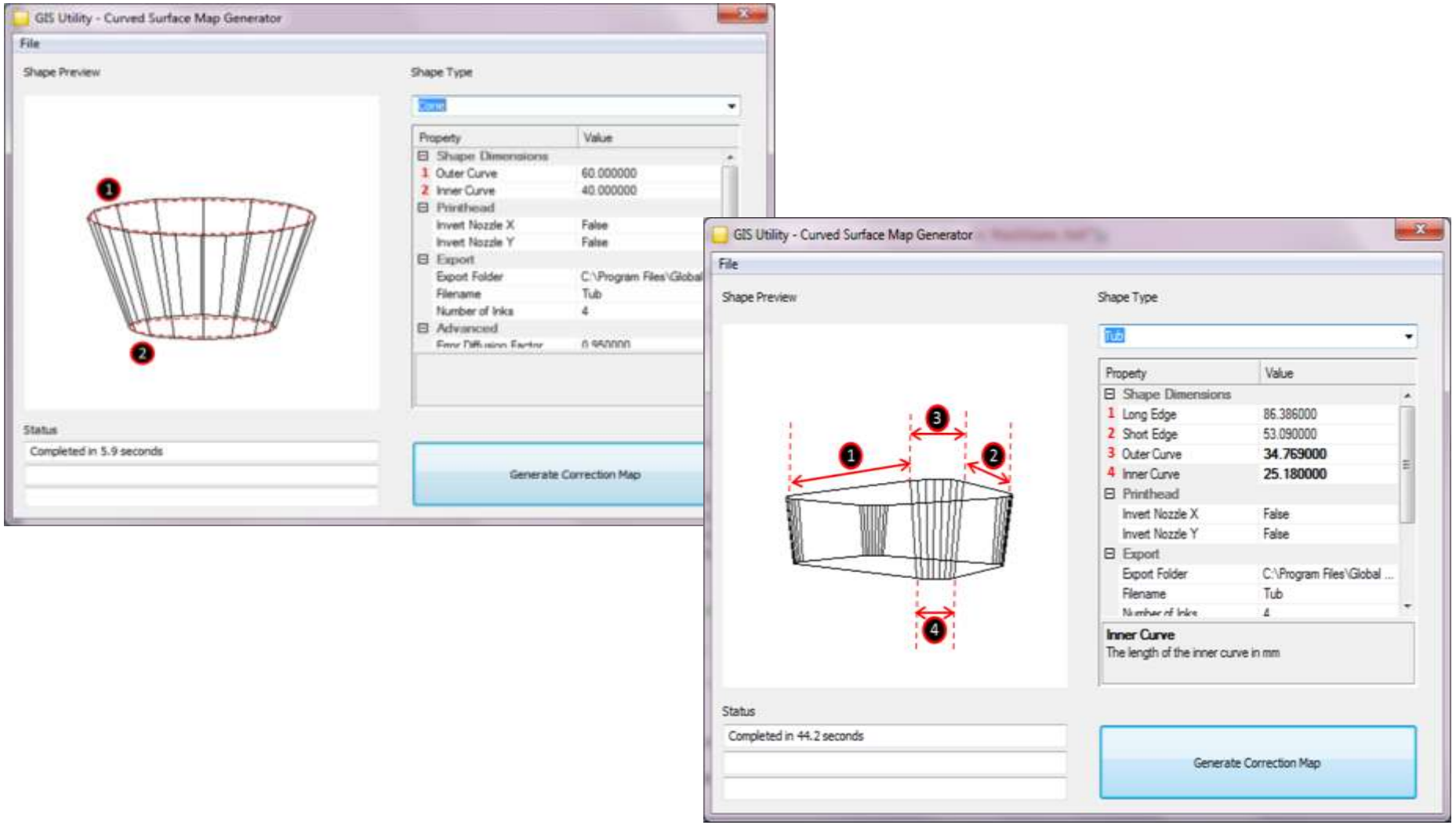
GIS Curved Surface Compensation Generator



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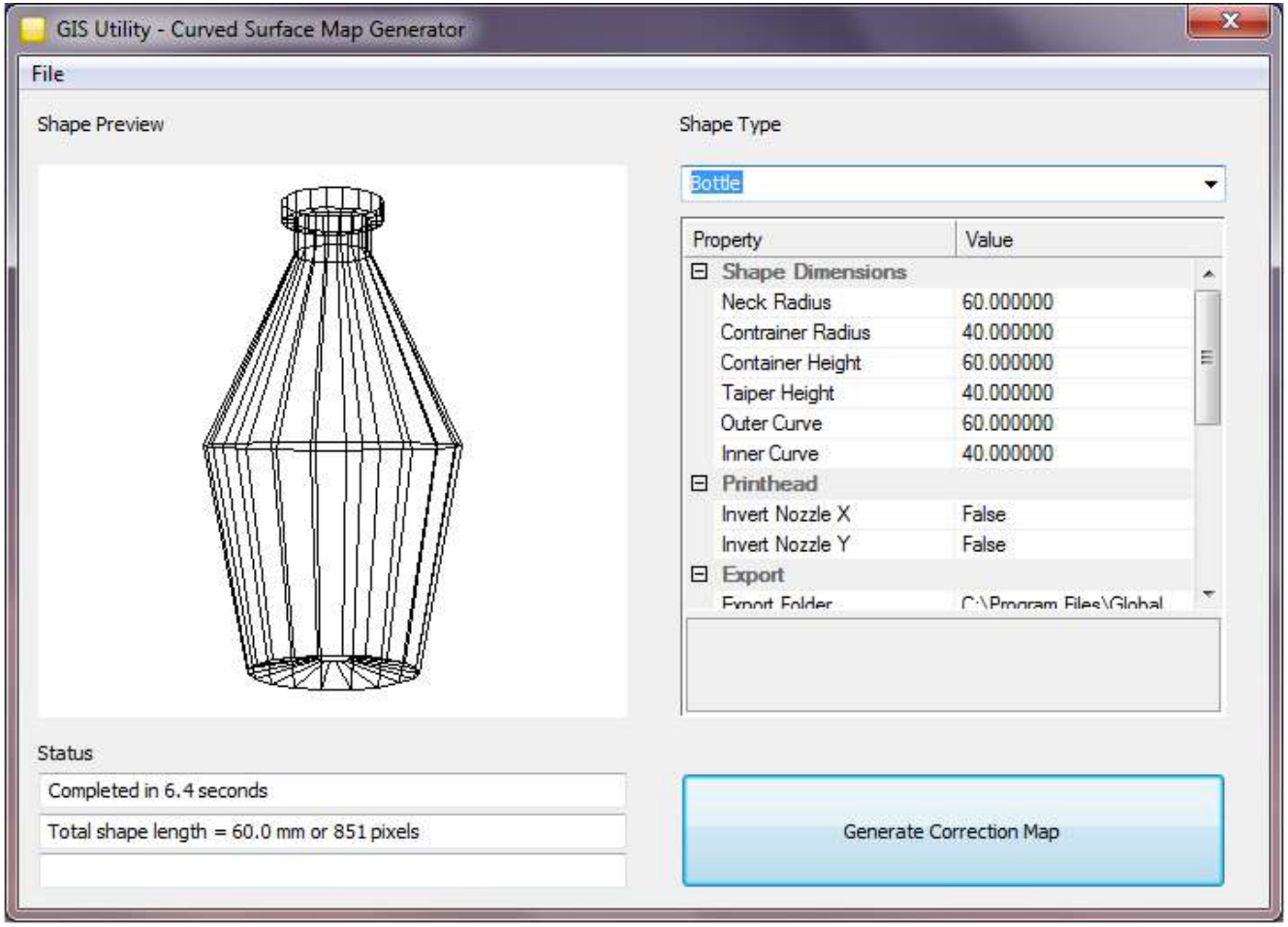
GIS Curved Surface Compensation Generator



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Thank you – Any Questions?

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