Direct to Shape Inkjet Product Decoration
A Rising Application

Debbie Thorp, Business Development Director

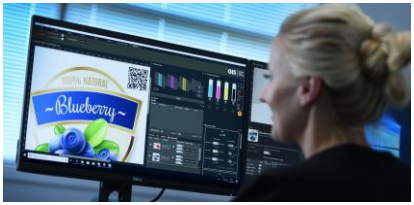
GIS – Company Overview

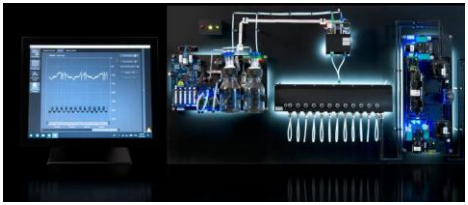
- Leading provider of technology solutions to industrial inkjet systems builders
- Support printheads from Fujifilm, Konica Minolta, Kyocera, Ricoh, SII, TTEC, Xaar
  - Epson in development
- Founded November 2006
  - Privately owned
- Based in Cambridge, UK
  - Technical support in UK, China & Japan
- Employees ~60
- Patent protected technology
- Supplier & partner to over 150 customers worldwide

GIS

GLOBAL INKJET SYSTEMS

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

Direct to Shape (DTS)

- **Part 1**
  - Tubes, Cones
    - Challenges & solutions
- **Part 2**
  - Spheres
  - More complex shapes
    - Challenges & solutions

Note: Many images used in this presentation are gathered from the internet to illustrate systems and applications in the market. Selection of any images does not indicate any connection or association with GIS

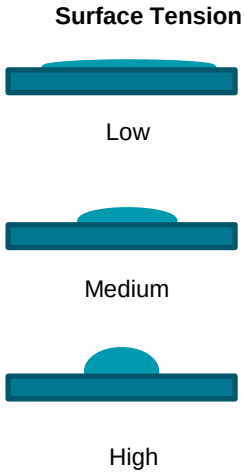
Drivers for DTS Decoration

- **Marketing benefits / Engagement with consumers**
  - Personalisation
  - Customisation
  - Promotional campaigns

- **Manufacturing flexibility**
  - Variable information capability
  - Faster reaction / turnaround times
  - Cost effective shorter runs
  - Energy reduction
  - Materials savings

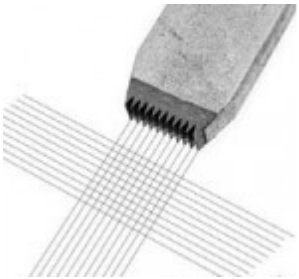
Challenges for Inkjet in Product Decoration

- **Printing mainly on plastics, metal and glass**
- **UV curable graphic inks dominate today**
  - Colour Gamut
    - Spot/brand colour
  - White
    - Opacity
  - Ink wetting and adhesion
    - Surface tension
    - Pre-treatment / Post-treatment
  - Curing
    - When? Pinning? Full cure
  - Resistance
    - Sunlight fade / Temperature / Scratch resistance/image durability
  - Migration
    - Regulatory issues



Challenges for Inkjet in Product Decoration

- **Odour**
- **Regulatory issues**
  - Pharmaceutical & food products
    - Medical syringes / Tablet blister foil
  - Industrial
    - Industry specific regulations
- **Image durability/adhesion**
  - Scratch / rub tests
  - Sunlight fading
  - Temperature
- **Recyclability**
  - Essential for PET market
- **Environmental issues**
  - Noise (electro-magnetic radiation) - impact of other equipment in a production environment



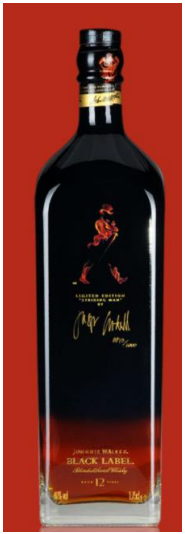
Challenges for Inkjet in Product Decoration

- **Throw distance**
  - Printheads designed to print onto flat surfaces – typically have short throw distance
    - Larger drops jet further
    - Small drops decelerate quickly
    - Smaller drops improve graphical image quality
  - Semi flat objects – machine panels/undulating surfaces
  - Container shapes – lips & ridges
    - Constraints of printhead mounting holes
  - Object tolerances
    - Surfaces not uniformly smooth
    - Product to product variation

Images courtesy of IIJ

Product Decoration – Flat

- **Decoration of flat surface only**
  - Promotional goods
  - Container products
  - Industrial products
- **Many opportunities – market that is not often discussed**



Product Decoration - Tubes/Cylinders

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

Product Decoration - Tubes

- **Symmetry**
- **Distance between nozzle banks**
  - The narrower the better
  - Reduce time of flight issues
- **Number of rows of nozzles**
- **Printhead orientation**
  - Printing downwards
  - Skyscraper mode

Product Decoration - Tubes

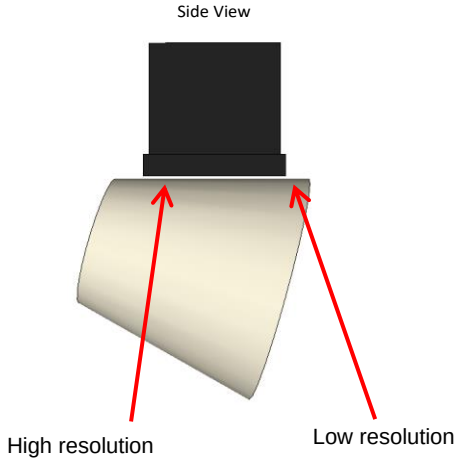
- **Full height printing**
  - Different stitching strategies

One head – wet on dry curing – lower throughput

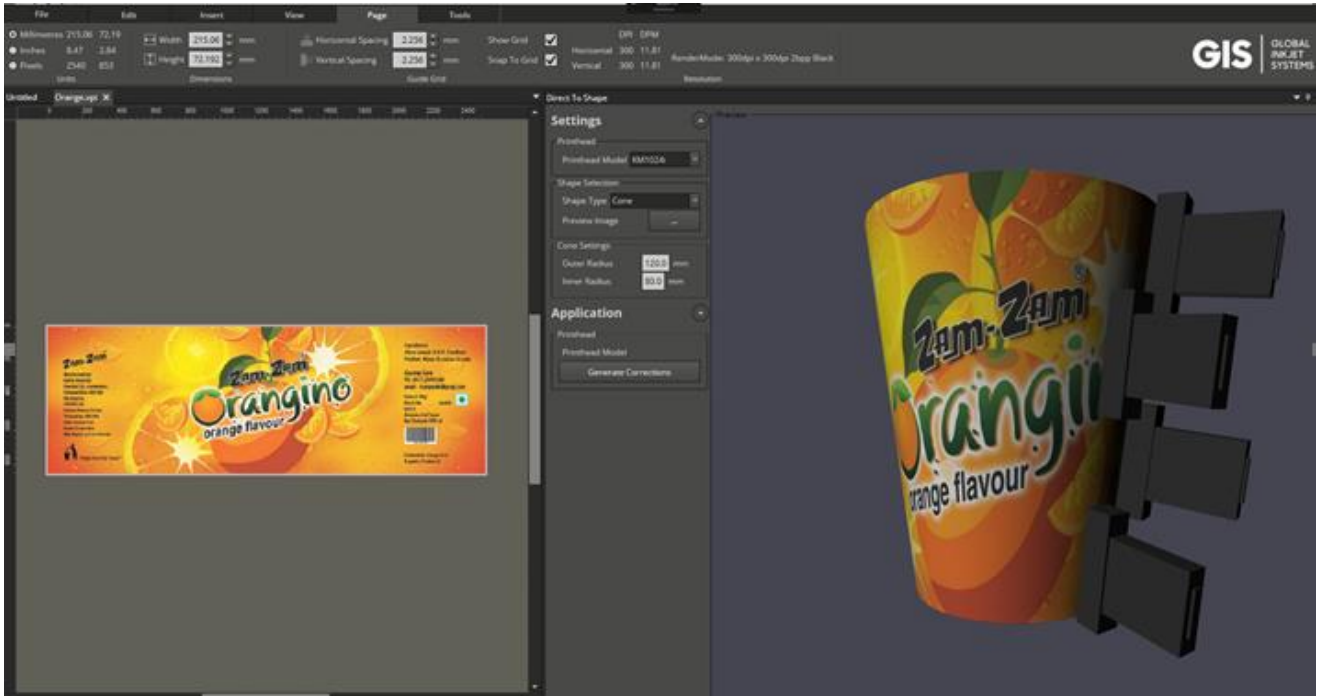
Two heads – wet on wet printing – higher throughput

Product Decoration - Cones

- **Image compensation software required for cones**
  - Resolution changes
  - Density correction
  - Screening more complex

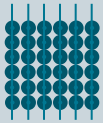
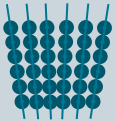
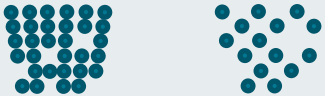


GIS Direct to Shape Studio Software

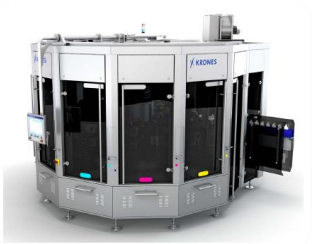


Inkjet Direct to Shape – Stage 1

GLOBAL INKJET SYSTEMS

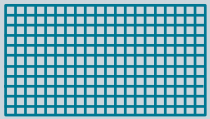
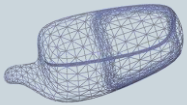
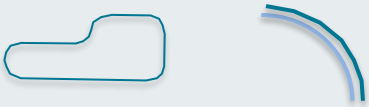
	Flat Surfaces	Curved Surfaces
Density Correction		
Throw Distance & Time of Flight		
Nozzle Alignment & Interleaving		
Screening		

Object/ Container Decoration Systems



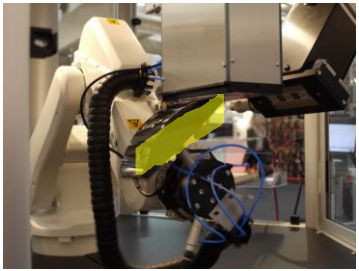
- **Established installed base of low throughput systems - promotional products**
- **Mid range growing – often customised machines**
- **High end – taken some time, but sales growing**
- **Expect more players in all sectors of the market**

Inkjet Direct to Shape – Stage 2

	Flat Surfaces	Curved Surfaces
Geometry	2 Dimensions 2 Degrees of Freedom	3 Dimensions 6 Degrees of Freedom
Print Path		
Shape Data		
Motion Control		

Inkjet & Robot Options

- **Printheads fixed**
  - Component fixed onto robot arm and presented to the inkjet printheads
  - Some limitations in size/weight



- **Printheads move**
  - Inkjet printheads mounted onto robot arm and move along the component
  - Enables large items to be printed

Images from IIJ, Heidelberg, Nakan & Xyrec/ SW Research Institute/ Airbus/Marabu

Complex Shapes - Opportunities

- **Industrial product focus rather than consumer products**
- **Inkjet competing mainly against**
  - IMD or screen for decoration
  - Spray for coatings
- **Demanding requirements**
  - Long life durability – years, not months
  - Specific industry requirements
- **Growing interest in automotive**
  - Interior trims
  - Instrument panels
  - Exterior part casings
  - Headlight covers
  - Grilles
  - Coatings – and decoration

Generic Images from internet – they are not related to specific projects at GIS

Inkjet Challenges - Jettability

- **Viscosity**
  - Most drop on demand piezo printheads require fluids with viscosities approx. 6-15 centipoise (cps) at jetting temperature
  - Automotive paints – viscosity challenging
    - Some activity in valvejet
    - Developments for higher viscosity capability in piezo inkjet
  - Automotive hardcoats – can be as low as 10cps
    - Opportunity for inkjet to add efficiency and precise drop placement
      - Materials savings - reduce wastage of overspray
      - Process efficiencies
        - » No need to apply masking tape
      - Environmental benefits
      - Selective area coating capability

Positioning Accuracy

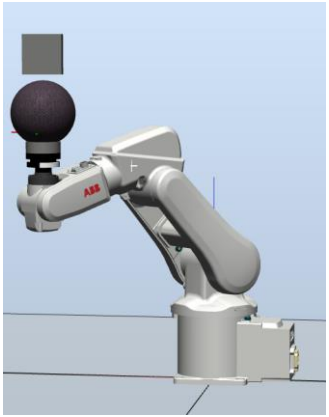
Industrial robots have sufficient accuracy for many industrial applications …

… but inkjet printing requirements are tight

- Typical industrial robots can achieve absolute pose accuracy with calibration of 200-500 µm
- Inkjet printing requirements for graphics are typically 5-10x finer - but not so precise for coating
- Robot repeatability is better than absolute accuracy, so further calibration is possible

Image source: ABB and Fanuc

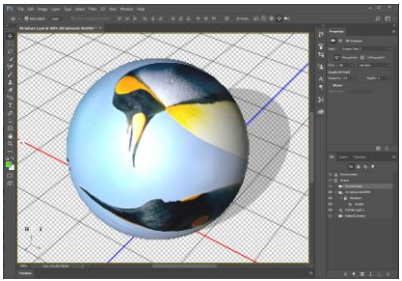
GIS R&D Project – Printing a Sphere



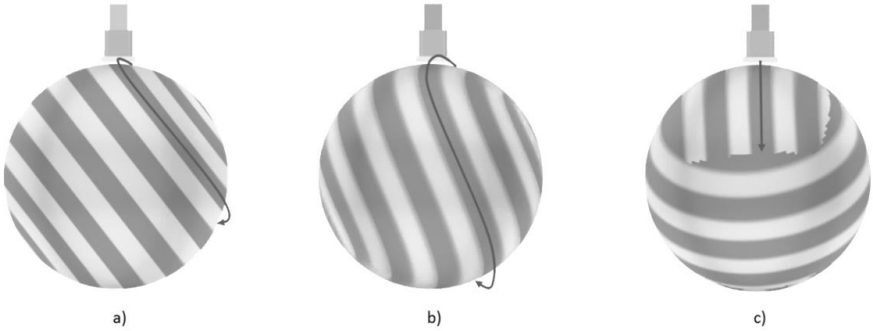
Mesh & Texture

3D Mesh **Texture**

- **Many tools available for wrapping**
  - Well established technologies from gaming, augmented reality industries, etc.
  - Many different ways to wrap, edit directly on to 3D surfaces
  - Result is expressed as a texture map



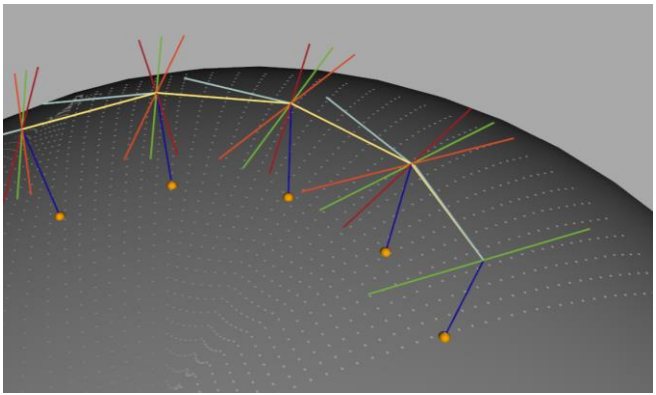
Developing Print Path



- **Must take into account the constraints of the object to be printed, inkjet printhead, capability of the robot**

GIS DTS Studio – Print Path Designer

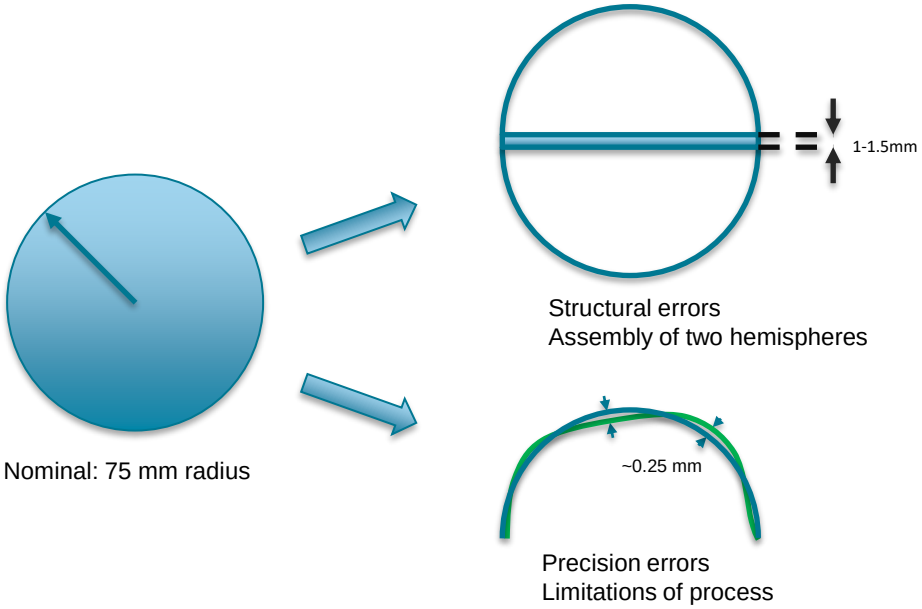
- **GIS software for designing print paths on complex shapes**
  - Place a series of points across the surface, guided by an interactive display of the area which will be printed
  - The points are joined to form a path, and given a flying height
- **Add masking as required**
- **When the path is complete, the system generates:**
  - Instructions for a robot moving either the printhead or the object, and
  - Image data for the print, including masking



Shape Variation

All manufactured objects have tolerances

- e.g. Polypropylene sphere
  - Inexpensive consumer product made up of two hemispheres glued together
- Same issue applies to injection moulded parts



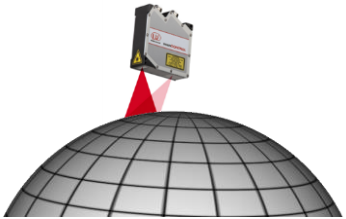
Stitching

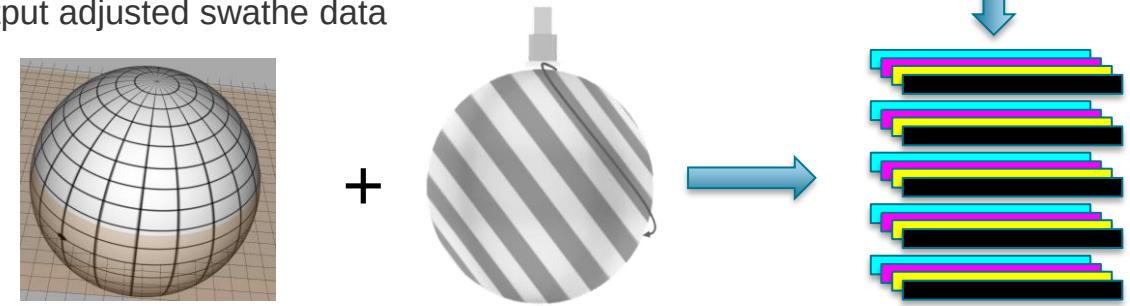
- **Stitching is a key area where inaccuracies will show**
  - Positioning errors cause gaps or overlaps, familiar from 2D printing

- **Careful control is required of multiple factors:**
  - Accuracy of transport
  - Print synchronisation
  - Variation of the target shape from nominal dimensions

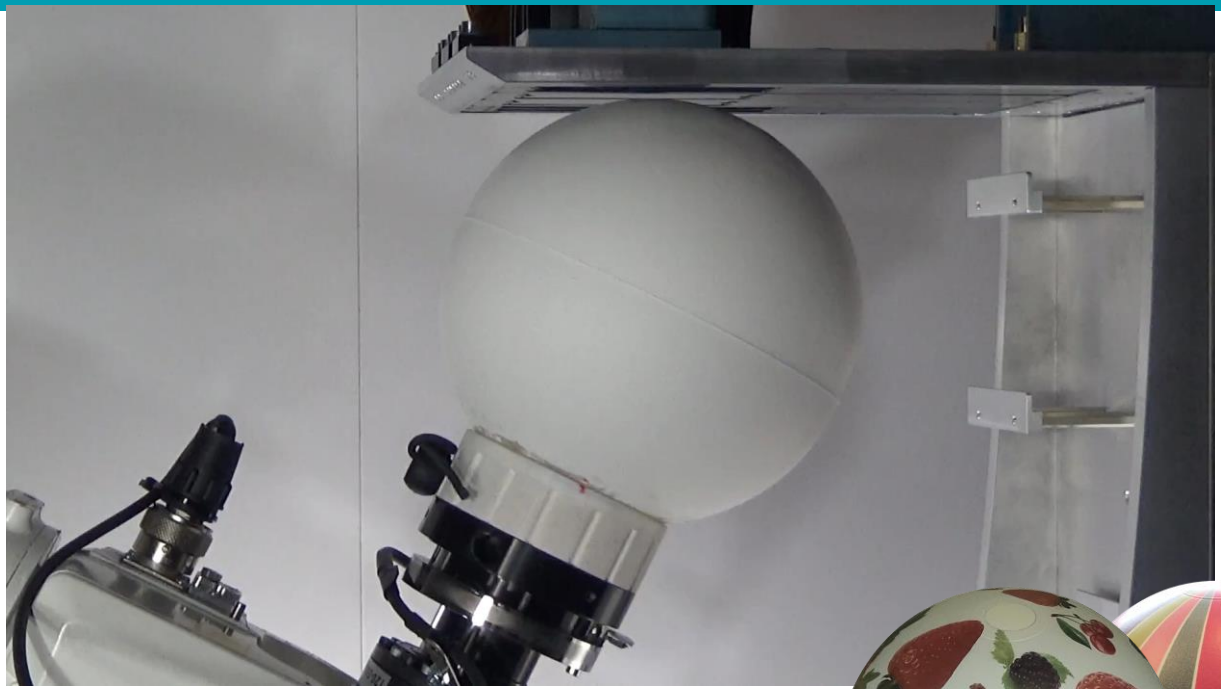
Shape Variation Compensation

- **Measure the target shape accurately**
  - Mechanical profile gauges
    - Adequate, but rather slow
    - Contact with target shape may be a problem
  - Laser triangulation sensors
    - Resolutions down to ~1 µm, sample rates 1-100kHz
    - Non-contact
- **Apply measurements as corrections to the mesh model**
  - For per unit variations this can be done as a late stage correction
  - Output adjusted swathe data



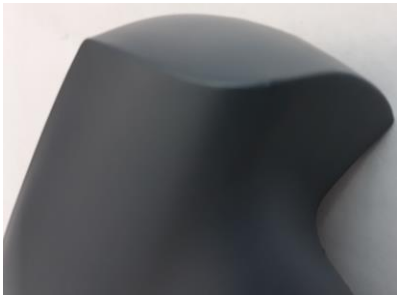


Sphere Printing - CMYK



GIS R&D Project – Wing Mirror Casing

- **Selected generic component with challenging features**
- **Wing mirror casing**
  - Sharp edges
  - Deep valley

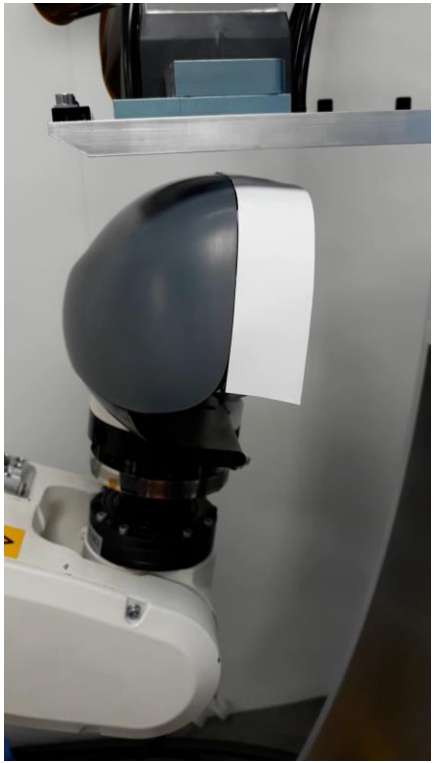


- **Step 1: Automotive hard coat**
- **Step 2: Decoration**

Key Drivers for Inkjet – Hard Coats

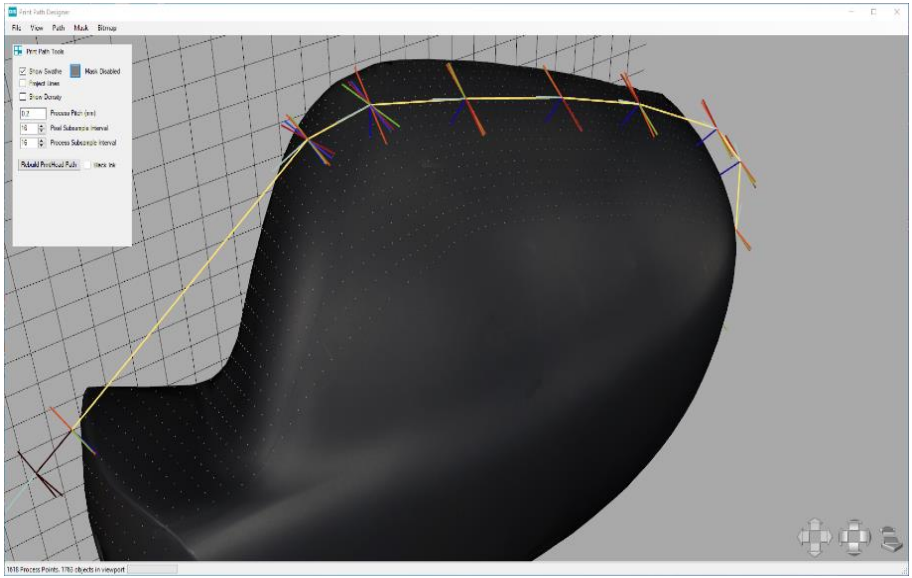
- **Reduction of waste**
  - No overspray
  - Precise positioning
- **Efficiency in manufacture**
  - Reduction in manual processes
    - No masking
- **Accuracy of coating**
  - Ability to selectively coat complex components
- **Ability to create textures**
  - Selective coating

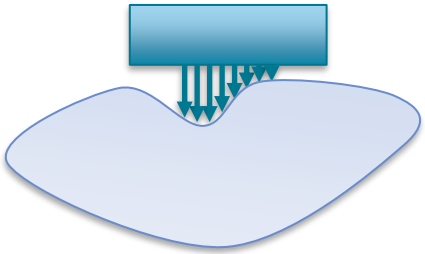
Demonstration – No Overspray



GIS Direct to Shape Studio Software

- **Print Path Designer**

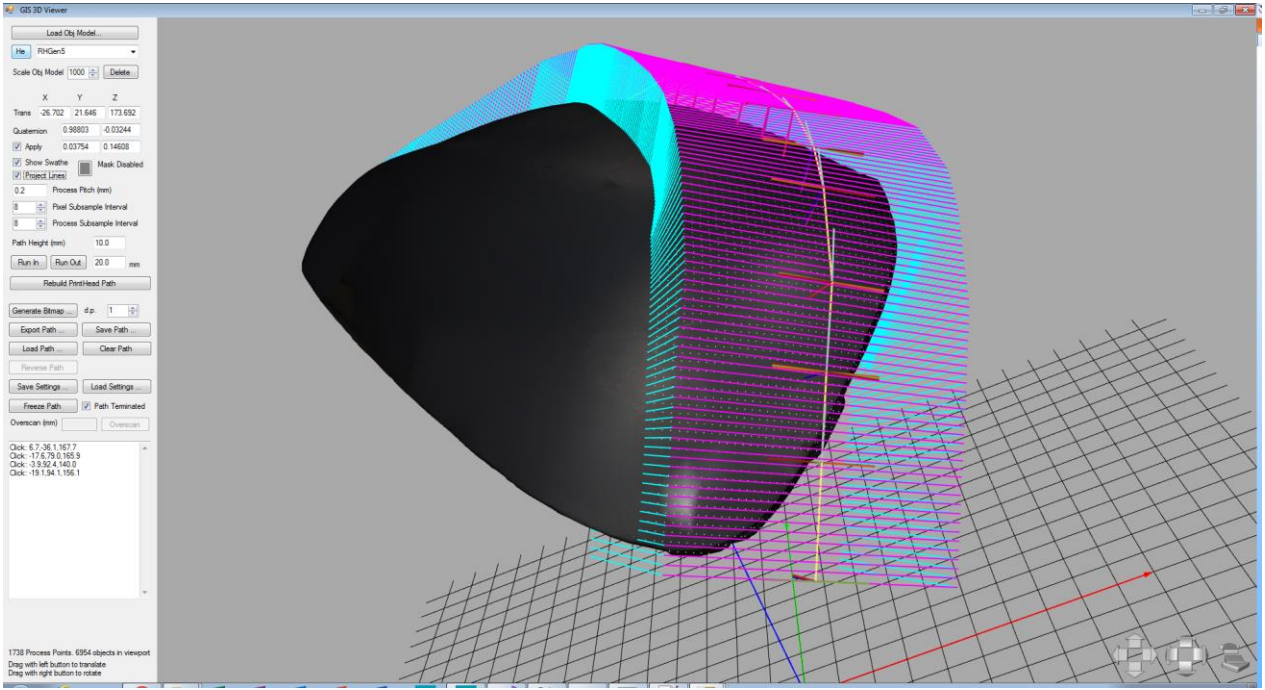




Coating coverage can be achieved even in concavities up to ~25mm depth

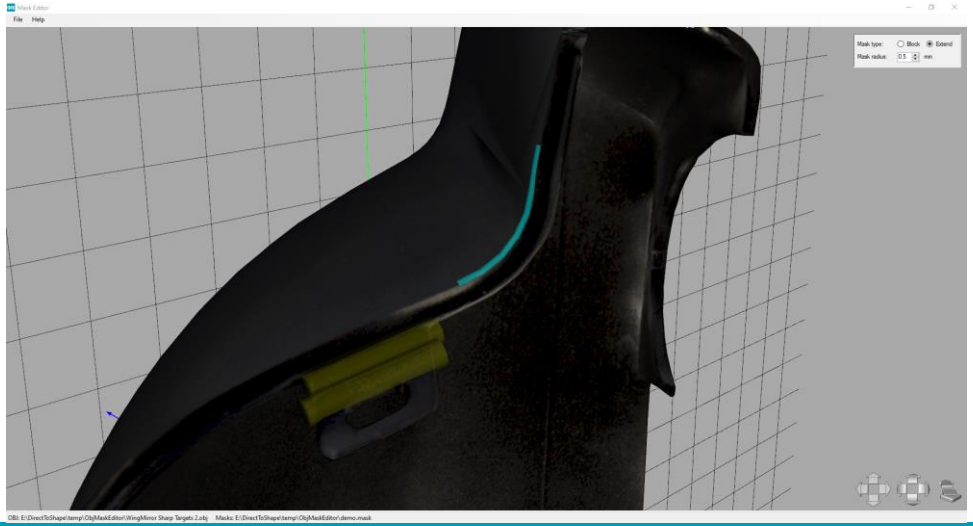
GIS Direct to Shape Studio Software

- **Swathe visualisation**



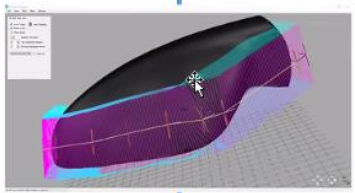
GIS Direct to Shape Studio Software

- **Digital Masking**
  - Selective coverage
    - Protecting areas that must not be printed
      - Blocking mask (shown in yellow below)
    - Controlled overspray at the edges of a shape
      - Extending mask (shown in blue below)

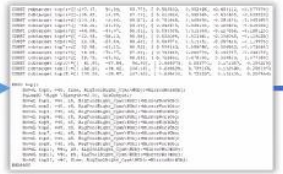


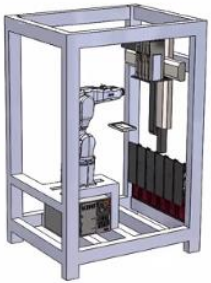
GIS Direct to Shape Studio

Print data



Transport control data





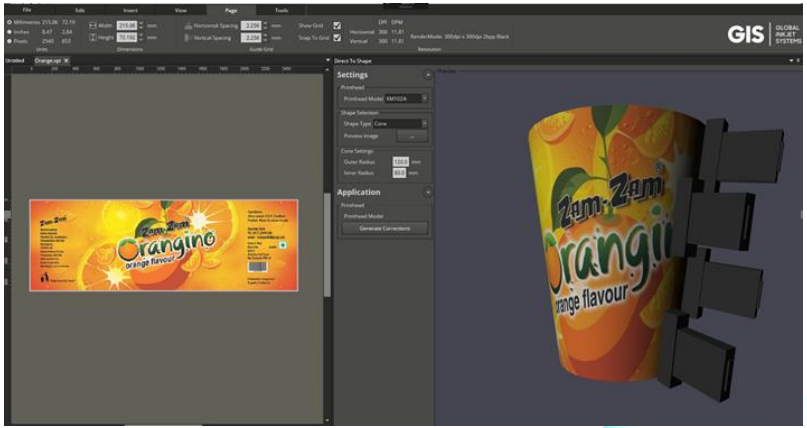
Example: Coating

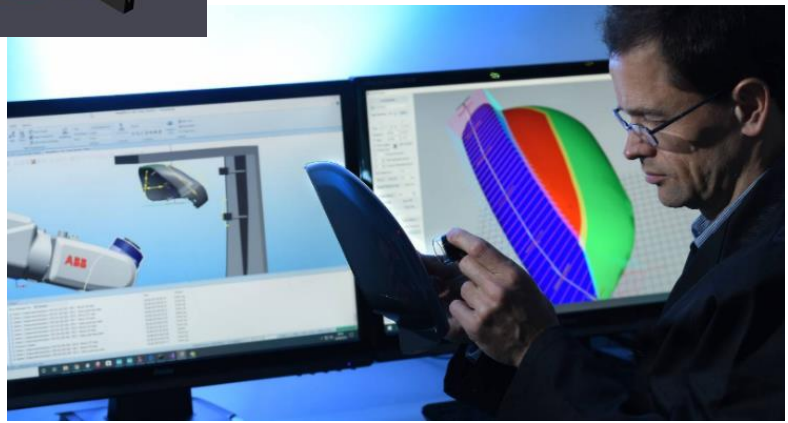
- **Applying an automotive approved hard coat**
  - Momentive SilFORT UV Hard Coat

Example: Decoration

- **Printing a graphic UV curable inkjet ink**

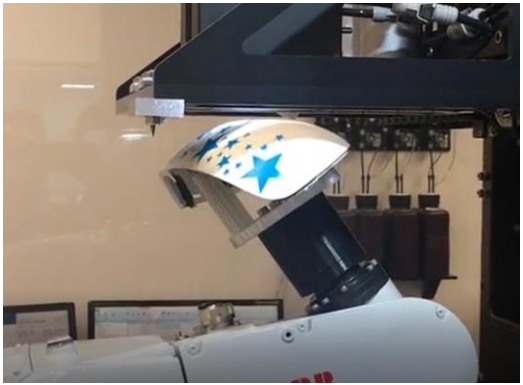
GIS Direct to Shape Studio Software





Summary – Inkjet Direct to Shape (DTS)

- **Container systems - becoming more established / growing**
  - Many different system suppliers – more expected
- **Industrial products - offer many opportunities**
- **Complex shapes**
  - Developing markets in consumer durables, automotive and aviation
- **Challenges of fluids / printhead capability remain – but advances in software creating new market opportunities for inkjet**



THE QUEEN'S AWARDS FOR ENTERPRISE

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