Inkjet in Coatings & Complex Shapes: Technologies & Processes

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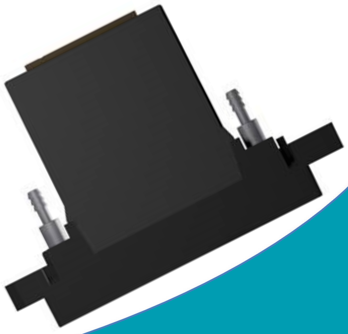
Global Inkjet Systems Ltd

Chicago – May 2019

Agenda

- **Brief introduction to GIS**
- **Overview of Direct to Shape (DTS)**
- **Challenges**
  - What are the problems?
- **Tubes, cones & tubs**
  - Well established
- **More complex shapes**
  - A generic approach, applied to a sphere
  - Some new challenges



Global Inkjet Systems

- **Leading independent developer of inkjet technology**
  - Supply critical inkjet technology and components to OEM system builders, specialist integrators and end users
- **Support a broad range of inkjet printheads in wide range of applications and industries**
  - Fujifilm Dimatix, Konica Minolta, Kyocera, Ricoh, Toshiba Tec, Xaar

- **Based in Cambridge, UK**
  - 12+ years of growth & technology innovation
  - 70+ employees
  - 130+ customers world-wide
  - Support offices in UK, Japan and China

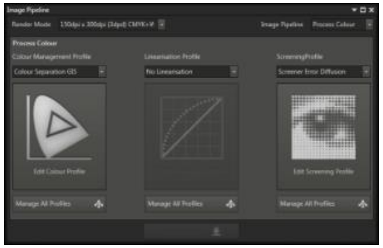
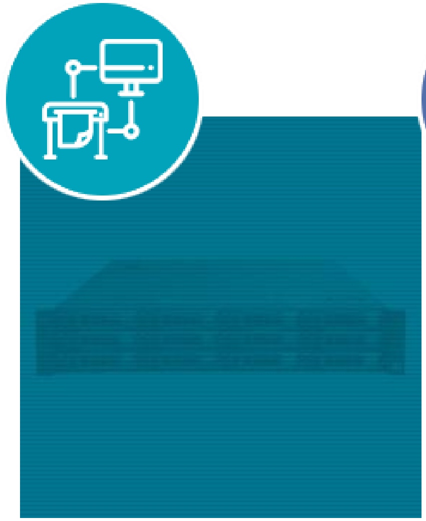


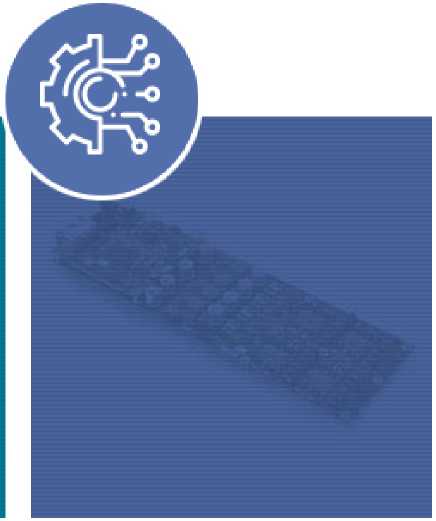
Image source: GIS

GIS – Products

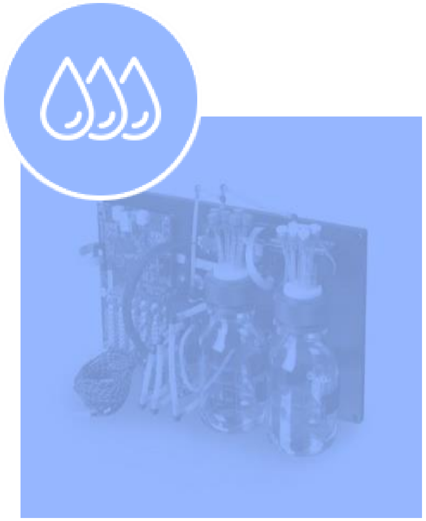
Digital Front End
Atlas® User Interface
Raster Image Processing



Machine Control
Atlas® Server



Print Controllers
Datapath &
Drive Electronics



Ink Delivery Systems
Controlled Temperature,
Pressure and Flow

Used in broad range of applications – textiles, labels, security printing, décor, spot varnish, product decoration, corrugated, ceramics, functional coatings, materials deposition, 3D, robotics and more

From pixels to droplets: we supply technology for the whole data pipeline – from image to print

GIS | GLOBAL INKJET SYSTEMS

Disclaimer

Global Inkjet Systems supplies inkjet technology and components to 130+ original equipment manufacturers world-wide. As a matter of policy, we do not disclose our customer relationships.

Some of the following slides contain images chosen to illustrate the range of inkjet print systems which are available in the market. The presence, or absence, of any manufacturer's products in these images does not in any way imply a commercial relationship between that manufacturer and GIS.

Inkjet DTS Development Timeline

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Flat & Semi-Flat

Tubes/Cylinders

Cones

Tubs

Complex shapes

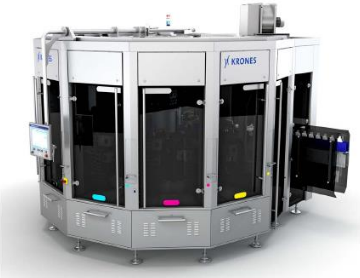

Image source: Mimaki, InkCups Now, EPS, Krones, Machines Dubuit, Nakan, ITW, Martinenghi, Plastic-Molds, Wifag

Tubes

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- **Well established/well understood technology**
  - Fixed radius of curvature
  - Cylinder unwraps to a rectangle or square
- **Flight time differences become more complex as print speed is increased, and/or radius of curvature decreased**
  - Printheads with slim format/two rows of nozzles popular
  - Flight time difference can be significant for multi-column print heads

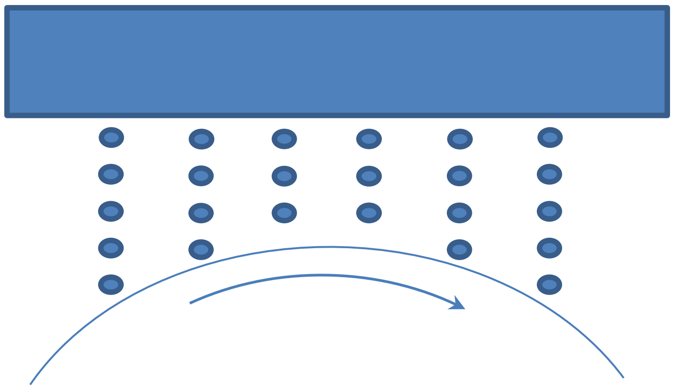

Image & animation source: GIS

Cones

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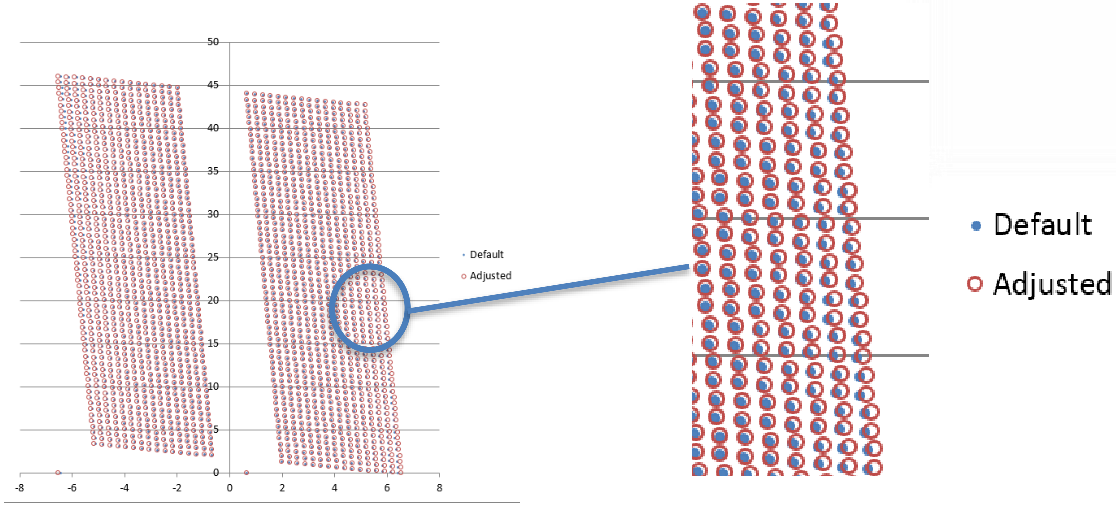
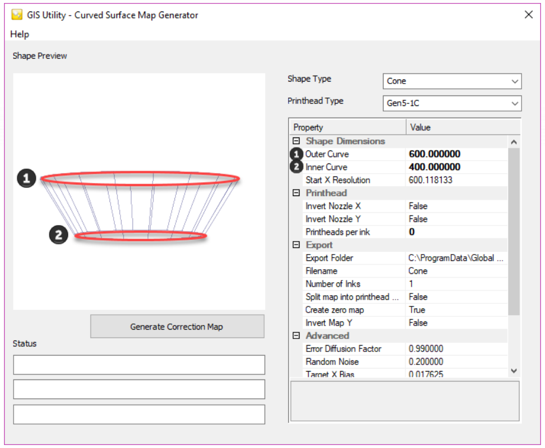
- **Cones or cone sections are useful for many applications**
  - Unfolds to an arced rectangle / section of a circle
  - Corrections are relatively straightforward, provided heads are narrow and mounted symmetrically – more complex for larger heads
- **Challenges**
  - Nozzle alignment
  - Density correction
  - Dot gain management
  - Avoid screening artefacts





Images of GIS software & animation - source: GIS

Tubs

- **Mixture of cone sections and flat surfaces**
- **Required corrections change during the print**
  - Often from pixel to pixel
- **Print system is more complex**
  - No longer rotating about a single axis
  - Transport design may require a synthetic encoder

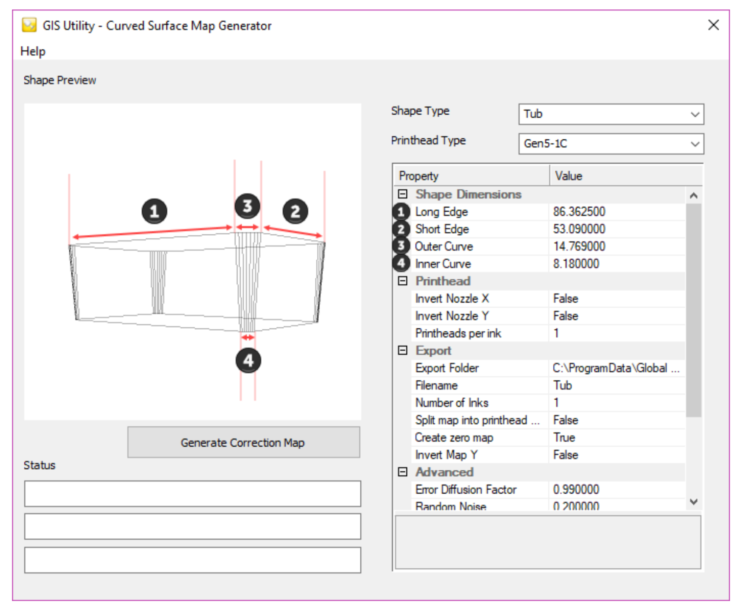
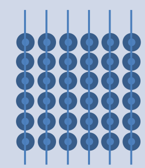
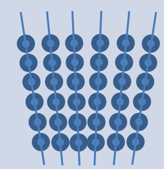
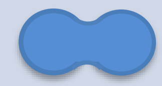
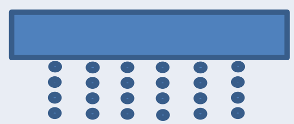
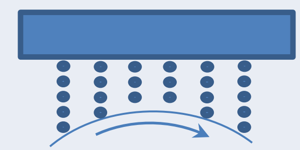
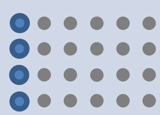
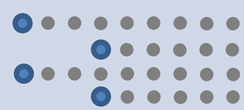
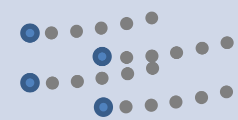
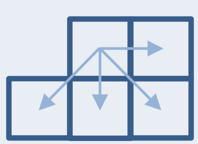
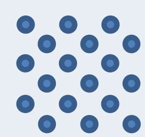
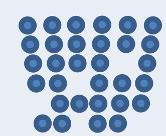
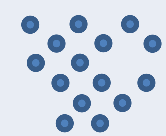


Image source: GIS software, Wifag

Inkjet Challenges – Curved Surfaces

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

More Complex Shapes

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- **Many complex shapes have eluded inkjet printing & coating**
- **Analogue technologies dominate**
- **Inkjet moving from partial to full coverage printing / coating of any object**

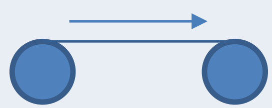
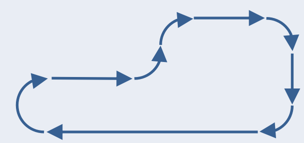
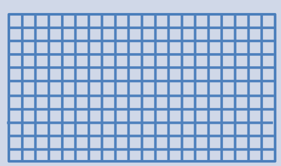
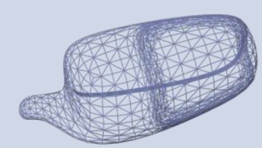
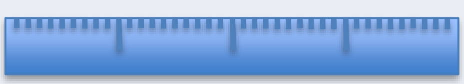




Photo credit: © Upper Austrian Research, Hartwig Zörgl

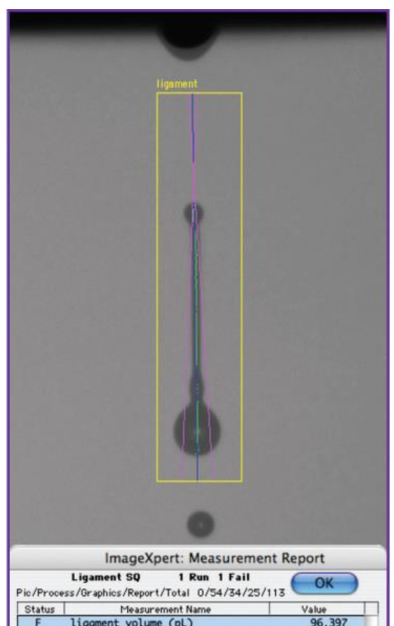
Other images from YouTube, Airbus & Ritzi (Heidelberg)

Inkjet Challenges – Navigation & Motion Control

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

Inkjet Challenges - Jetability

- **Viscosity**
  - Most drop on demand printheads require fluids with viscosities in the range 7-15 centipoise (cps) at jetting temperature
  - Higher viscosity fluids can be heated to reduce viscosity to be jettable
  - Some new printhead developments will enable higher viscosities



Ligament volume measurement

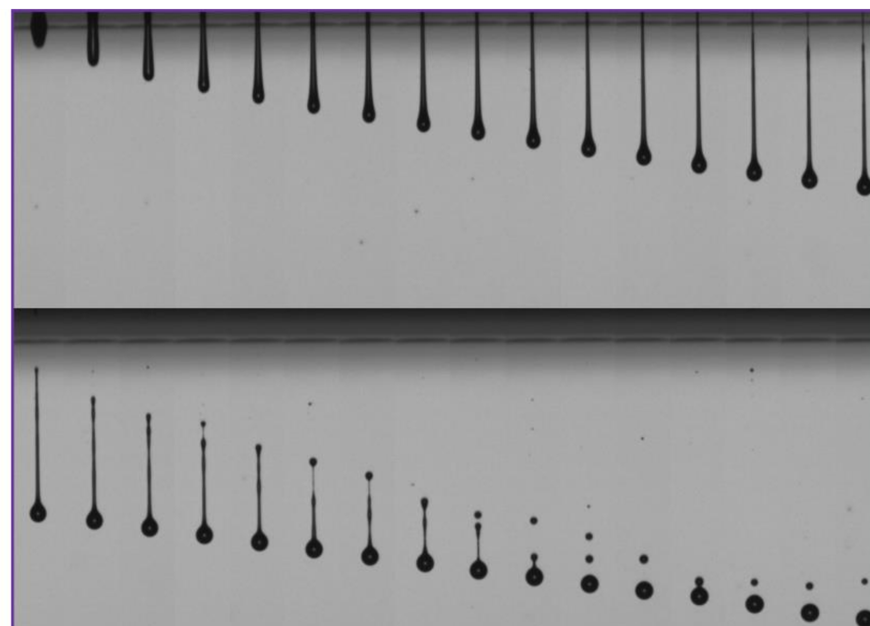

View droplet formation

Image source: JetXpert

Inkjet Challenges – Throw Distances

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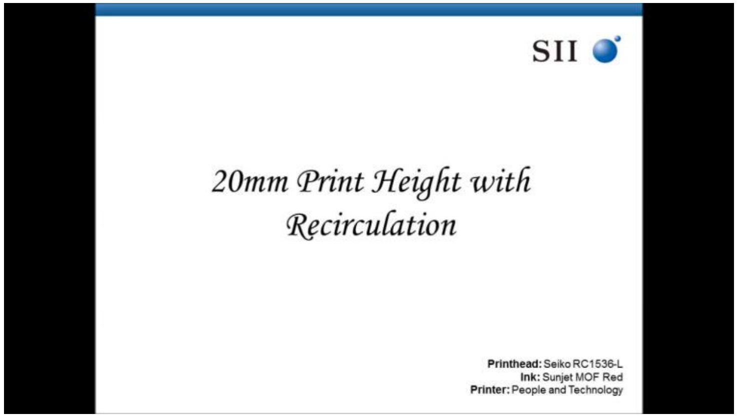
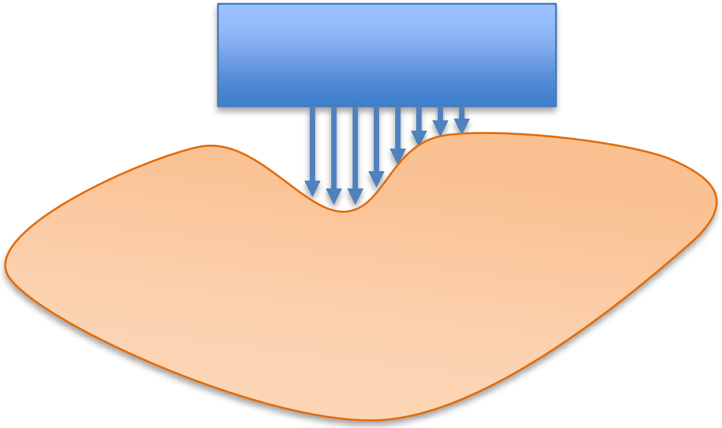
- **Inkjet typically designed to throw ink drops a distance of 1 – 2mm to the surface**
  - Produces sharp, detailed graphics and text – down to 2pt @ 1200dpi
  - Also works well even when the head or surface are moving at up to 5m/s relative speed
  - But has created a perception that greater throw distances are a problem
- **In fact, nozzle drop velocities are in the range 5-8m/s**
  - Medium to large drops will travel over 20mm
  - Placement accuracy does degrade with range, so a trade-off must be found
    - Fine detail can be achieved on near-flat surfaces with shorter throw distances
    - Coating coverage can be achieved even in concavities up to ~25mm depth





Videos acknowledgement: SII You Tube

Case Study – Cyan Tec

Disadvantages of Spray

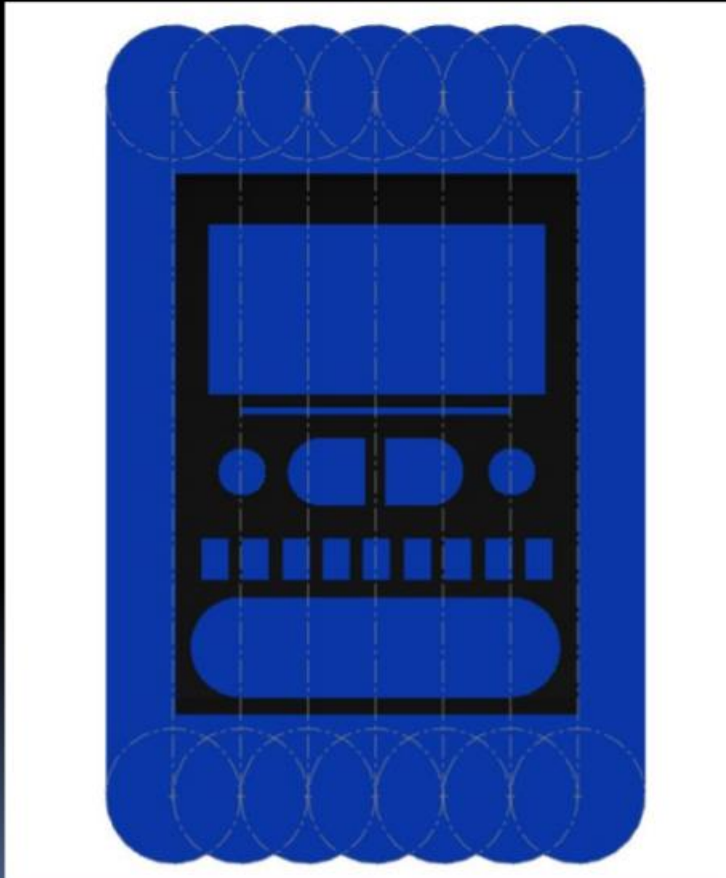
- Typical interior trim part
- With high gloss piano black coating

Permission granted by Cyan Tec

Case Study – Cyan Tec

Disadvantages of Spray

- Typical spray path
- Two passes overlap
- Begins & finishes off the part
- Can't be controlled over gaps



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Case Study – Cyan Tec

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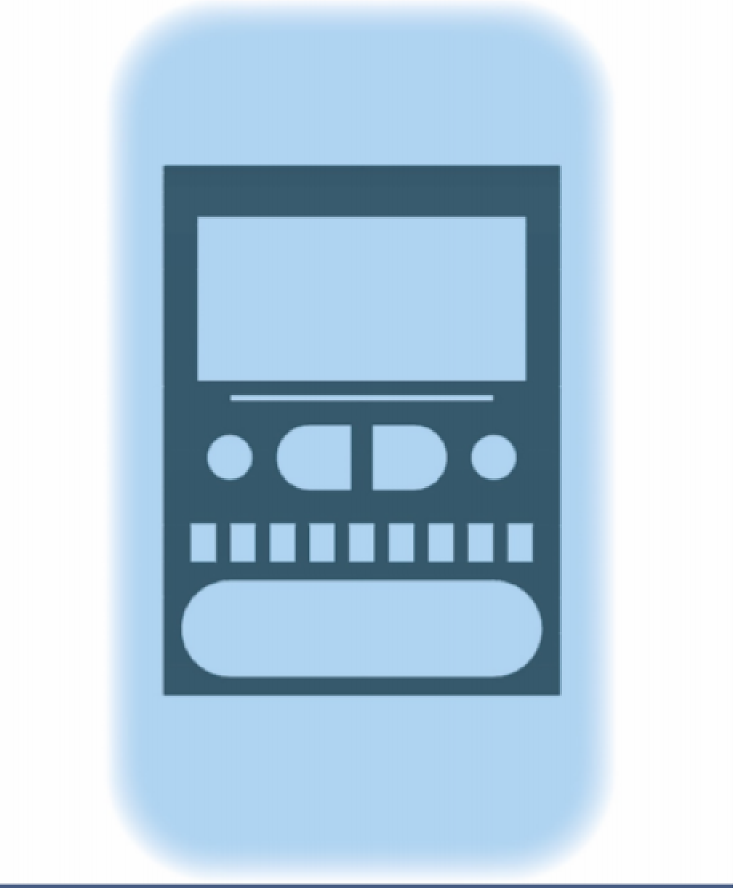
cyan Tec

Disadvantages of Spray

- Product surface 575cm²
- Spray pattern 2,243cm²
- Waste 1,668cm²
- Waste 74%



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Case Study – Cyan Tec

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The Robotic Digital Deposition Process

- Complete piano black facia
- Scratch resistant coating
- Zero overspray
- Virtually zero waste
- >70% material reduction
- >70% VOC emissions reduction

  www.cyan-tec.com 06/03/2019

Permission granted by Cyan Tec

Complex Shapes - From Concept To Reality

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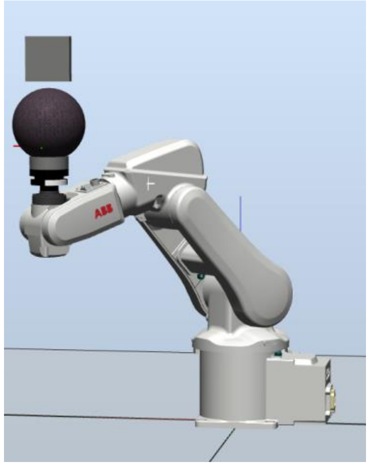
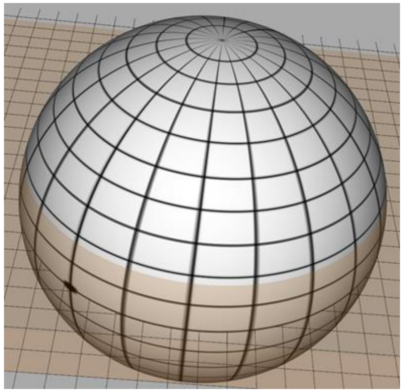
- **Starting with a sphere**
- **Using a robot to position the shape under the printheads**
- **We built a test print rig**



Mesh & Texture

3D Mesh



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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

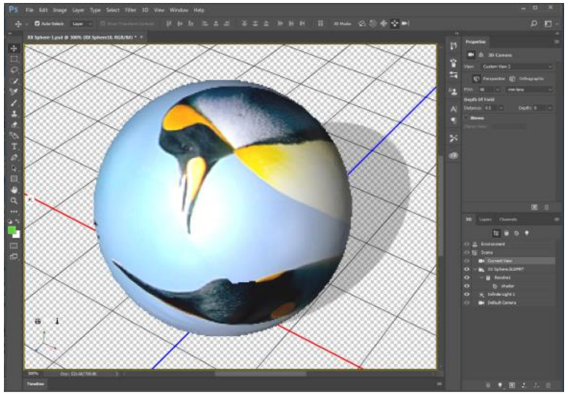

Image source: GIS

Print Paths

a) b) c)

- **Design a print path**
  - Taking into account the constraints of the object to be printed, inkjet printhead, capability of the robot

Positioning Accuracy

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Industrial robots have sufficient accuracy for many industrial applications …

… but 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

Generic Curved Surface Workflow

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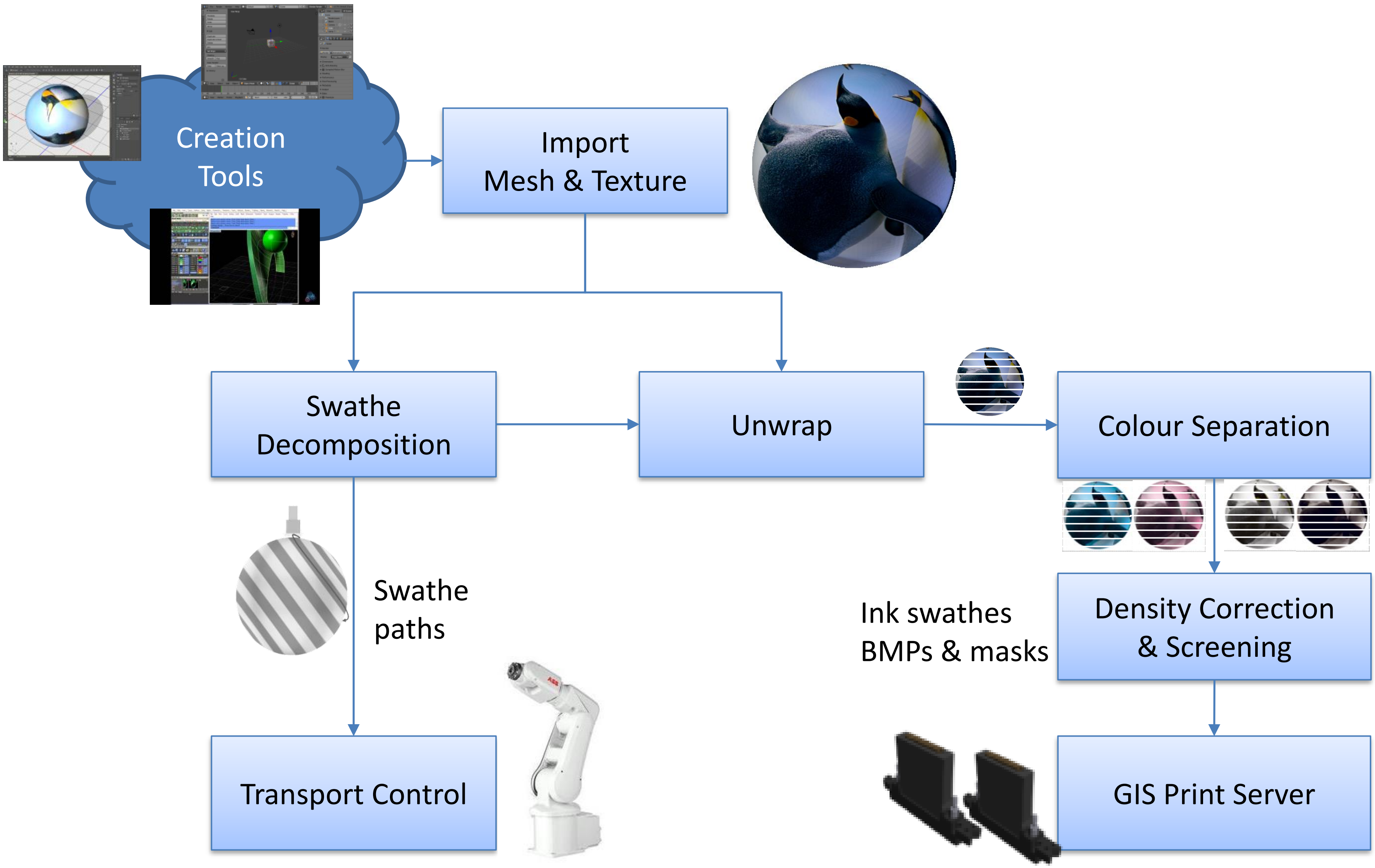
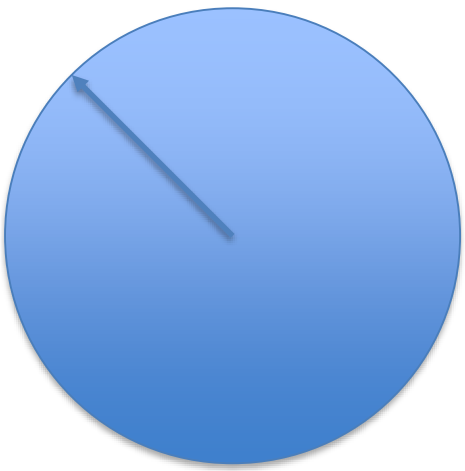


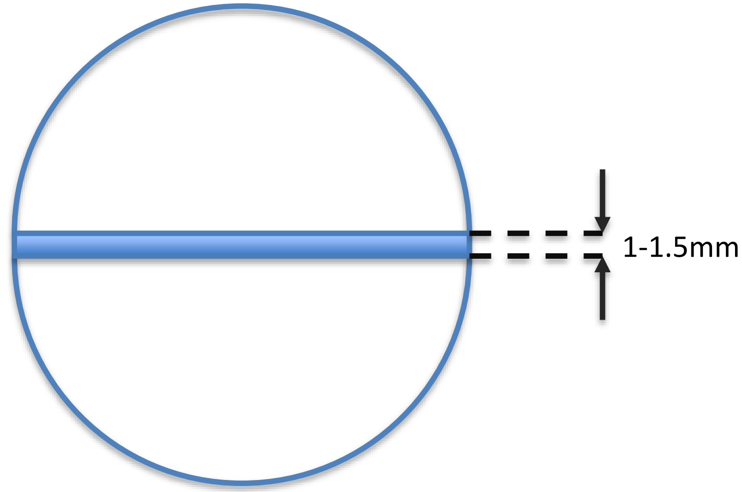
Shape Accuracy

All manufactured objects have tolerances

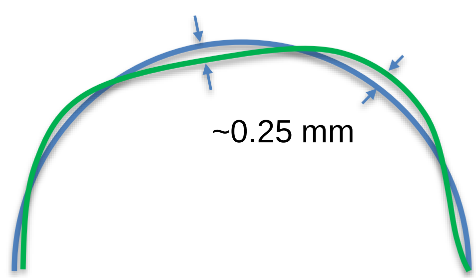
- E.g. Polypropylene sphere
- Inexpensive consumer product



Nominal: 75 mm radius



Structural errors
Assembly of two hemispheres



Precision errors
Limitations of process

Stitching

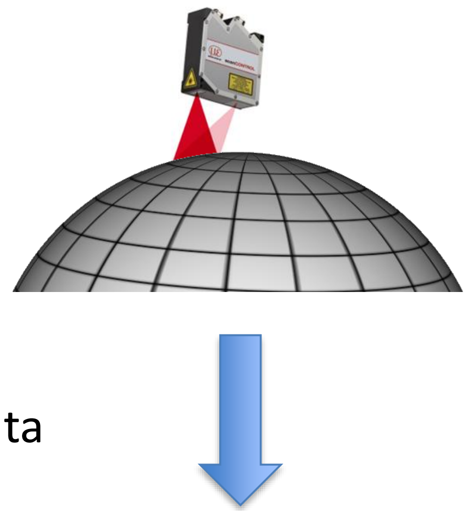
- **Stitching is a key area where inaccuracies will show**
  - Positioning errors cause gaps or overlaps, familiar from 2D printing

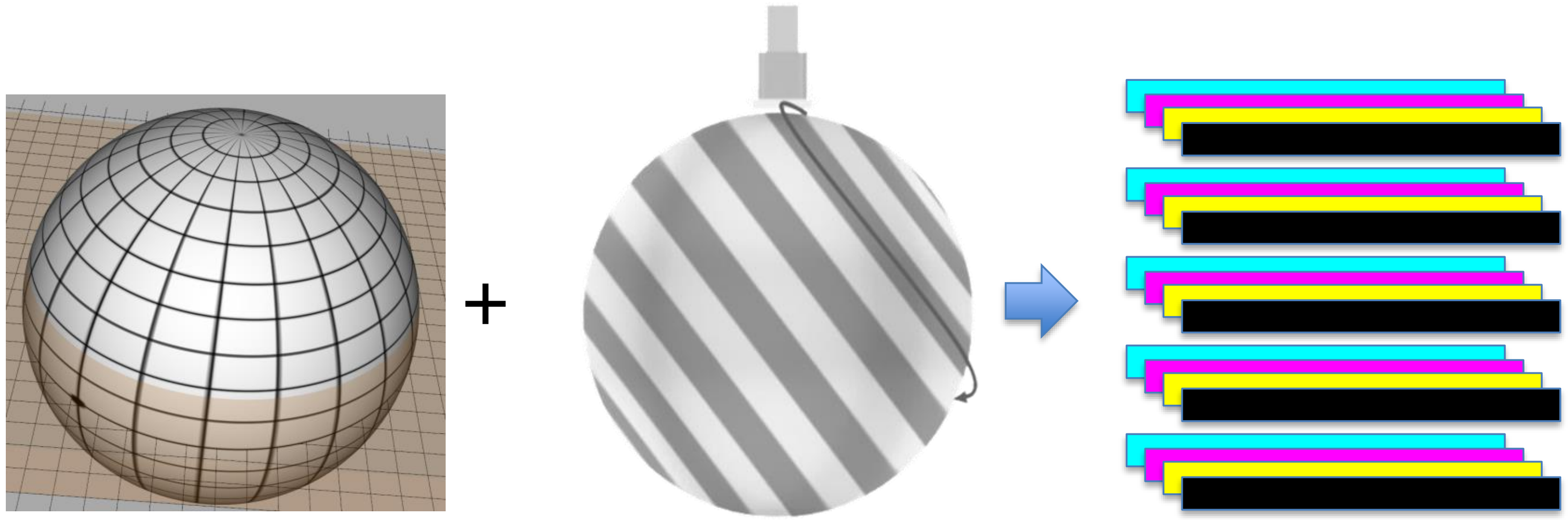
- **Careful control is required of multiple factors:**
  - Accuracy of transport, especially robots near to singularities
  - Print synchronisation
  - Variation of the target shape from nominal dimensions

Image source: GIS

Shape Accuracy 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 10^{-6}m, 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 delta
  - Output adjusted swathe data





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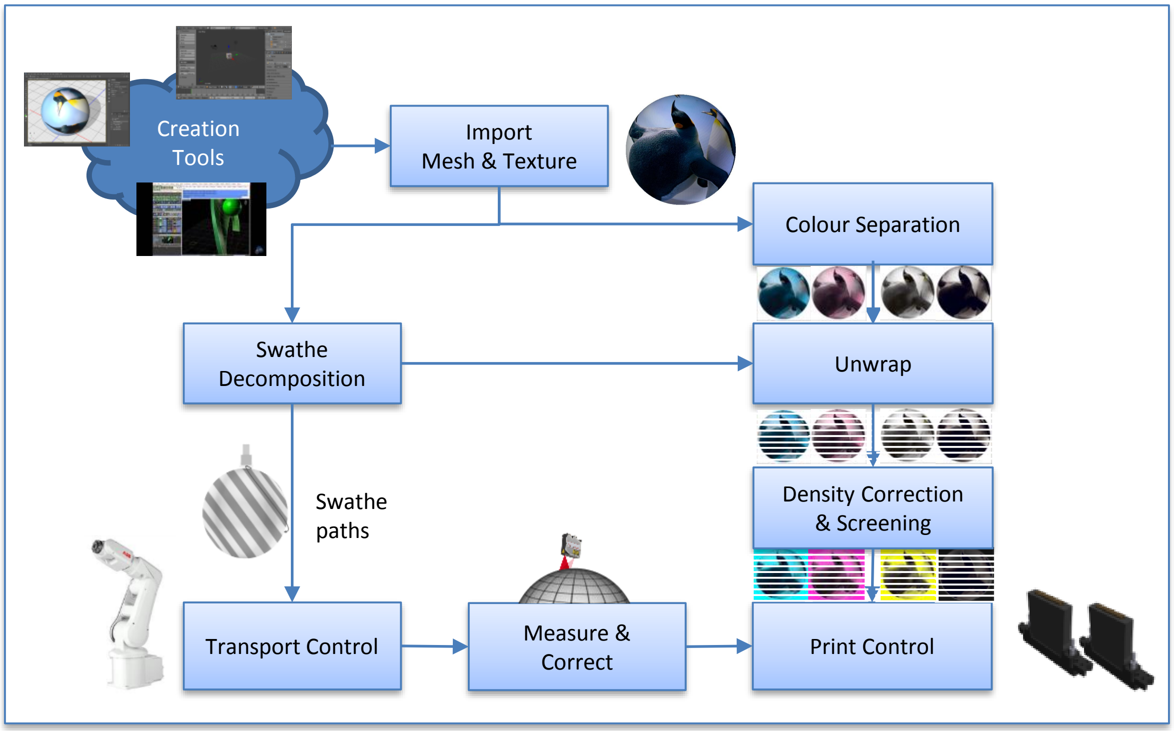
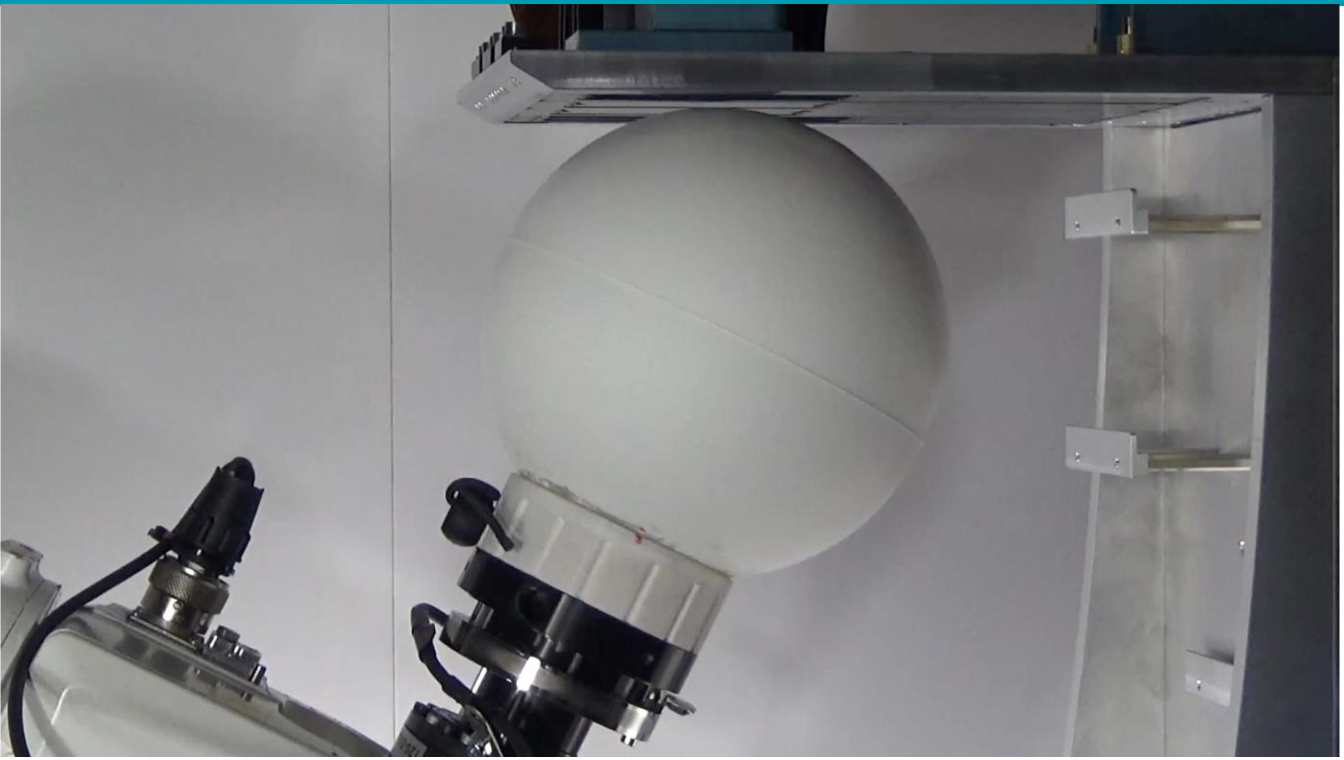


Image source: GIS

Video



Result: a printed polypropylene spheroid

- CMYK 1200 dpi
- Latitude swathes
- 300dpi native x 4 interleave

Summary - Implications & Opportunities

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- **Inkjet already being used in many decorative and functional coating applications**
- **Advances in printhead technologies, software and fluids continues**
  - Some highly viscous fluids for coatings remain a challenge
  - Ink jettable fluids - key to unlocking more applications
- **Inkjet no longer constrained to flat surfaces**
  - Precision positioning is vital, and is much more complex than for 2D
- **Great potential for further usage – particularly in industrial products**

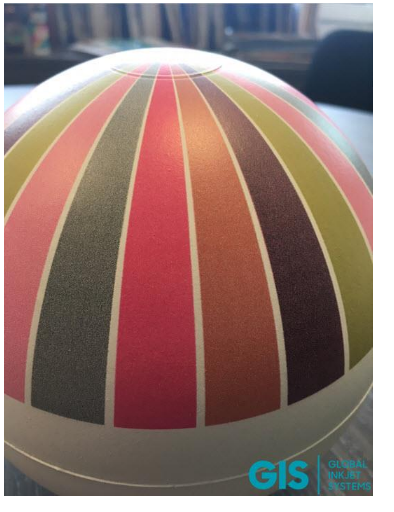

Image source: GIS

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