

# Direct to Shape (DTS) Inkjet Printing Many Opportunities - Many Challenges

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IMI INKJET CONFERENCE – ORLANDO, FLORIDA

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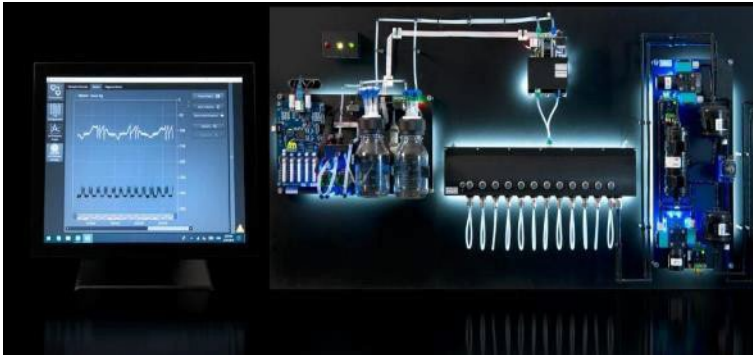
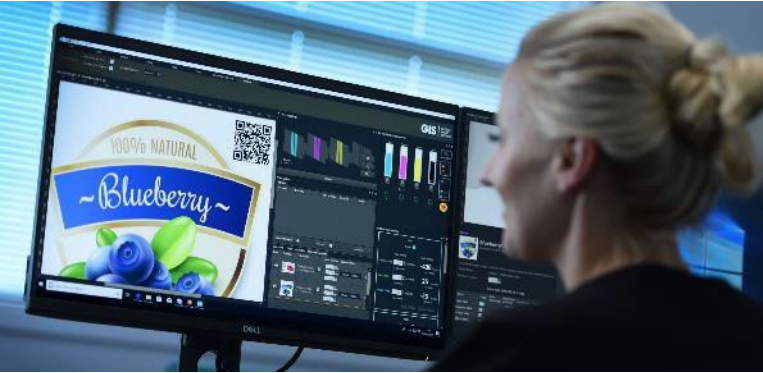
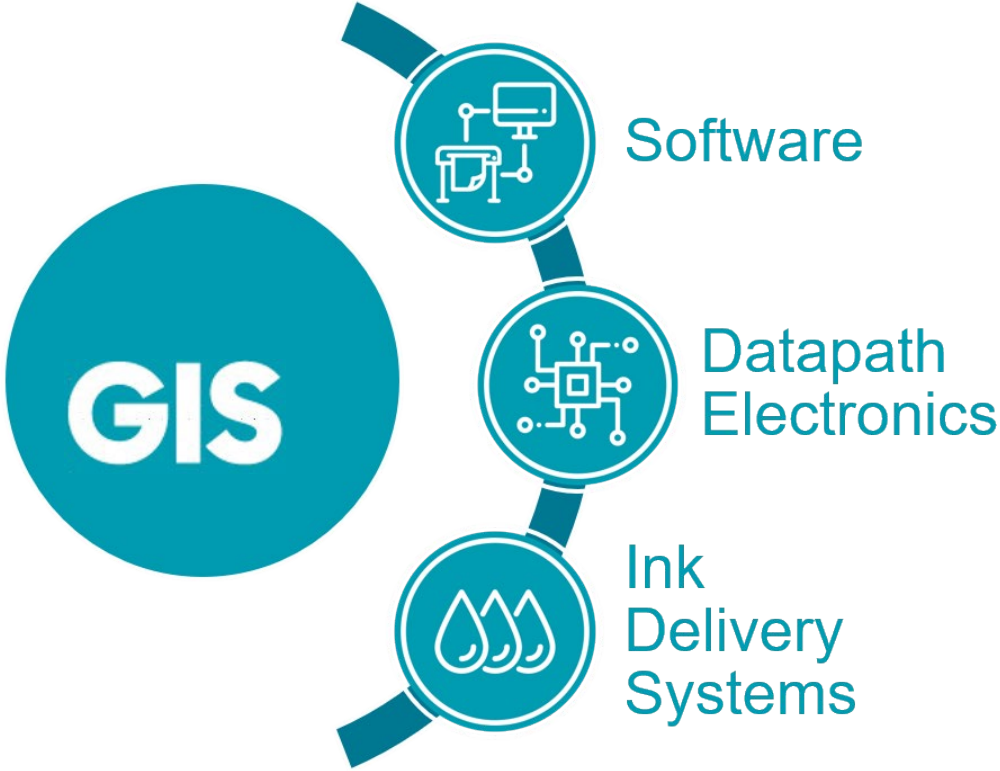
# GIS – Company Overview

- Leading provider of technology solutions to industrial inkjet systems builders
- Support printheads from Epson, Fujifilm, Konica Minolta, Kyocera, Ricoh, SII, TTEC, Xaar
- Founded November 2006
  - 100% acquired by Nano Dimension January 2022
- Based in Cambridge, UK
  - Technical support in UK, China & Japan
- Employees 60+
- Patent protected technology
- Supplier & partner to over 150 customers worldwide



# GIS Products and Services

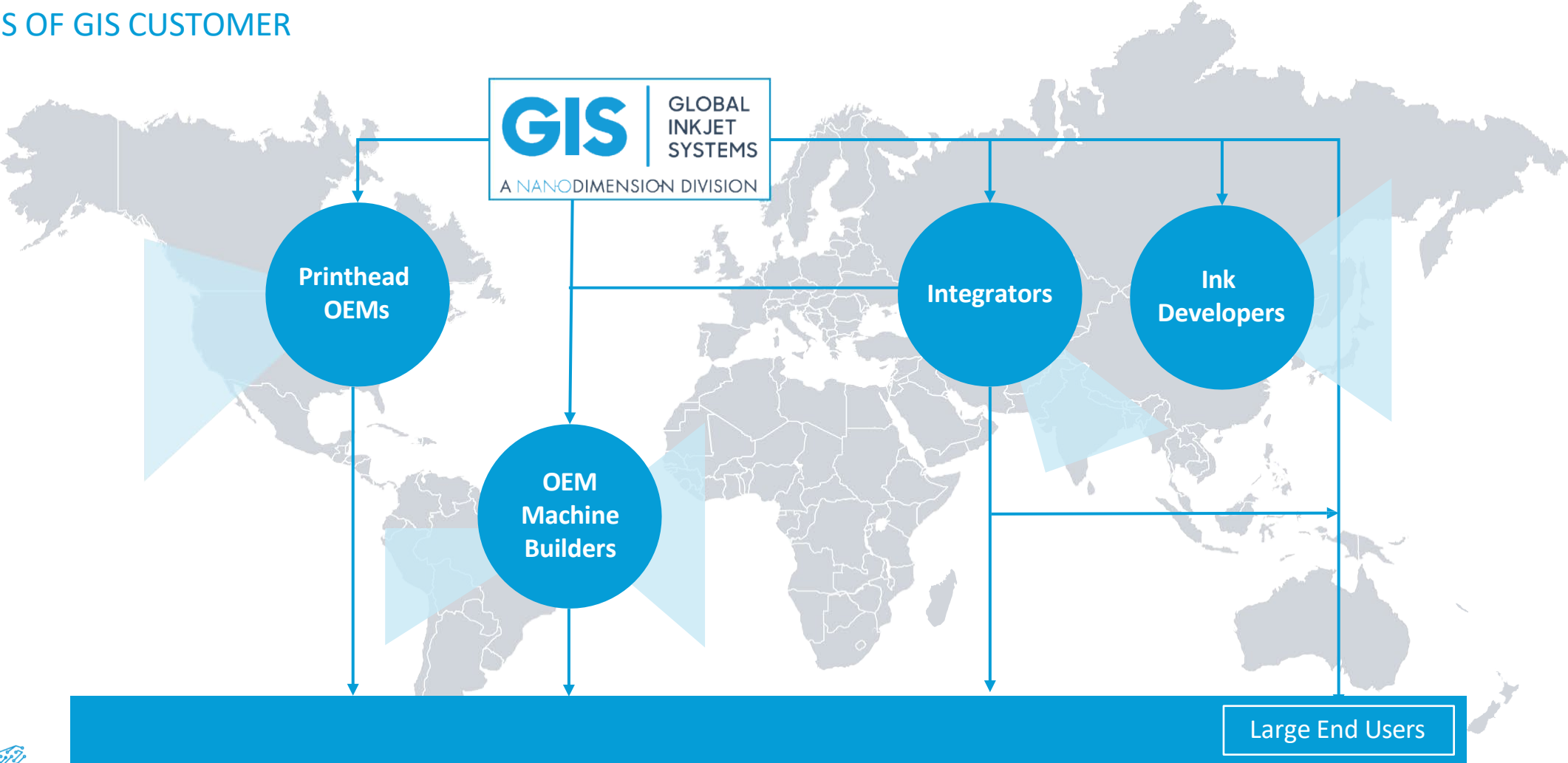
COMPLETE IMAGE MANAGEMENT FROM PIXEL TO DROP



We work with customers from R&D, Prototype Development - through to Production

# GIS customers

## TYPES OF GIS CUSTOMER



# Agenda

- Categorising the DTS market
- Update on container printing
  - Developments
  - Market size
  - Recent activity
- Update on complex / arbitrary shapes
  - Challenges
  - Recent activity
  - GIS DTS Studio software - project examples

# Disclaimer

Global Inkjet Systems supplies inkjet technology and components to 150+ OEMs, integrators and end users world-wide. As a matter of policy, we do not disclose our customer relationships.

This presentation provides a general overview of market activity (both GIS and non-GIS) and slides contain images chosen to illustrate the range of inkjet print systems and printed output 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 company and GIS.

# Drivers for DTS Printing / Coating

- **Packaging Containers: Marketing benefits / Engagement with consumers**

- Personalisation
- Customisation
- Promotional campaigns
- Cost effective shorter runs
- Variable data capability

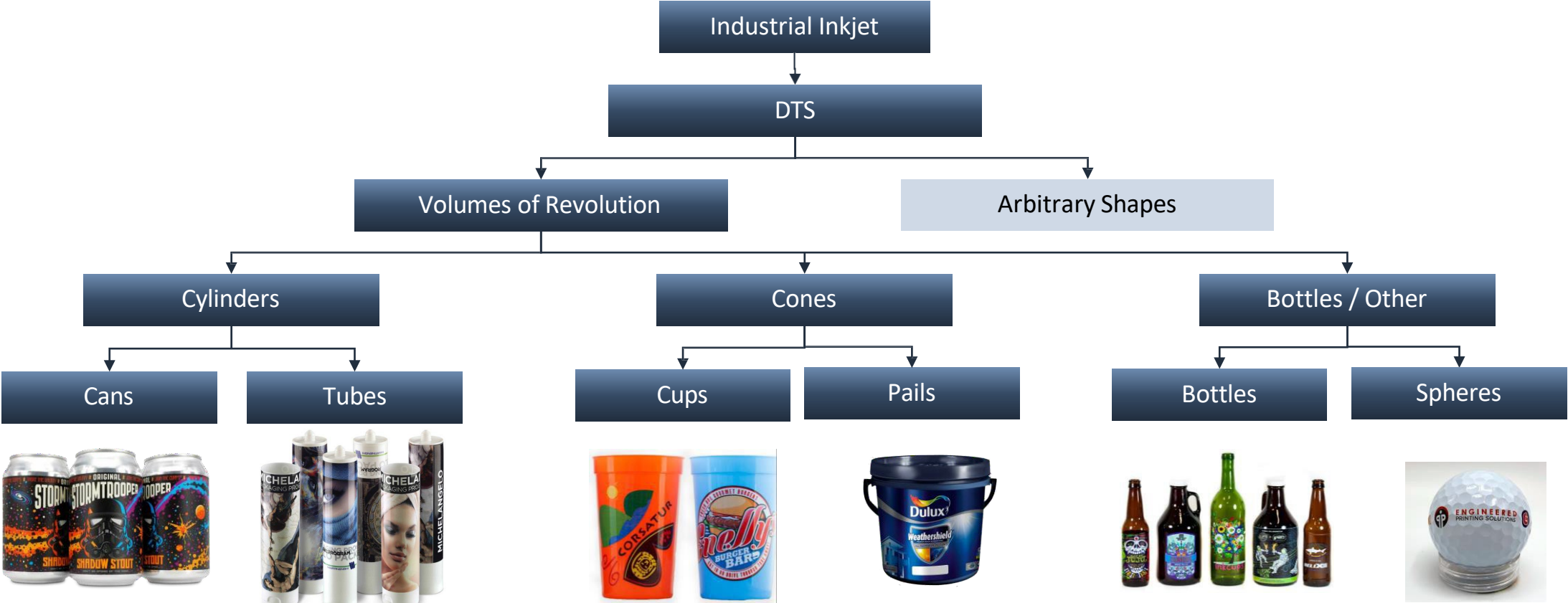


- **Industrial: Manufacturing flexibility**

- Materials savings
- Energy reduction
- Cost effective shorter runs
- Customisation
- Design freedom



# DTS Categories





# DTS Container Market

## TAKEN TIME TO DEVELOP

- Range of devices
  - Production – over 100 units/min
  - Mid Range – 50 units/min
  - Low end – single/dual units
- In 2013/2014 lot of product introductions (see GIS's IMI presentation 2016) – but not all have thrived or even remain in the market
- Ahead of their time? Was the market ready?
- Some companies have adapted their business models – offering bureau services
- Production system sales increasing – new vendors entering the market
- Proliferation of low end systems – particularly in China
- Further innovation in system design and software
- Certain printheads still popular – but usage broadening to multiple vendors

# DTS Container Market

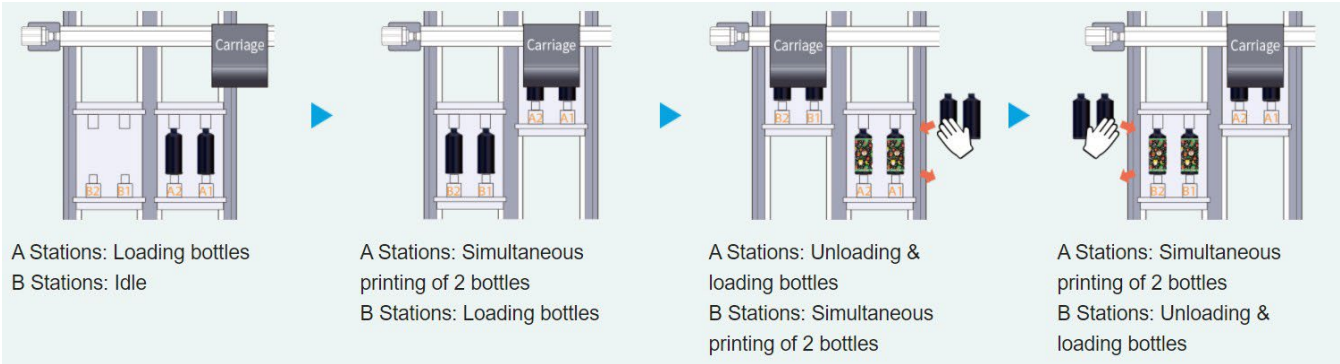
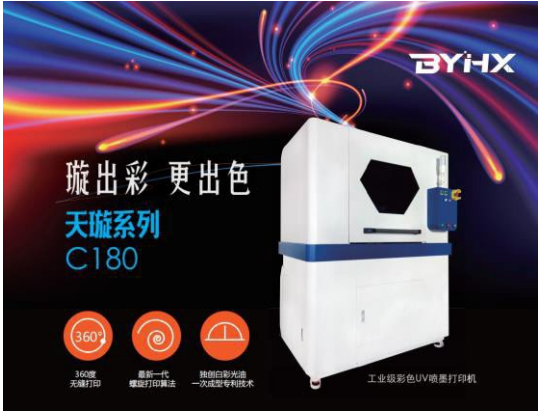
- According to Future Market Insights, the global direct-to-shape inkjet printer market is estimated at USD 3.8bn in 2022 and is projected to reach USD 6.6bn by 2030, at a CAGR of 7.2% from 2022 to 2030
- The US, China, Japan, India and Germany quoted as being among leading markets
  - 27% US market share
  - South Asia represents most lucrative region in terms of CAGR in the direct-to-shape inkjet printer market
- Bottles and cans cumulatively account for nearly 40% off the global direct-to-shape inkjet printer market by value by 2022 end

Market Size 2022	US\$ 3.8 Bn
Market Size 2030	US\$ 6.6 Bn
Value CAGR (2022-2030)	7.2%

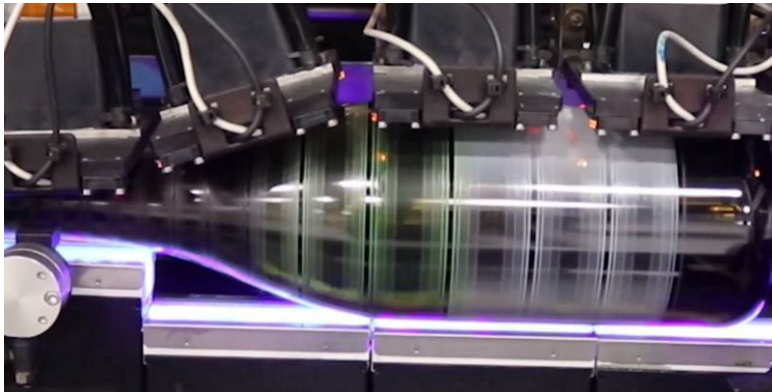


# Recent Activity

- Growth in helical systems – particularly low end in China
  - Reduces number of printheads needed for full coverage
- Increased production workflows in lower end systems



- Contour following – full object coverage



# Recent Activity

## TACTILE / RELIEF PRINTING - FAUX EMBOSSING

- Growth in tactile / texturing
  - Also trending in wood composites, laminates, ceramic tiles, labels, commercial print, braille etc
- Avg 3mm layer thickness



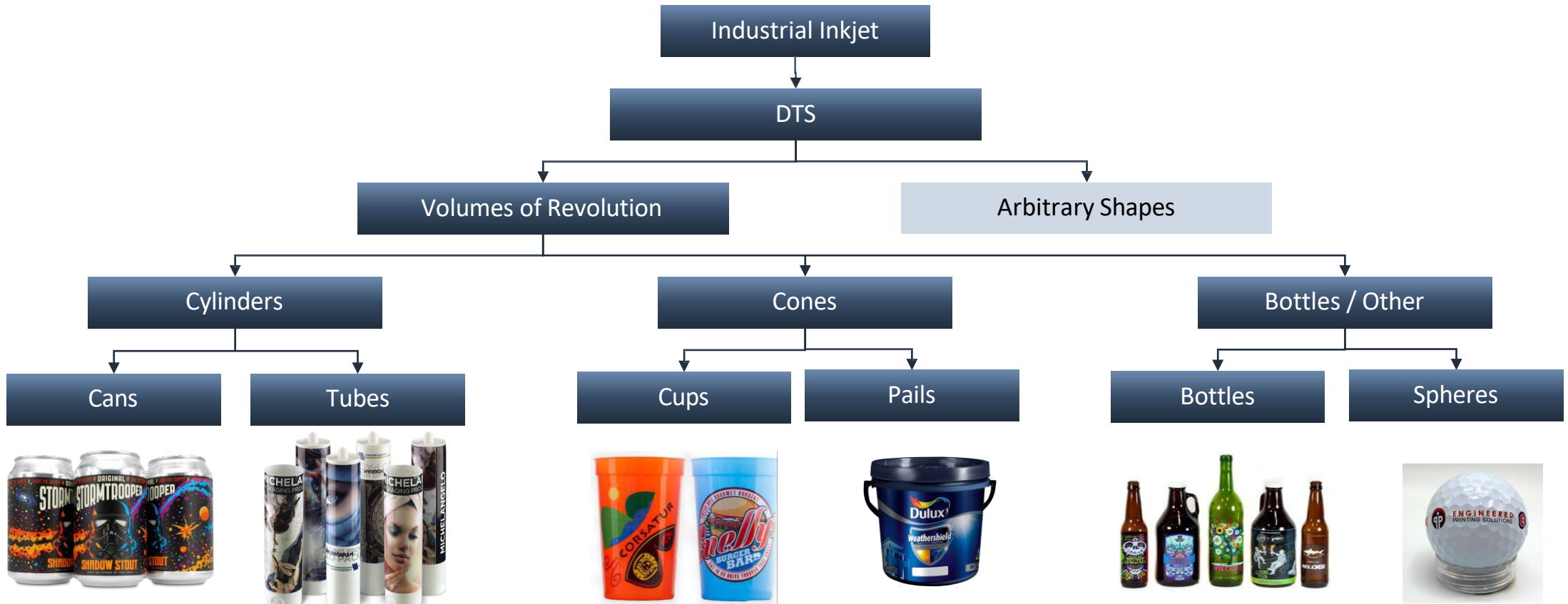
# Recent Activity

## MORE ACTIVITY IN CANS

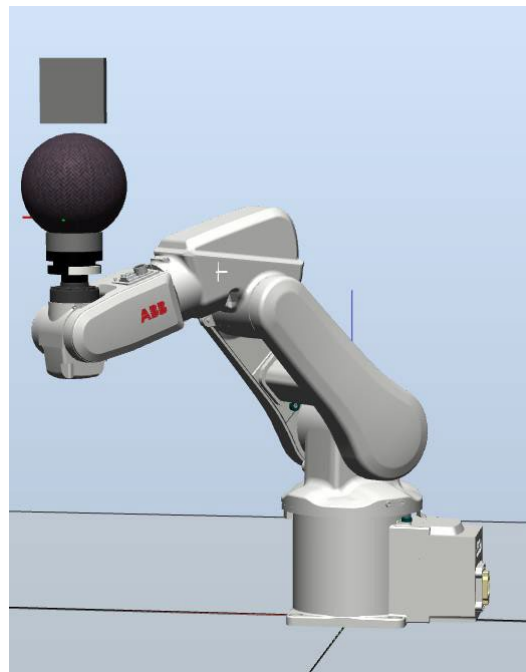
- Velox partnership with Crown (October 2021)
  - 500 cans/min
- Tonejet
  - 60 cans/min
  - New white primer coating
- Quantix Digital
  - 150 cans/min
  - Canned wine (US & Aus)
  - Embellishment



# DTS Categories

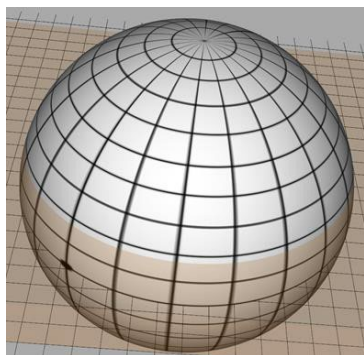


# GIS R&D Project – Printing a Sphere



# Image Wrapping & Print Path

3D Mesh

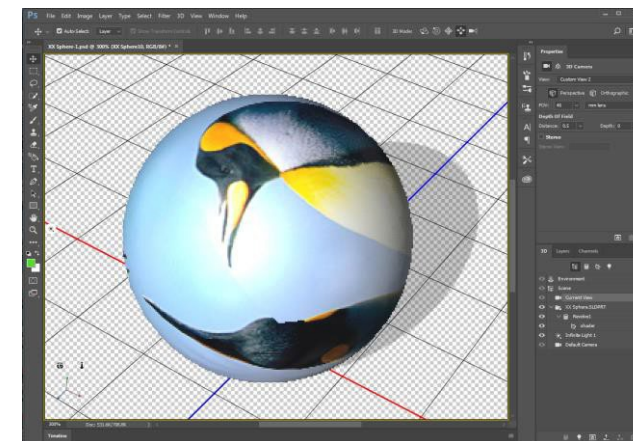
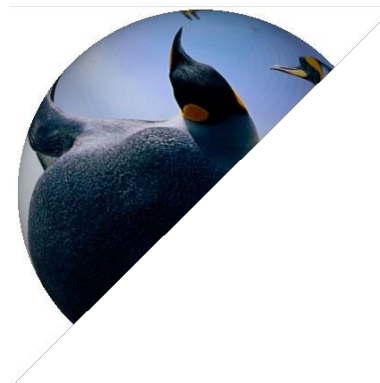


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Texture



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- **Many tools available for wrapping**
  - Well established technologies from gaming, augmented reality industries
  - Many different ways to wrap, edit directly on to 3D surfaces
  - Result is expressed as a texture map
- **Developing print path**
  - Take into account the constraints of the object to be printed, inkjet printhead, capability of the robot



a)



b)



c)



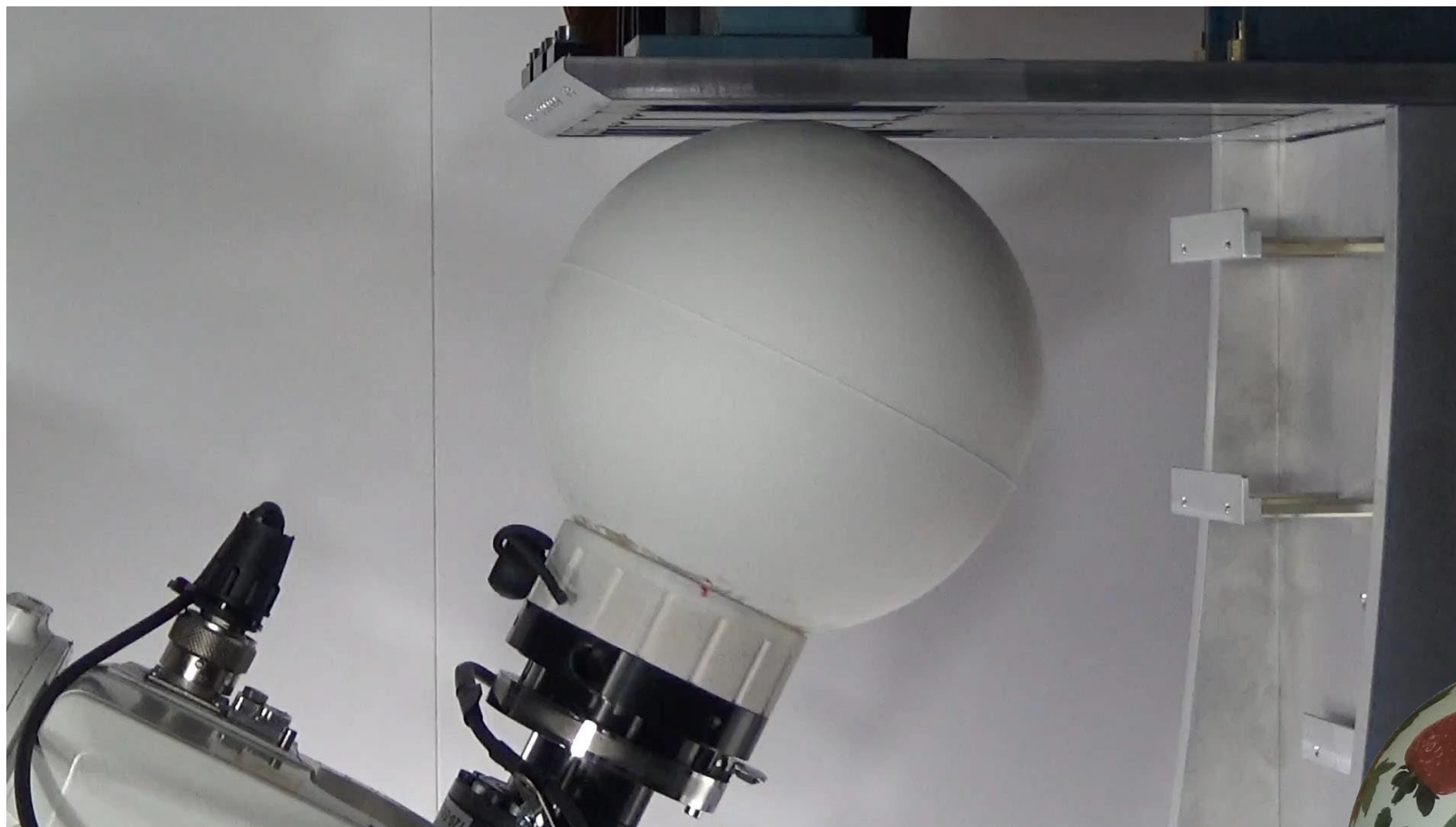
# Stitching

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

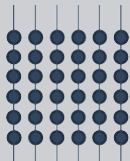
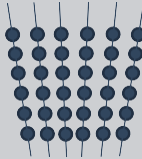
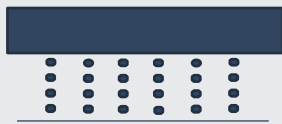



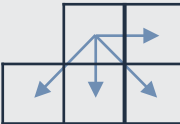

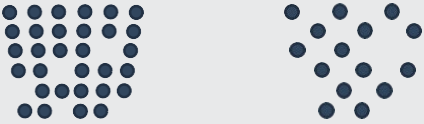



- **Careful control is required of multiple factors:**
  - Accuracy of transport
  - Print synchronisation
  - Variation of the target shape from nominal dimensions

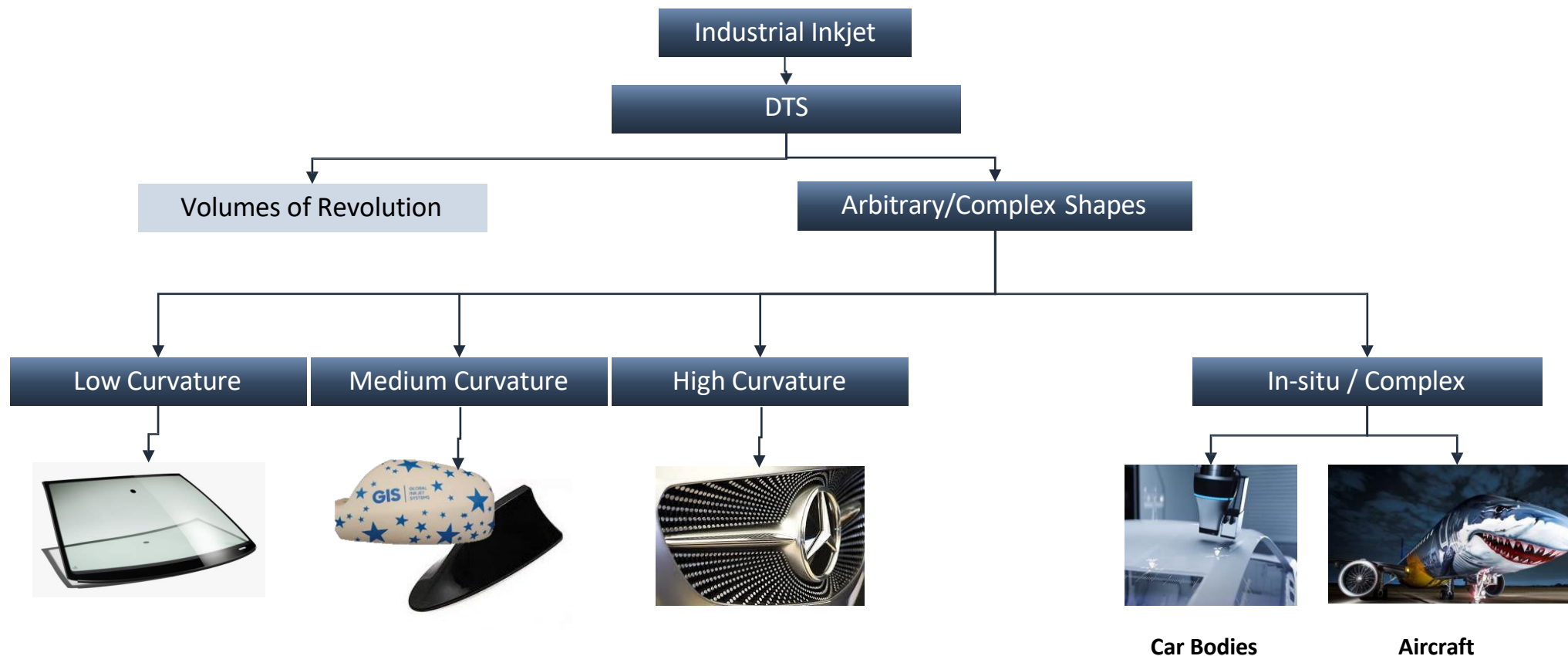
# Sphere Printing - CMYK




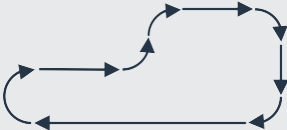
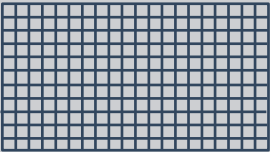
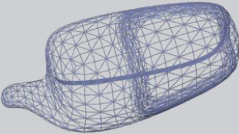


# Inkjet Direct to Shape – Volumes of Revolution

	Flat Surfaces	Curved Surfaces
<b>Density Correction</b>		
<b>Throw Distance &amp; Time of Flight</b>		
<b>Nozzle Alignment &amp; Interleaving</b>		
<b>Screening</b>	 	 

# DTS Categories



# Inkjet Direct to Shape – Arbitrary / Complex

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

# Complex Shapes - Opportunities

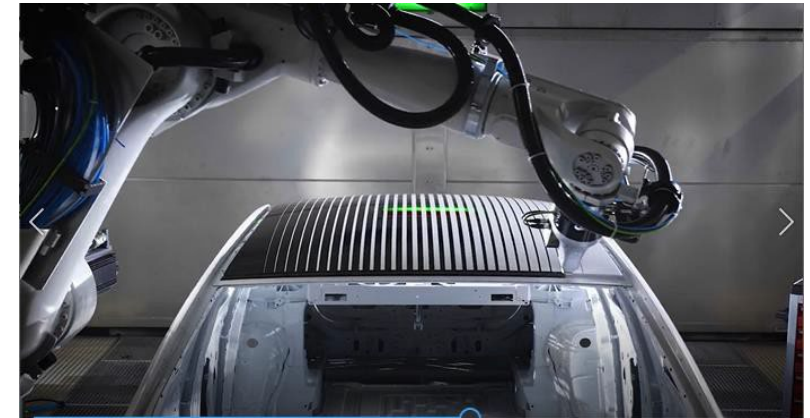
- **Industrial product focus**
- **Inkjet competing mainly against**
  - Decoration: IMD, pad, screen, vinyl wrap, hydro dipping, hand painting
  - Coatings: Spray
- **Demanding requirements**
  - Long life durability – years, not months
  - Specific industry requirements
- **Growing interest in automotive**
  - Interior trims
  - Instrument panels
  - Exterior part casings
  - Grilles
  - Headlight covers
  - Windows/windshields



# Key Drivers

## CHANGING MARKET FORCES

- Manufacturing and economic issues dominate
  - Complex designs / shapes – increasingly difficult for traditional processes (EV designs)
  - Reducing material waste and energy usage
    - Cost
    - Environmental - emissions – sustainability
- Customisation
  - Typically secondary to manufacturing and economic drivers
- Example – Dürr (world leader in planning and implementing paint shops)
  - Developed EcoPaint Pro

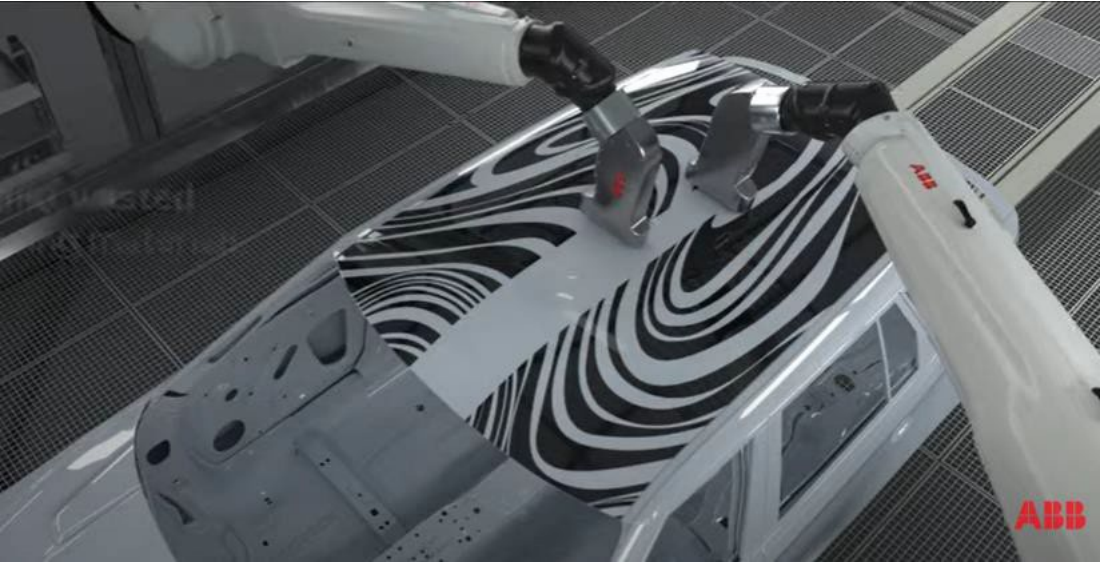


“The paint shop is the main energy consumer in automotive production, accounting for 40 percent of the energy used. In addition to the energy for drying the paint, the energy needed to remove overspray is a major contributor to this high consumption. Even highly advanced technology cannot ensure that all of the sprayed paint actually reaches the vehicle surface. The rest of the paint forms overspray, which has to be separated in the spray booth. Avoiding overspray reduces the air consumption, and this measure alone reduces the energy consumption in a spray booth by 50 to 65 percent.”

# Recent Activity

## JUST A FEW EXAMPLES

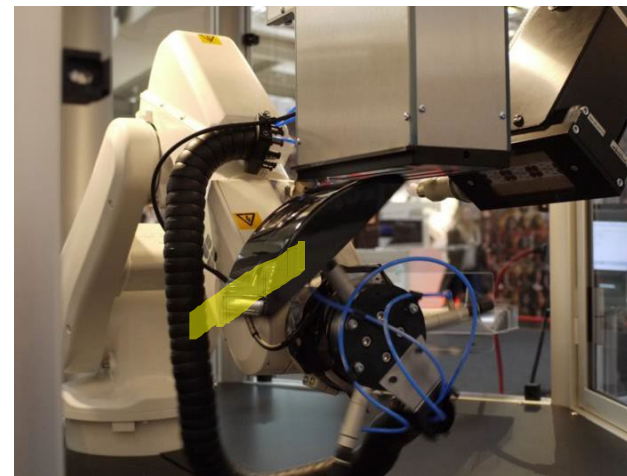
- Durr – EcoPaintJet Pro
- ABB - PixelPaint
- Ricoh Digital Painting
  - Lac Corporation
- Boeing - Alaska Airlines
  - Inkjet & hand paint





# 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 IJJ, Heidelberg, Nakan & Xyrec/ SW Research Institute/ Airbus/Marabu

# 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
  - Increasing activity in valvejet
  - Developments for higher viscosity capability in traditional 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
    - Lower energy usage
    - Selective area coating capability
    - Texturing capability

# Positioning Accuracy

Industrial robots have sufficient accuracy for many industrial applications ...

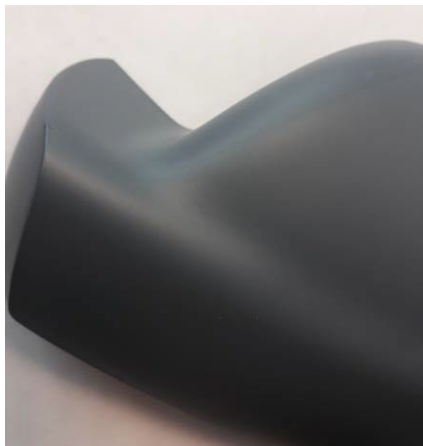


... but inkjet printing requirements are tight

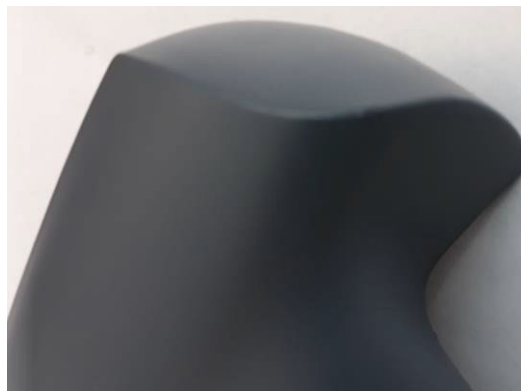
- Typical industrial robots can achieve absolute pose accuracy with calibration of 200-500  $\mu\text{m}$
- Inkjet printing requirements for graphics are typically 5-10x finer - but not so precise for coating
- Robot repeatability is better than absolute accuracy, so further calibration is possible

# GIS R&D Project – Wing Mirror Casing

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

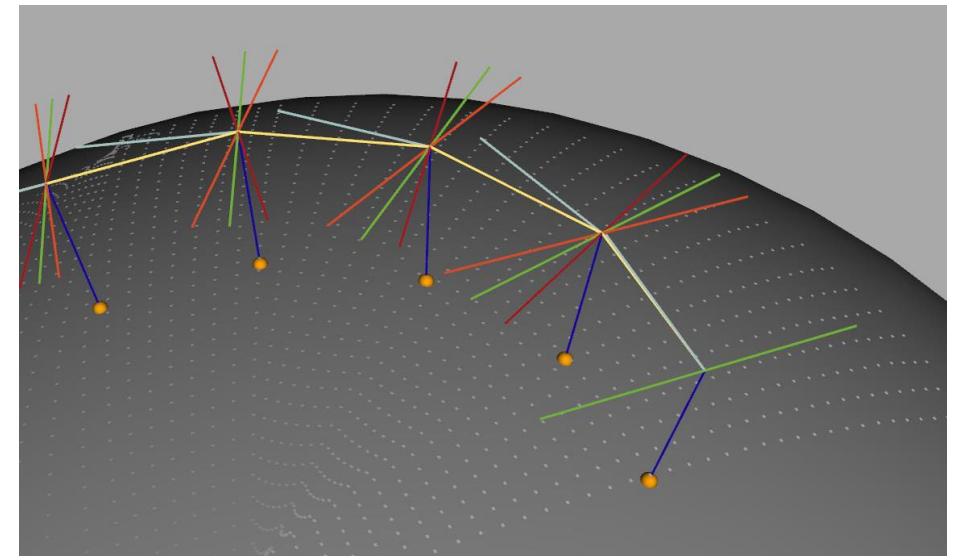
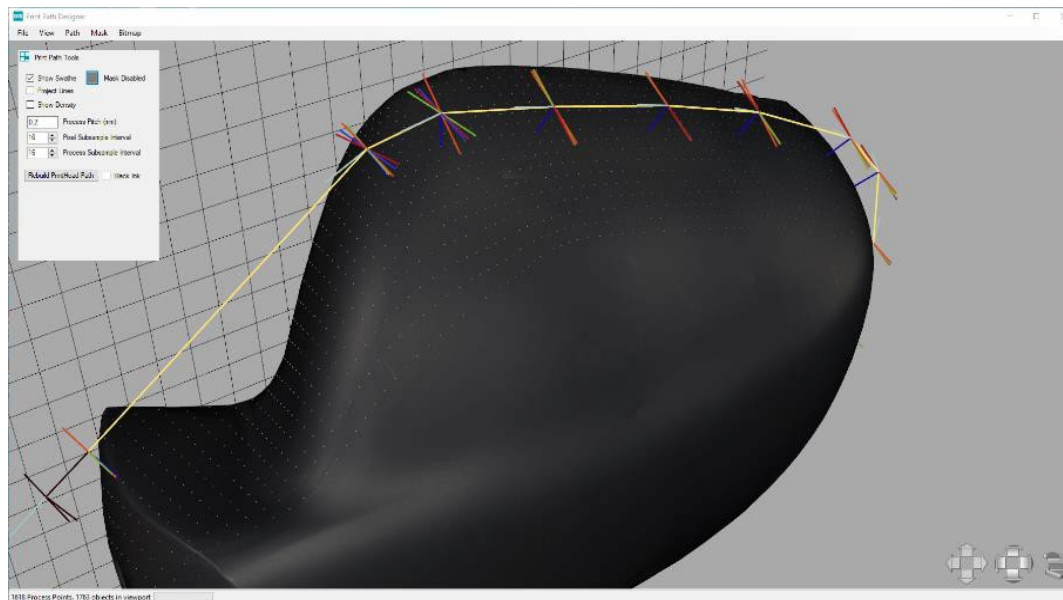


- **Step 1: Automotive hard coat**
- **Step 2: Decoration**

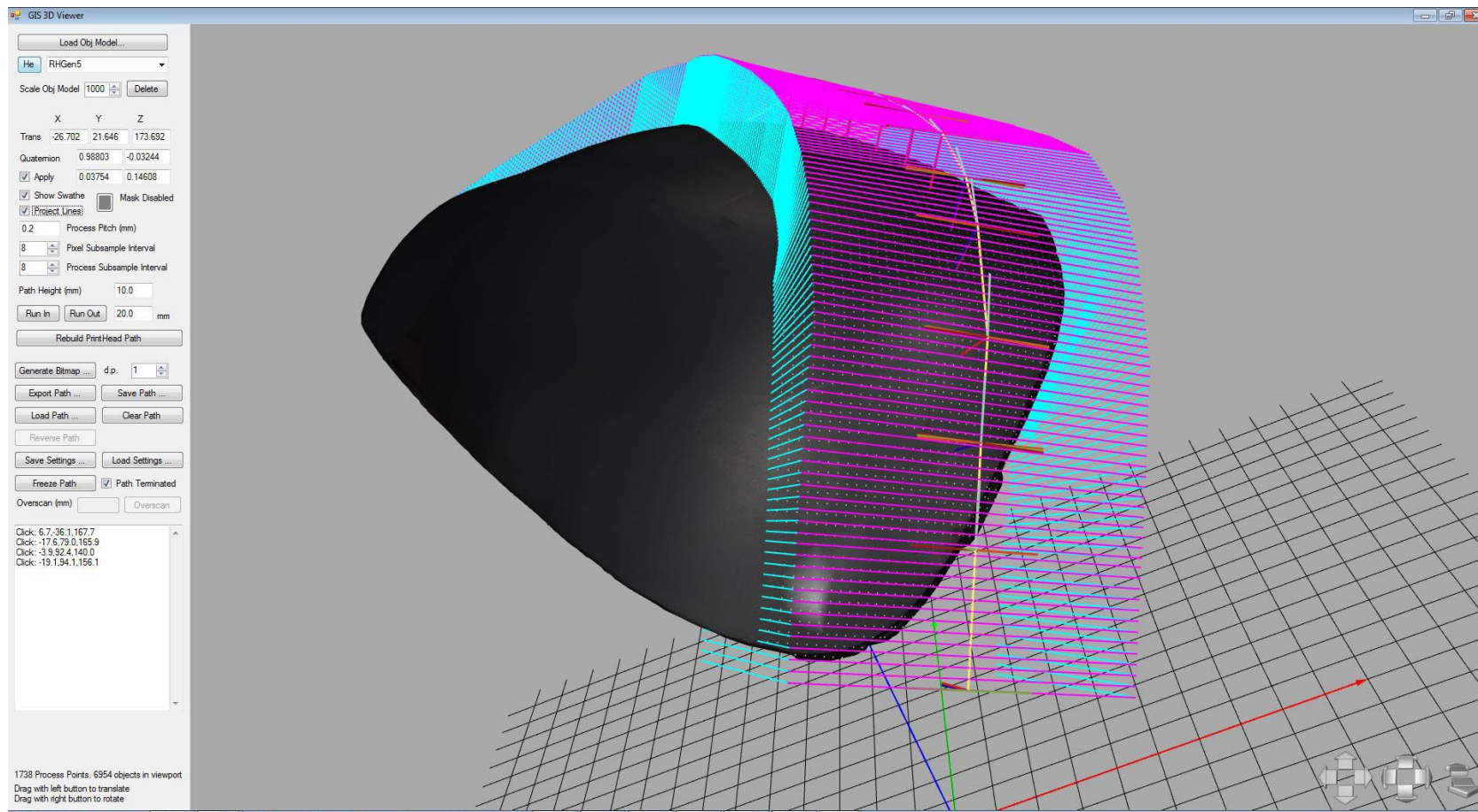


# GIS DTS Studio Software

- **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
- **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



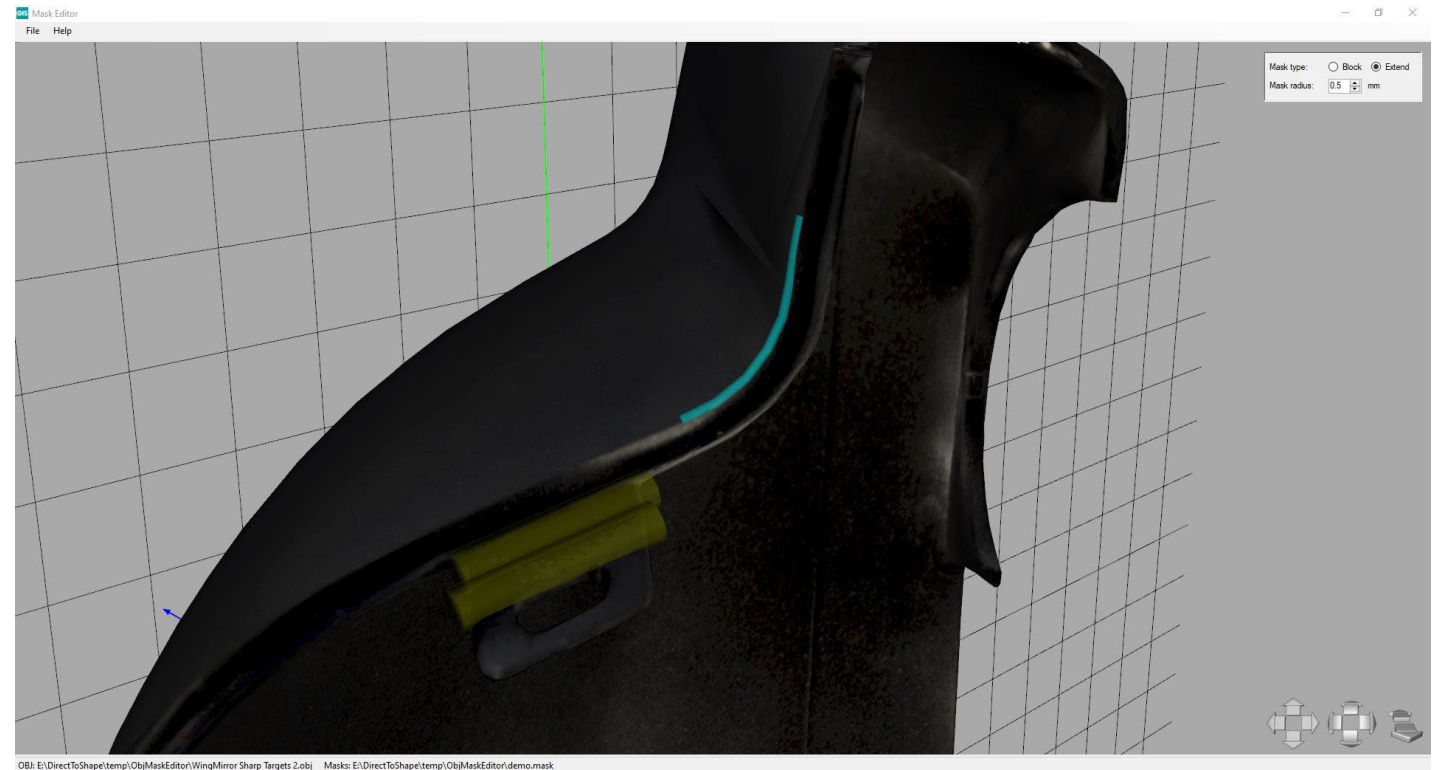
# GIS DTS Studio Software



## Swathe visualisation

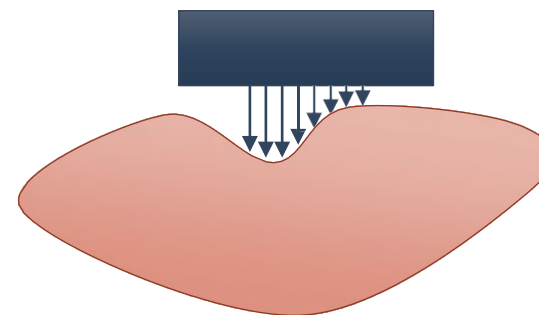
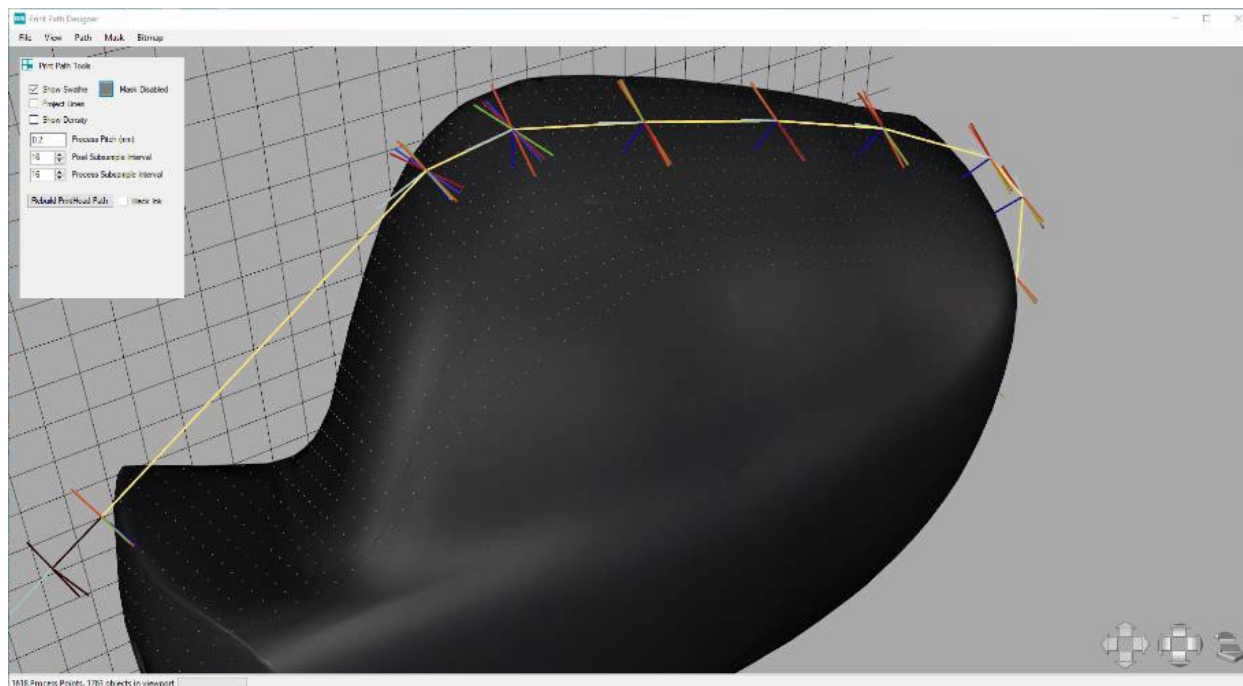
# GIS DTS Studio Software

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



# GIS DTS Studio Software

- Throw distance – waveform development

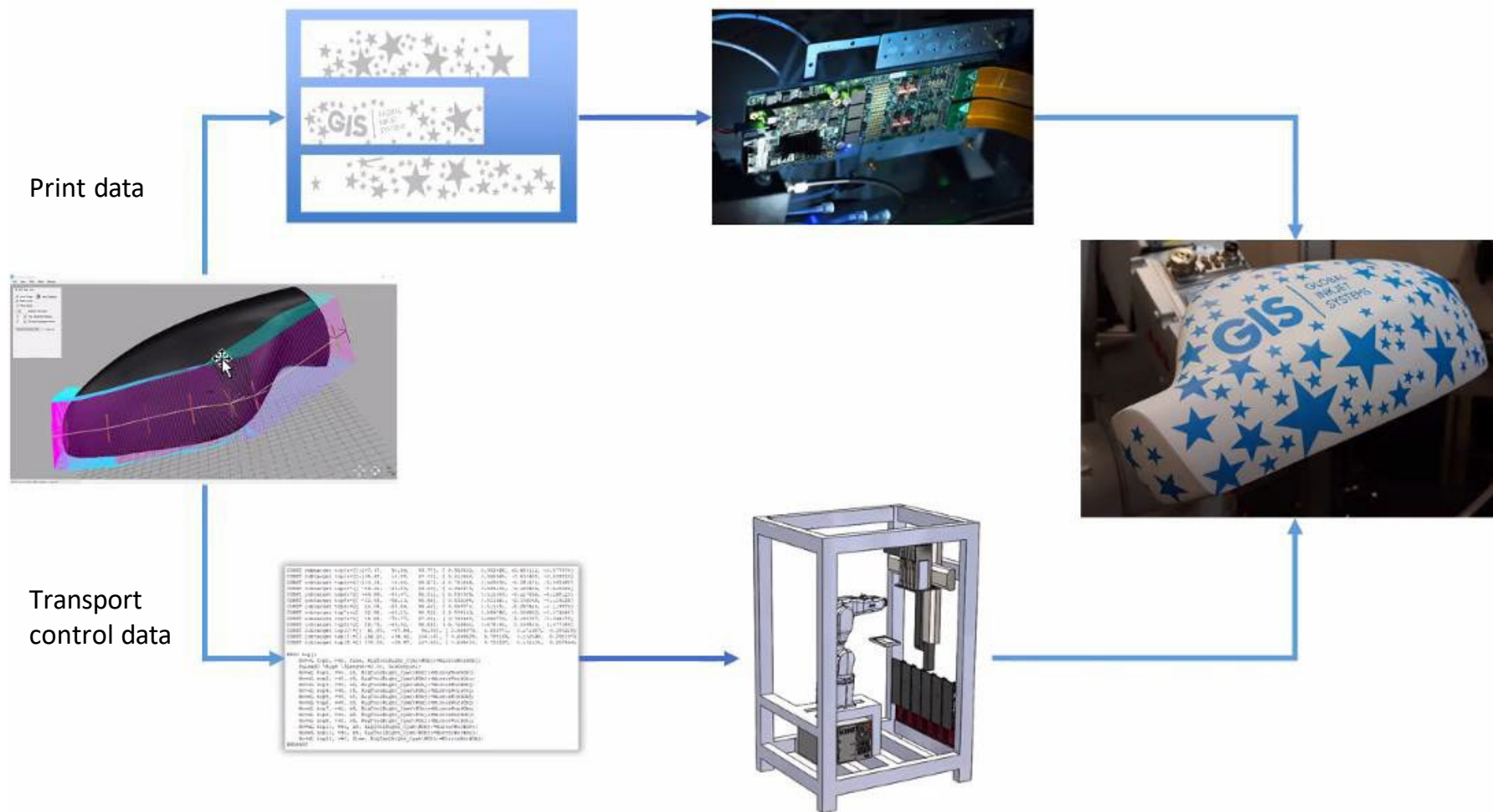


Coating coverage can be achieved even in concavities up to ~25mm depth





# GIS Direct to Shape Studio

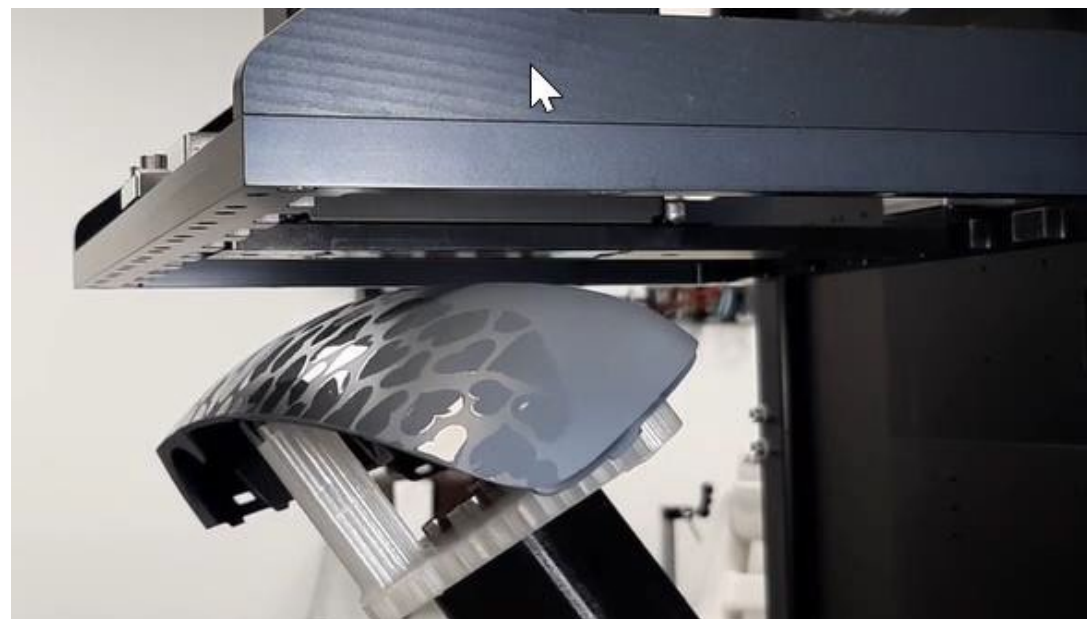


# Example: Coating

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



<https://vimeo.com/376156000/b2a720f1e5>



<https://vimeo.com/650328141/7411c800d6>

# Example: Decoration

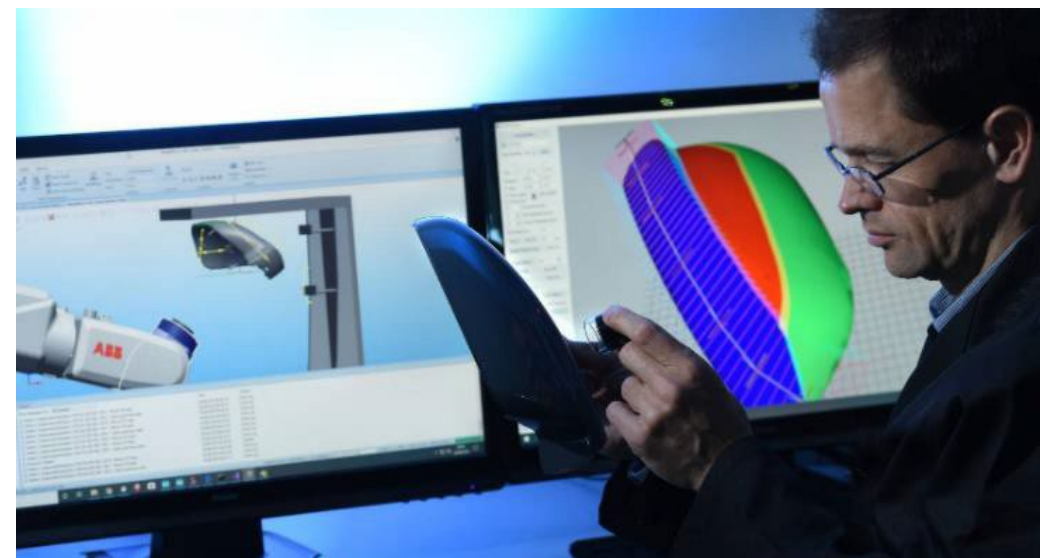
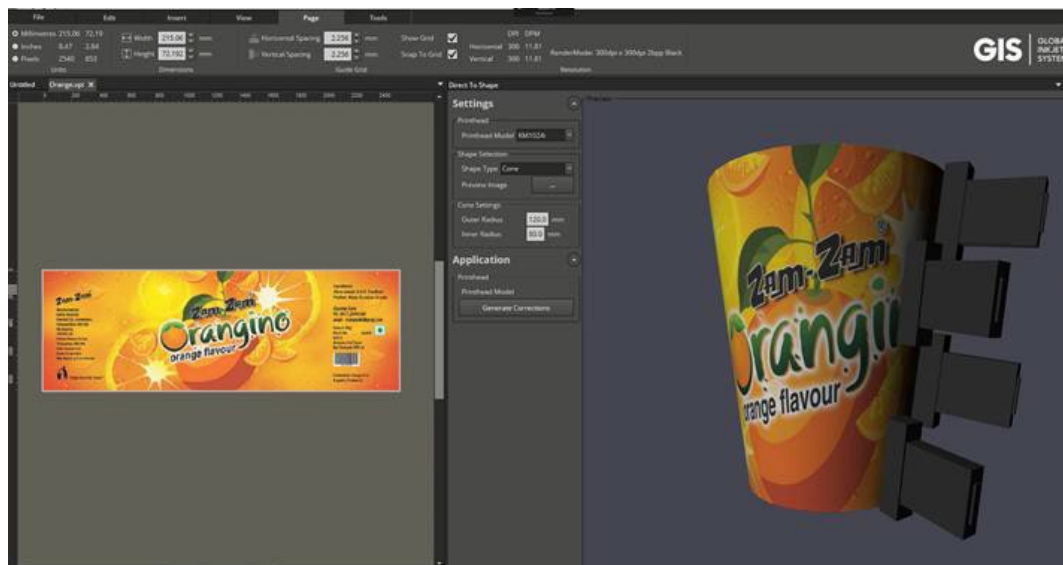
- Spot colour using a graphic UV curable inkjet ink from Marabu



<https://vimeo.com/390778004/a6df6d1fcf>

# Summary – Inkjet Direct to Shape (DTS)

- Container systems – well established / growing
- Complex/arbitrary shapes
  - Developing markets in automotive, consumer durables, and even aviation
- Challenges of fluids / printhead capability remain – but advances in software creating new market opportunities for inkjet



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