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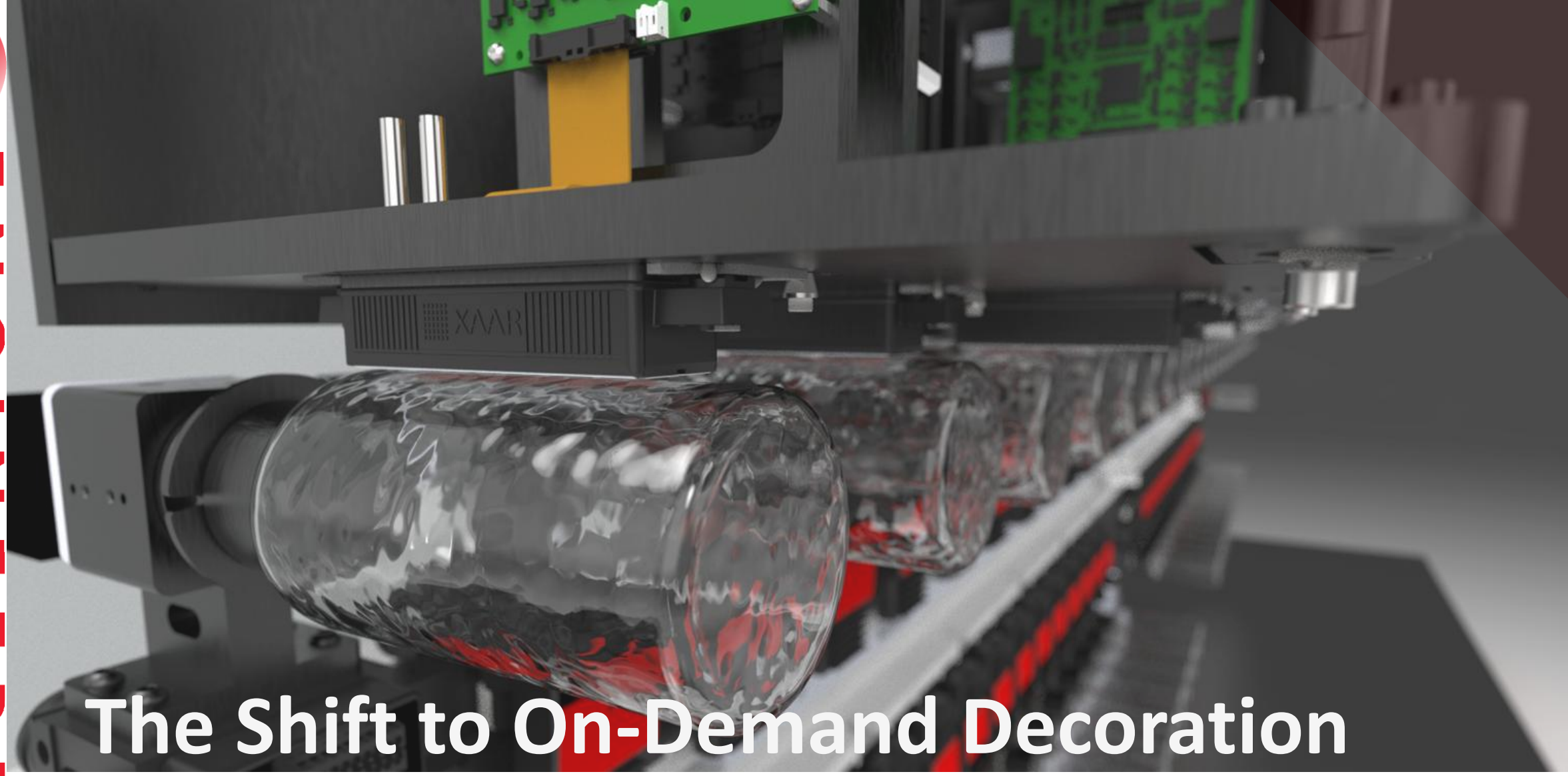



# The Shift to On-Demand Decoration

## How Direct-to-Object Inkjet is Reshaping Glass Drinkware Production

# Agenda

## 01

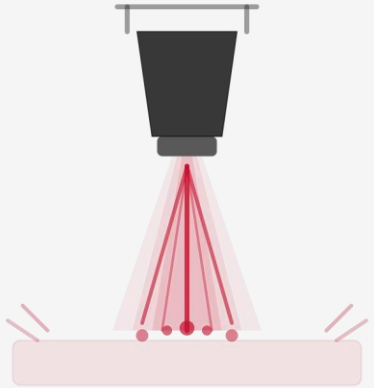
**The Shift**

- Market forces driving the change
- Impact on production
- The honest gap

## 02

**The Current Process**

- Methods Available
- Process involved
- Current Options Today



## 03

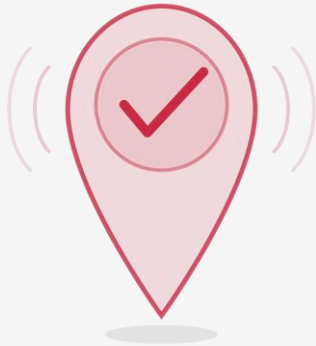
**The Future**

- High viscosity
- XAAR's Role
- Impacts on Glass


## 04

**Takeaways**

- EPS positioning
- What's next
- Q&A



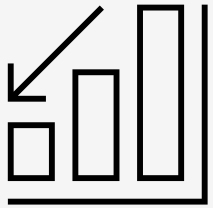
# The On-Demand Shift

## $4.2B → $11.8B

Direct-to-object inkjet market, 2024–2033 | 11.9% CAGR | Drinkware: fastest-growing segment

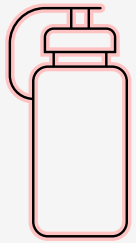
### Collapsing Run Lengths

Digital eliminates setup — 10 unique items costs the same as 10 identical



### Personalization Economy

Drinkware is #1 hot product of the decade — 9% of $25.8B promo market



### E-Commerce Integration

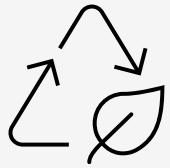
Web-to-print: order online → auto-queue → scan & print. Zero inventory risk

### Brand Differentiation

Direct decoration feels premium & permanent vs. labels and sleeves


### Sustainability Alignment

No labels, no adhesives, fewer VOCs — regulatory & marketing advantage

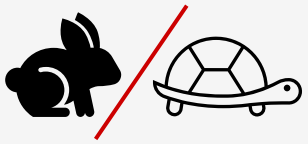


# What Reshaping Production Looks Like

| | | |
|---|---|---|
| Make-to-Stock | **Make-to-Order** | No unsold inventory, no obsolescence, no warehousing costs |
| Single-Design Runs | **Mixed-Production Queues** | Different design on every piece — dozens of orders per shift, zero changeover |
| Spot Color | **Full Color Default** | CMYK + white + varnish natively — photorealistic costs the same as simple logos |
| Weeks Lead Time | **Days/Hours Lead Time** | Artwork file to finished product in minutes — transformative for events & promos |
| Decoration as Service | **Decoration as Product** | Print-on-demand enables D2C — decorators sell finished drinkware directly |

# The Honest Gap: What Digital Can’t Do Yet

## Throughput at Scale



**50–300 pph vs. 200+ ppm**

Screen/Pad (Analog) printing still wins for millions of identical commodity glasses. Digital closes the gap with multi-spindle configs and pinning elimination.

## Ceramic Enamel Durability

**2,000+ cycles vs. unlimited**

Fired ceramic fuses into the glass permanently. UV ink sits on the surface — proven at 2,000+ industrial cycles, but not infinite – Does it need to be?

## Food-Contact Limitations

**Non-food-contact surfaces only (mostly)**

UV inks are suitable for exterior decoration only. Ink manufacturers are actively pursuing closing this gap, UV & UHV inks are making headway as Nestle, Swiss Ordinance, EuPIA compliant inks now available.

## Handle Geometry

**Standard cylinders only**

Mugs and handled vessels need specialized fixtures or flatbed approaches. Standard cylindrical printers can’t reach behind handles. Landscape here is changing quickly, but not without higher cost systems with lower throughputs.

# 02

# The Current Process

Methods and processes available today to decorate directly to the object

# Pretreatment at a Glance

*Glass surfaces resist all inks — cold-end coatings + hydrophilic surface require pretreatment regardless of method*

### Chemical

- Many options
- Lowest cost entry point
- Labor costs and time increased
- Inconsistent

### Flame

- Burns off coatings
- Lowest cost
- Added guarding and safety

### Pyrosil®

- $SiO_2$ nano-layer via Flame
- 250+ Residential DW
- Reoccurring costs

### Plasma

- Ionized gas
- No VOCs
- Higher cost
- Narrow widths
- Creates Ozone

### Coating Delivery System

- Flame + spray primer
- Prop 65, FDA compliant
- 15–20 items/min
- Expensive long term consumable cost

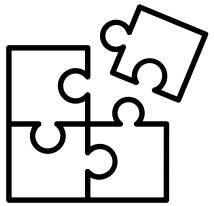
Key insight: Digital inks can’t include hardeners (they’d clog nozzles) — this is why pretreatment + adhesion promoters are essential for durability.

# The UV Ink Challenge

## Why UV Inks Degrade

- UV inks absorb warm water/vapor, causing them to **swell and soften** — the primary dishwasher degradation mechanism
- Digital inks **can't include hardeners** — they'd clog nozzles. Pad/screen inks can use 2-part systems
- Industry solving via: protective UV clear coats, better pretreatment, **high-viscosity formulations**

# Complementary, Not Adversarial



## Pad & Screen Printing

- 2-part ink systems (hardener mixed before printing) deliver **superior chemical resistance**
- Economical for 1-7 spot color, long-run commodity work
- 200–400+ bottles/min on high-speed lines
- Unmatched fine line fidelity
- Full spot color/Alternate ink types readily available

## UV Inkjet

- Full CMYK + white + varnish natively — photorealistic at **no premium**
- Variable data / personalization on every piece, zero changeover
- Web-to-print integration: order → queue → scan → print
- High Laydown/High-viscosity digital inks are pushing the boundaries of print from labels/marking to artwork showcase pieces.

Pad printing = spot color, max durability, lowest cost per print. UV inkjet = full color, variable data, photorealistic at scale.

# Today's Print Systems

## Engineered Printing (GLASS) Solutions -

- **Multipass UV Inkjet systems**
  - Slower output – 50-300pph ranges
  - Single load/multiple load stations available
  - Higher image quality/finishes available, specifically photographic
- **Single Pass UV inkjet**
  - Higher throughputs
  - Turnkey automated systems
  - Fast topographical effects

50/60pph


2k-4kpph

# What's Next For Cylinders & Glass

## EAOT Printing

- Complex curvatures now capable with contour following inkjet
- Implementation to current lines with limited space available
- Up to 4 colors possible on 1 EOAT

# What's Next For Cylinders & Glass

## Hi-speed Inkjet

- Scalable transport system for speeds exceeding 10Kpph
- Fully automated w/ Pretreat/Print/Vision Inspection
- Embellishment/Topographical effects at speed



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# 03

# The 3–5 Year Outlook


High-viscosity inkjet, creative effects analog can’t match, and the EPS roadmap

# The Viscosity Revolution

### Traditional UV Inkjet

## 10–12 cP

~50–100 cP at ambient. Constrains ink to thin, watery chemistry — limits pigment loading, opacity, and adhesion additives

### XAAR Ultra High Viscosity

## Up to 100 cP

~1,000 cP at ambient (10× traditional). Opens formulation space: higher pigment, better opacity, adhesion chemistry, tactile effects

## Why This Matters for Glass

- Ink manufacturers gain freedom to formulate for **durability first** rather than fitting chemistry into a narrow viscosity window
- Higher pigment loading = fewer passes = **lower ink consumption** and faster throughput
- Potential to **eliminate pretreatment steps** as ink adhesion chemistry improves
- New tactile and textured effects previously impossible with thin inkjet inks

# XAAR Core Technologies


## TF Technology

Through Flow (TF) ink recirculation via Hybrid Side Shooter architecture:

- High-rate flow directly past the back of each nozzle
- Nozzles self-recover from blockages; 24-hr idle restart proven

## High Laydown

Higher ink volume per pass delivers:

- Greater opacity in fewer passes
- Vibrant colors on dark/opaque substrates
- 50–70% reduction in ink consumption vs. multi-pass

## XaarGuard

Self-cleaning nozzle plate technology:

- Prevents ink buildup and misfires
- Extends printhead service life
- Reduces maintenance downtime

**Combined, these technologies enable the Xaar Nitrox platform (Pro for glass, Elite for UV decoration) to handle inks from 6–100 cP — the widest viscosity range in the industry.**

# What High Viscosity Means for Glass

## Ink Freedom

Ink manufacturers can formulate for performance—adhesion, durability, color gamut—without being constrained by a 10–12 cP ceiling

## Reduced Consumption

Xaar Nitrox delivers up to 120 g/m² in High Laydown mode at 25 m/min (3× standard). Up to 50% less ink by volume for equivalent opacity

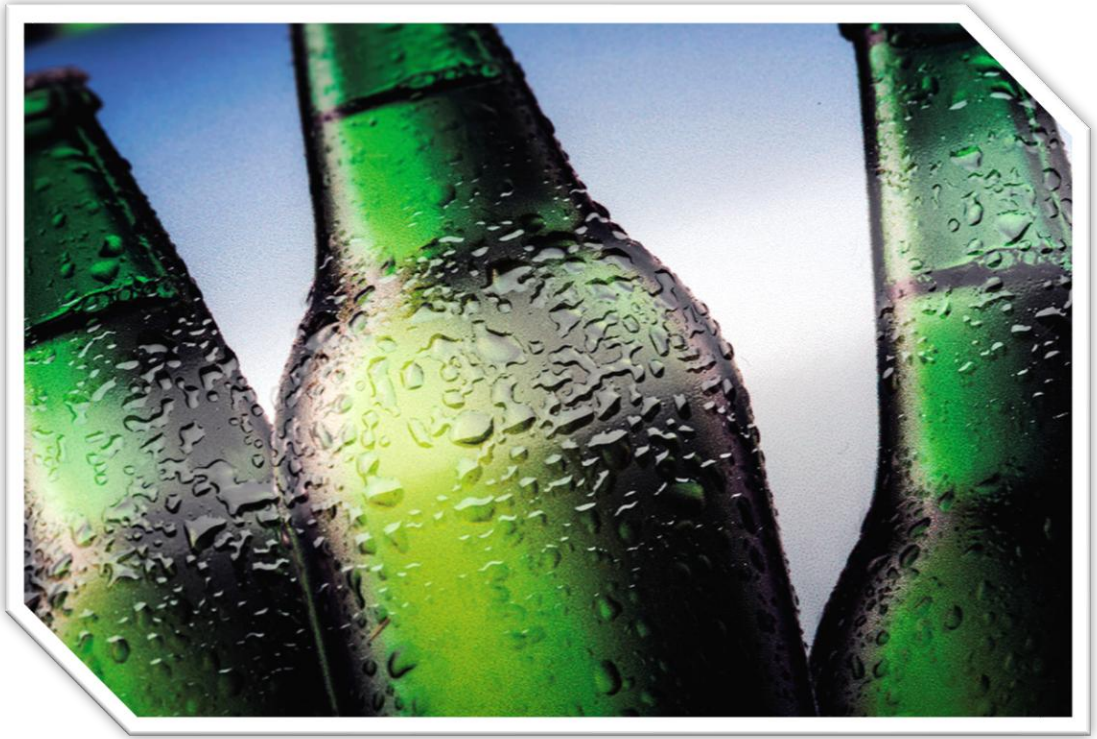
## Simplified Process

High-viscosity inks eliminate inter-color pinning (partial UV cure between layers) — alone this can more than double production speed

## Tactile Effects

Digital embossed effects up to 3 mm build height with sharp contours — previously only achievable through mold tooling or multi-step screen

# Performance Comparison: Traditional vs. UHV



High Laydown + High Viscosity is changing the shape of what is printable

| Metric | Traditional Inkjet | XAAR UHV Technology |
|---|---|---|
| **Jetting Viscosity** | 10–12 cP | **Up to 100 cP** |
| **Ambient Viscosity** | ~50–100 cP | **Up to 1,000 cP** |
| **Pigment Loading** | Limited | **Significantly increased** |
| **Ink Consumption** | Standard | **Up to 50% reduction** |
| **Pinning Required** | Yes, between colors | **Often eliminated** |
| **Embossed Effects** | Very time consuming, often requiring multiple print files | **Up to 3 mm build height, but limitless in theory** |
| **Production Speed** | Baseline | **2× or more (pinning elim.)** |

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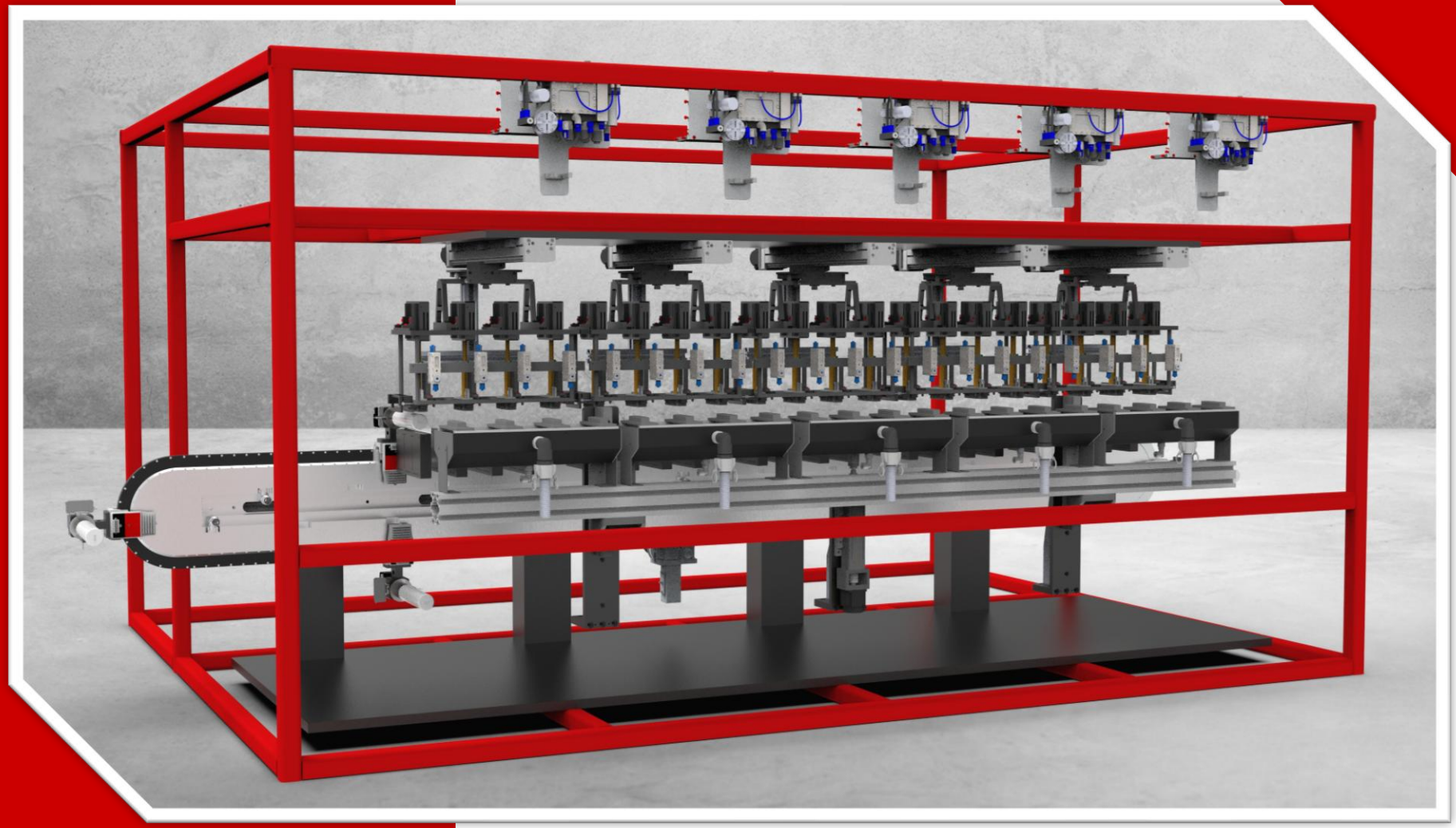
# 04

# Roadmap & Takeaways



# EPS Technology Roadmap

## Now – 12 Months

- Analog + UV inkjet dual platform (status quo)
- Pyrosil, plasma, manual primer pretreatment options
- Qualified high-durability UV ink systems

## 1 – 3 Years

- Further UHV printhead integration testing
- High-viscosity UHV ink qualification
- Adoption of High Laydown
- Jettable primer + UHV ink compatibility

## 3 – 5 Years

- Full UHV drinkware production systems
- Converged pretreatment + printing inline
- Jettable ceramic-equivalent inks
- Aquinox water-based HV inks (sustainability)
- Robotic load/unload, lights-out production

# Key Takeaways

1. The shift is real — a $4.2B→$11.8B market driven by collapsing run lengths, personalization, and print-on-demand economics

2. Digital durability proven with proven pretreatments — the gap with analog is narrowing, and high-viscosity inks accelerate the trajectory

3. Creative effects are where digital doesn't just close the gap — it creates new value that analog can't match at any cost

4. EPS offers pad + UV inkjet + the Nitrox UHV roadmap — a single-source partner bridging analog to digital at the customer's pace

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