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A NANODIMENSION DIVISION

Mind the Gap

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JITF2023
Japan Inkjet Technology Fair

R&D Investment – Industrial Inkjet

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Mind the Gap

1. Between the way it has been and the way it has to be
2. Between OEM & end-user expectations and realistic possibilities
   (set by industrial inkjet vendors)
3. System componentry for a maturing industry
4. R&D cost and available funding

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Experience

- 10 years – printer OEM – Xerox
- 13 years – printhead producers – Xaar and Ricoh
- Applications globally – label & flexible packaging to robotic painting
- 6 weeks – GIS

Passionate about the sensible application of inkjet technology in industry

Piezo-electric inkjet is nearly 40 years old but not mature

Time to Change – the Party is Over

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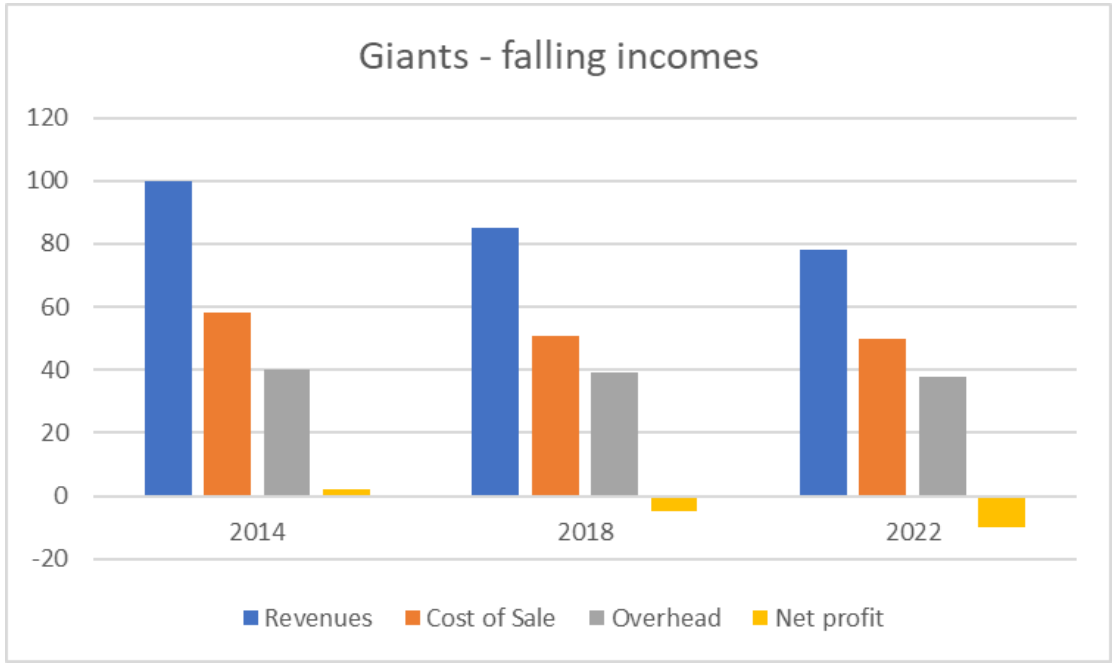
Source of Funding

- Printhead producers – technology originators for industrial inkjet – part of larger corporations – **Print Giants**
- **Giants** mainly produce MFPs & commercial print products, plus display graphics
- **Giants** use their own printheads to build printers but printhead production – R&D and manufacturing – needs scale. A share of general industrial markets is critical.
- **Giants** originating this technology rely on office and desktop for their major revenue streams.

- Since COVID office attendance has dramatically switched
  - Work from home or anywhere
  - People have learned not to print documents
  - Click charges and spend on MFPs has dipped
- Mature, competitive field - small dip in print volumes or MFP purchasing tips the P&L from black to red
- Hardening for industrial inkjet investment
- Tightening of R&D belts and change



Introduction

Industry Life Cycle Phases

Innovators create and start marketing new products or services.

Information on the products and industry participants is often limited, so **demand tends to be unclear**.

Customers learn more while the new providers are still developing and honing offerings.

Industry tends to be **highly fragmented in this stage**.

Participants tend to be **unprofitable** because expenses are incurred to develop and market the offering while revenues are still low.

Growth

Industry Life Cycle Phases

Customers come to understand the value of offerings, and demand grows rapidly.

A handful of important players usually become apparent, and they compete to establish a share of the new market.

Immediate **profits are not top priority as companies spend on R&D or marketing**.

Business processes are improved, and geographical expansion is common.

Once products demonstrate viability, larger players enter from adjacent industries through acquisitions or internal development.

Industry Life Cycle Phases

Maturity

Growth slows - a shakeout period starts as focus shifts to **expense reduction, and consolidation**.

Some players achieve **economies of scale**, damaging the sustainability of smaller competitors.

With maturity, barriers to entry become higher, and the competitive landscape becomes clear.

Market share and profitability become primary goals of the remaining companies as growth becomes less important.

Price competition becomes much more relevant as product differentiation declines with consolidation.

Industry Life Cycle Phases

Decline

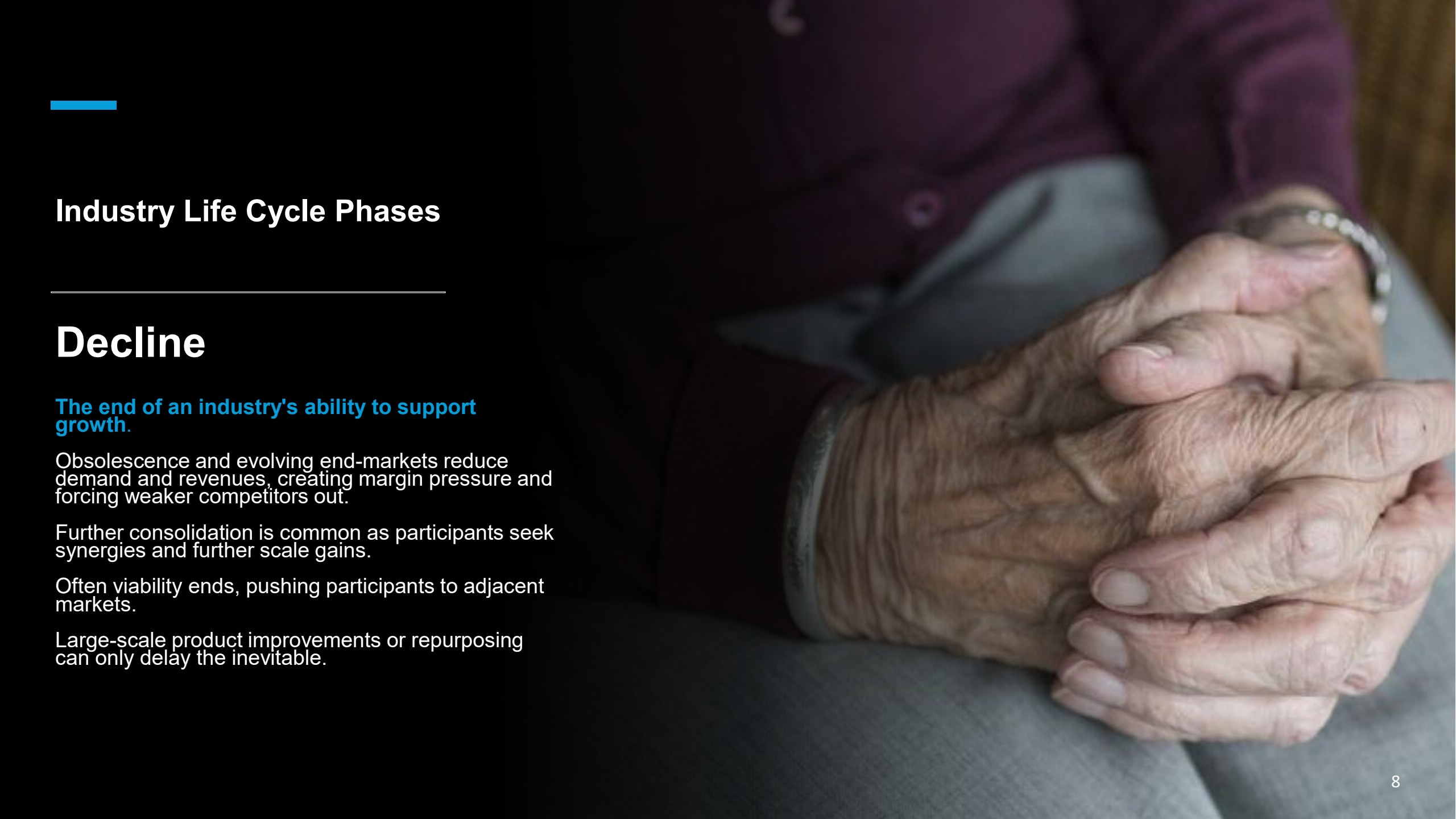
The end of an industry's ability to support growth.

Obsolescence and evolving end-markets reduce demand and revenues, creating margin pressure and forcing weaker competitors out.

Further consolidation is common as participants seek synergies and further scale gains.

Often viability ends, pushing participants to adjacent markets.

Large-scale product improvements or repurposing can only delay the inevitable.



Acceptance & Demand for Industrial Inkjet

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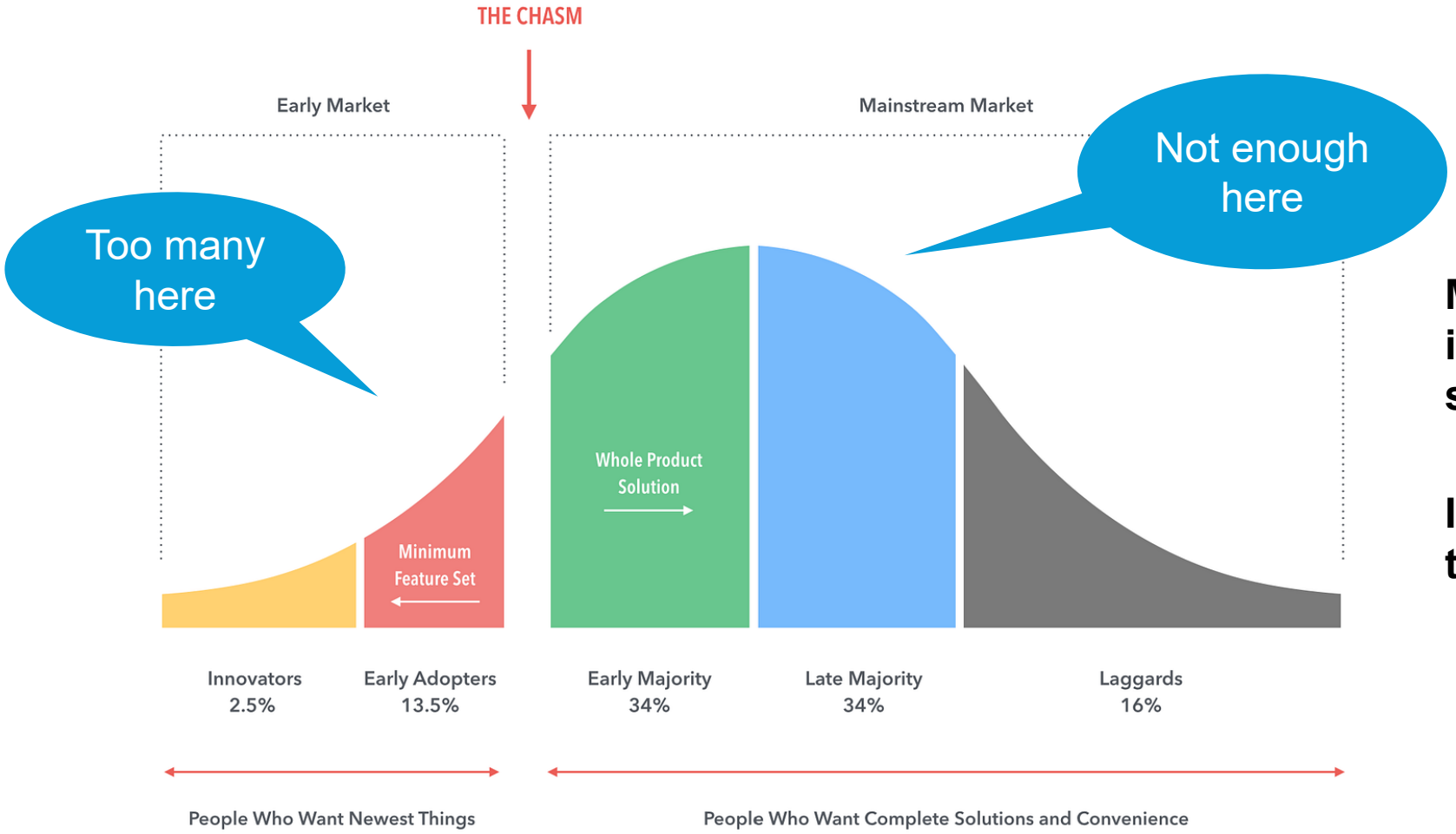

Many segments targeted for industrial inkjet remain stubbornly analogue

Inkjet is getting insufficient traction and share

Why?

The R&D Party

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Conventional Thinking

- Image quality
- Speed
- Reliability…

- Constantly promising better tomorrow
- More sexy tech. to do more incredible things
- Specifiers & OEMs ask for twice as many nozzles to jet twice as fast and cost half
- **Risks & real drivers?**

Resolution X	Y	Printhead cost per nozzle	Printhead cost per inch		Pixels per sq. inch				Speed m/min	Pixels per inch swath per minute				Drop size pL	Greyscale for full area	pL per pixel
360	360	$1.40	$504.00		129,600		1		25	3,240,000		1		6	8	42
600	600	$1.20	$720.00		360,000	x	3		75	27,000,000	x	8		7	4	21
1200	1200	$1.00	$1,200.00		1,440,000	x	11		150	216,000,000	x	67		3.5	3	7

Responsible to manage down expectations rather than promising new and better

- Adventurous development of new printheads may not be so possible
- The R&D party is over – optimise and utilise what we have today

Exponential complexity

Mature Design & Manufacture

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Automotive

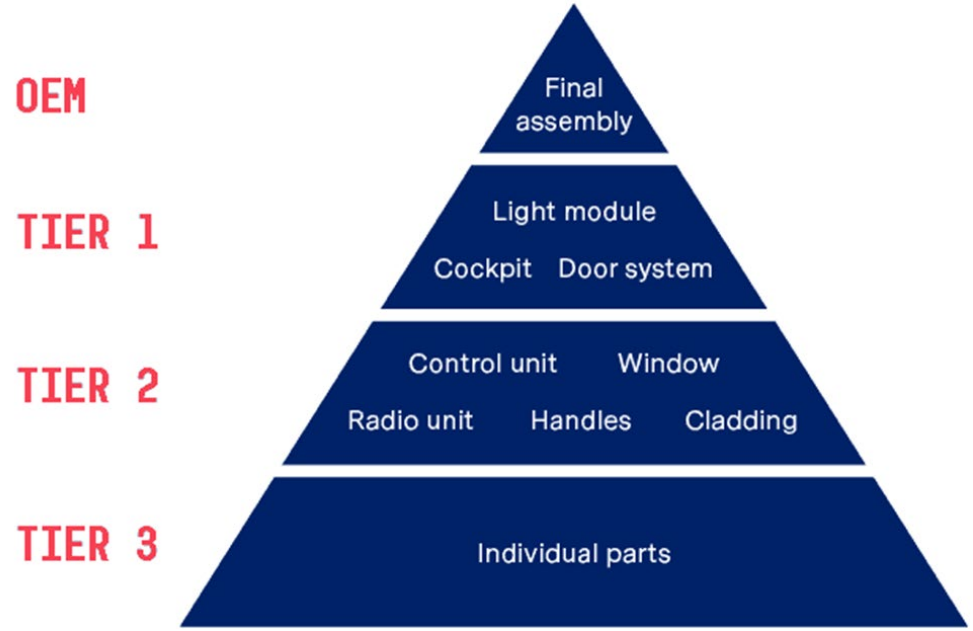
OEMs at the top – develop and market the final product

Design and assemble “chunks”, not parts

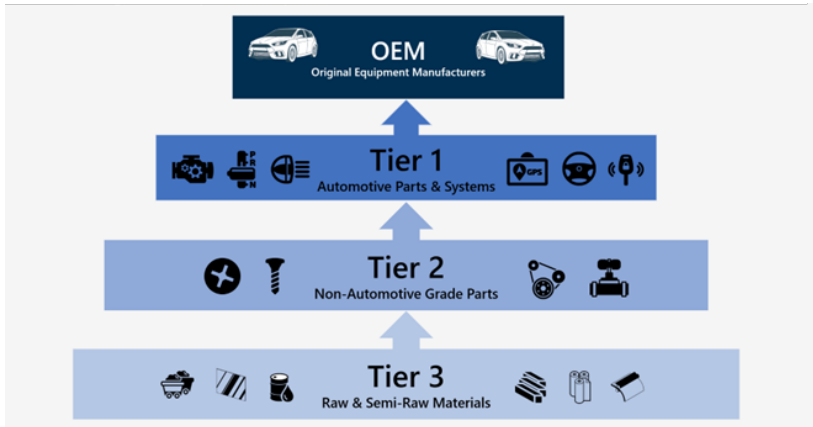
Cars comprise 30,000 parts. Printers can be similar

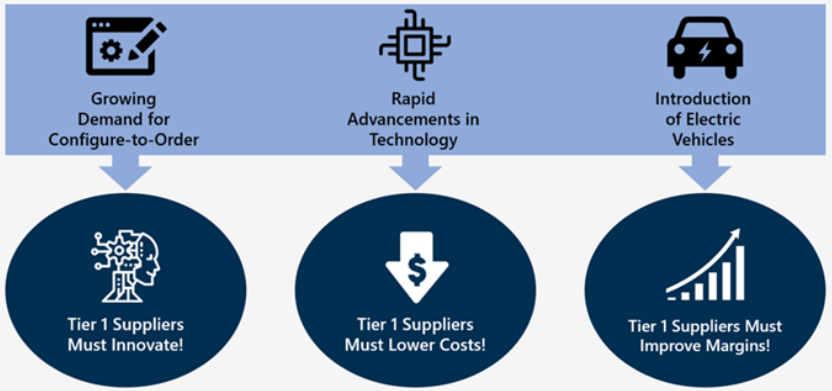
Supply chain for parts is segmented - manageable and efficient

- **Tier 3** – materials and some parts – general and unspecific
- **Tier 2** – specialist parts – expertise in a technology and not necessarily specific to the OEM sector
- **Tier 1** – parts, systems and sub-assemblies, specified for the OEM sector and for specific OEMs

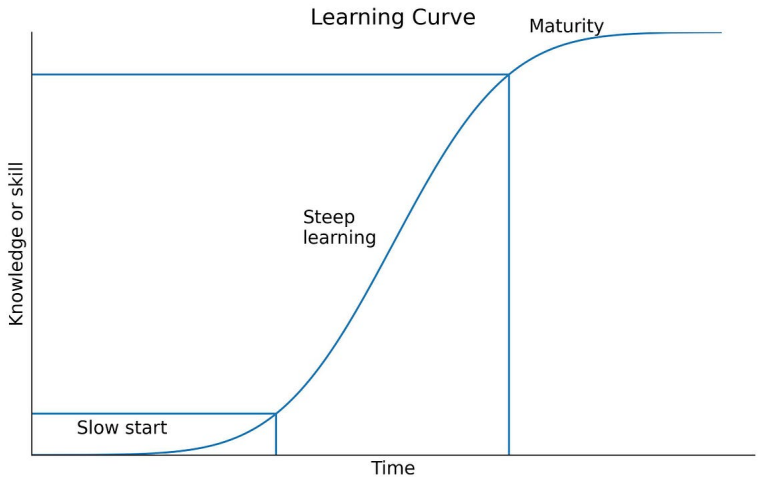


Tier 1 build their business on long-term relationships with OEMs with whom they often share product development and cost targets





Make or Buy?



Serial producing OEMs forced to DIY

However, not easy…

a) Strategic competitive advantage?
b) Develop capabilities that **specialists already have**? (often DIY has compromises for richness of technology),
c) Keep it fresh to exploit next opportunities from other technology advances.
d) High-cost, **high R&D investment**
e) Scale – can advantage be accessed?
f) Is this core for OEMs?

Viable model for the long term?

Time & delay total cost compromise

Cost-effectiveness of the whole system results from key components in industrial print equipment.

- Printheads
- Datapath and drive component specialists
- Ink Delivery Systems
- Software

Drive Electronics & Ink Delivery Systems

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Off-the-shelf basic drive electronics

- Good-better-best
- Feature-rich drive
- Data rates
- Speed matched to printhead capabilities
- Waveform integrity

- Start-up is different to mature product
- Serial products' needs differ versus bespoke

Optimisation for cost and design of the whole system

- Form factors
- Feature-sets
- Architecture – no. of printheads & boards in an array
- Data processing

Same applies for ink delivery systems

Automotive OEMs don't reinvent wheels

Custom-design optimised for printer design, using functional modules

Make or buy needs serious consideration

Cockpit or Dashboard

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What fits a plane isn’t fit for a car & vice-versa
Neither Boeing nor Mercedes Benz make their own

Clever Software

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Quote

“Why don’t printhead producers make better printheads so clever software isn’t necessary?”

Software configuration and image compensation can assist with machine imperfections

Printhead & Nozzle Density Compensation

GIS PRINTHEAD PROFILER IMAGE CORRECTION SOFTWARE

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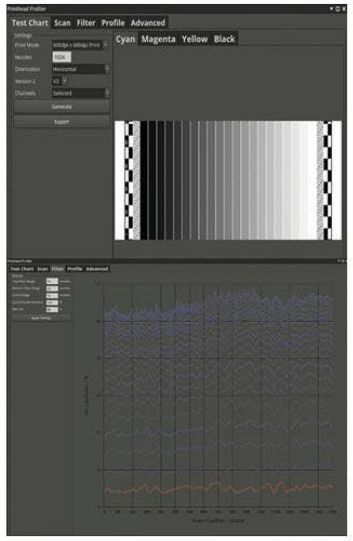
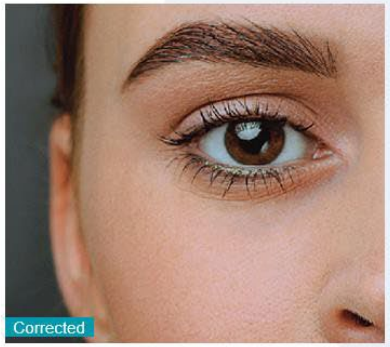
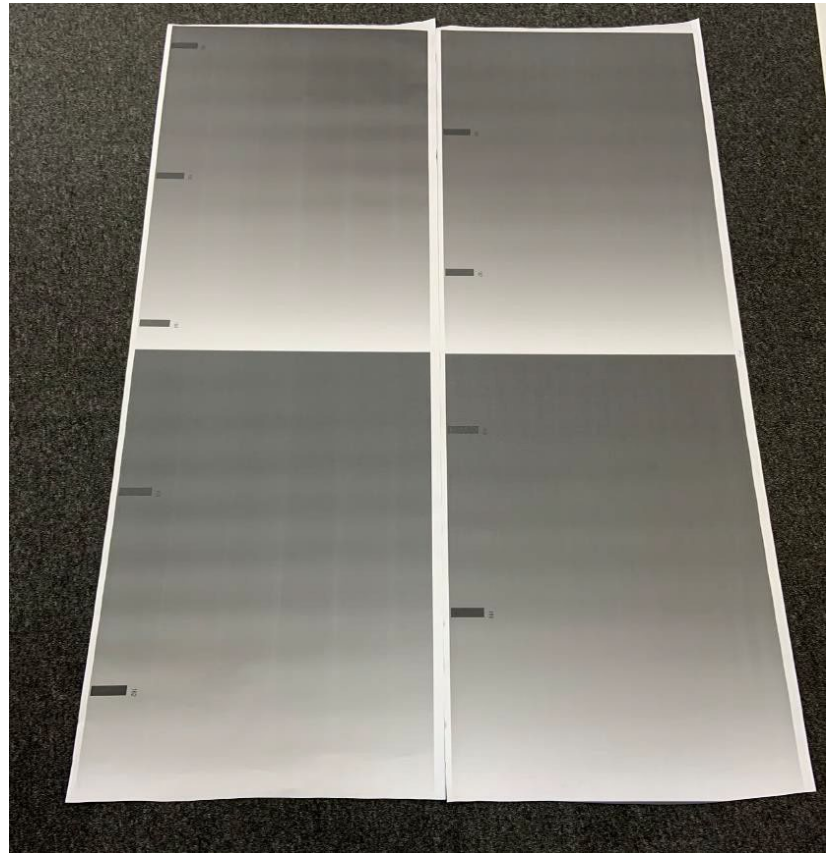




Nozzle Density Compensation

Nozzle Density Compensation adjusts every pixel in the original image with the aim of producing the same output print density for the same input density of the original image for every nozzle.

The application of the GIS Printhead Profiler image correction software can be tightly integrated with the screener software to achieve the fastest correction possible and maintain the highest possible performance of the datapath from original image file to printed output.



Printhead & Nozzle Density Compensation

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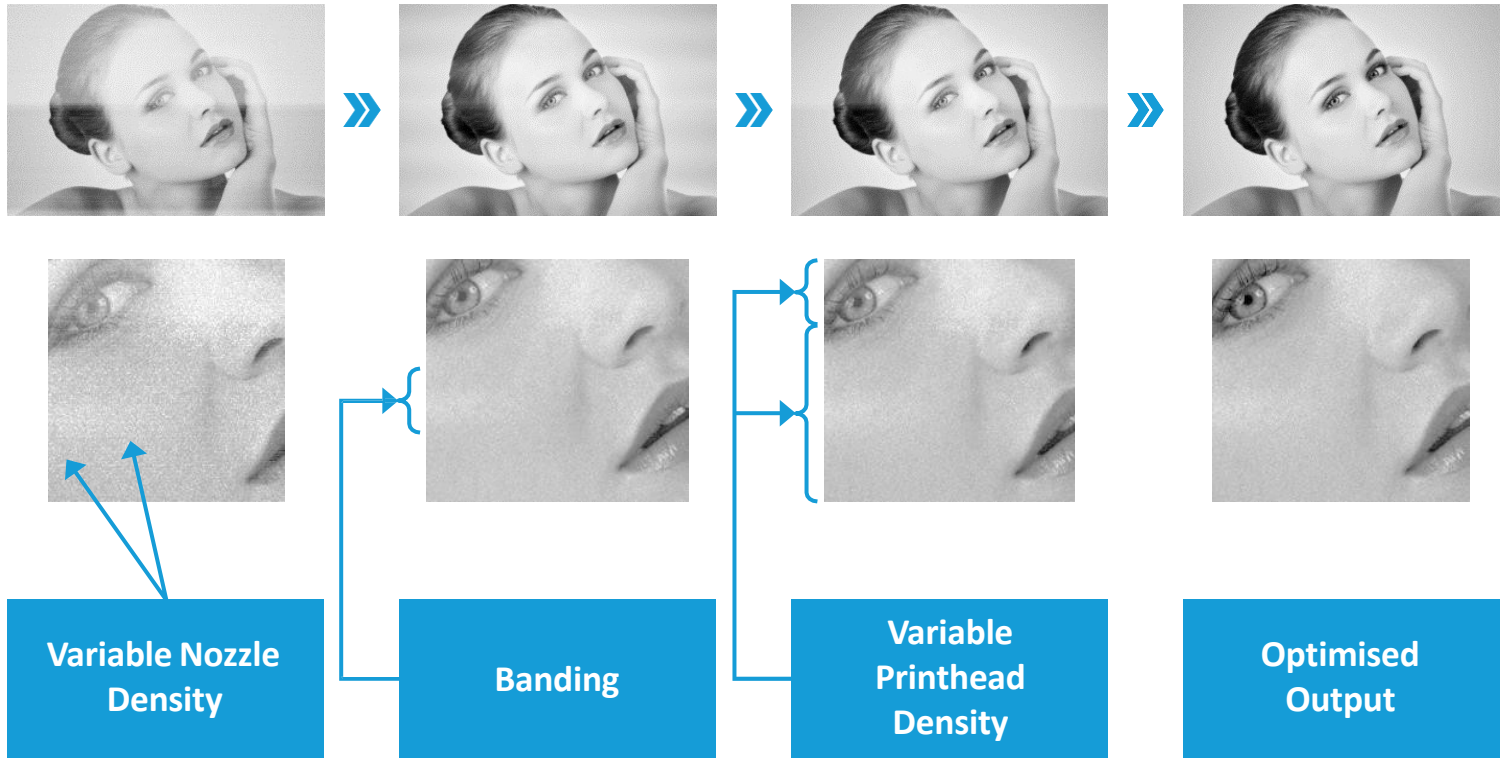
GIS PRINTHEAD PROFILER SOFTWARE

Able to correct density mismatches **per printhead, per bank of nozzles and per nozzle**



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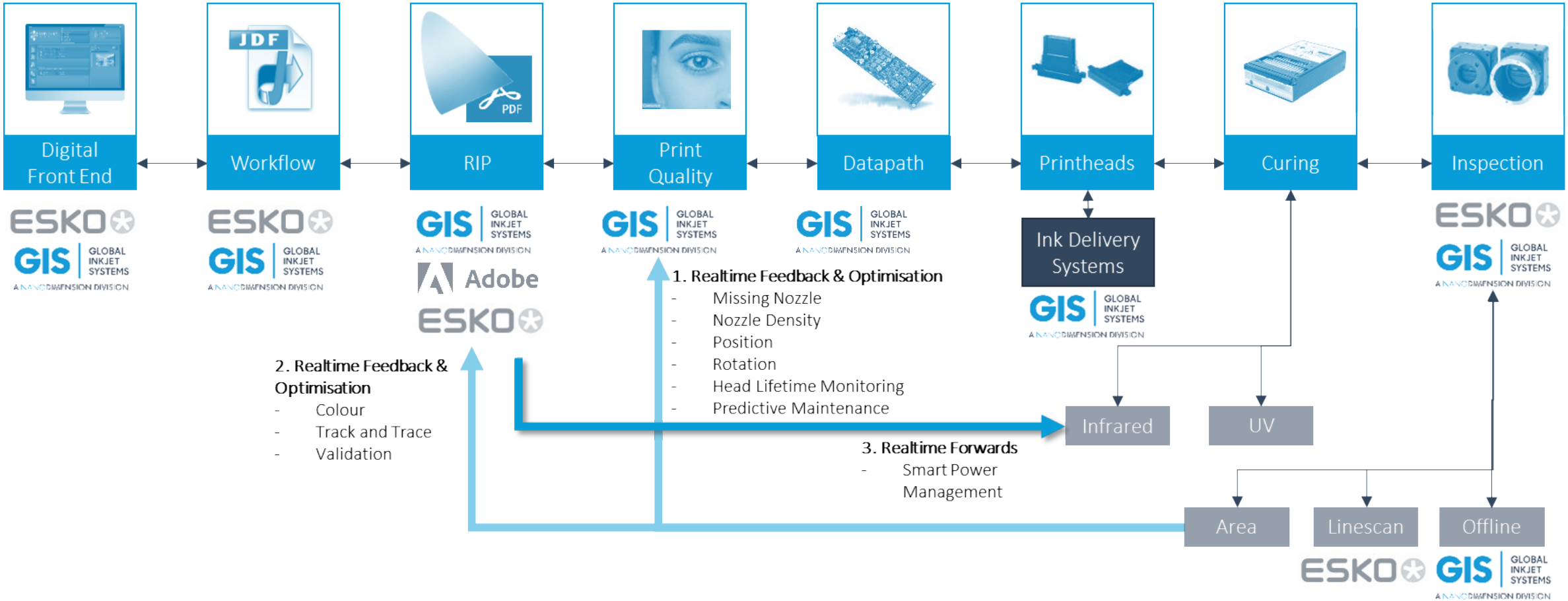
Closed Loop, Automated Systems

AUTOMATION

- Closed loop, automated systems are the primary way to achieve long term, consistent performance
  - Machine vision
    - Nozzle, density, and colour compensation
    - Printhead lifetime monitoring
    - Correction of rotation
  - Feed-forward power management
    - Heating, drive electronics
    - Power efficiency
  - Predictive maintenance for the whole machine
- Added benefit of building a sustainable ecosystem
  - Efficient use of power and materials, with minimal waste to create an optimal product

Example - Closed Loop, Automated Systems

THE FUTURE IS AUTOMATION



Deep Cube - Machine Learning

DEEPCUBE
acquired by Nano Dimension in 2021

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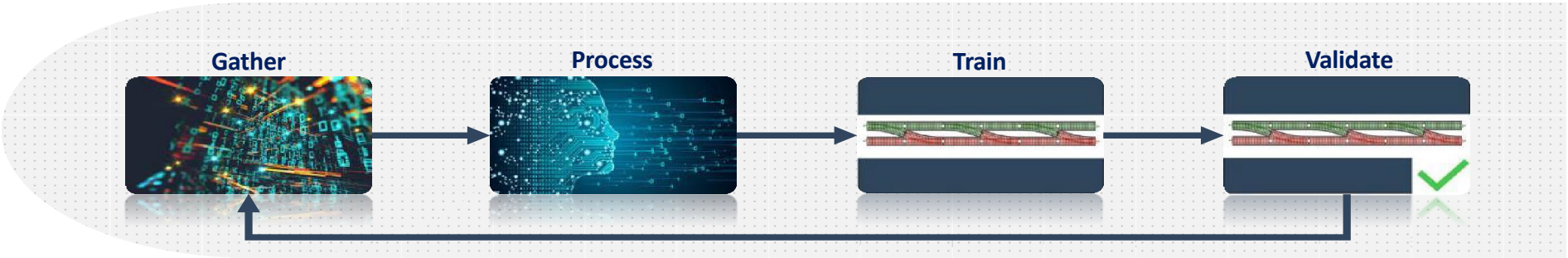
- **DeepCube –**
- **Real-time error detection and correction**
  - applies neural network training from photo and speech recognition to print and manufacturing
- **Improved output quality**
  - sensors can spot defects the human eye can't
- **Increased part yield**
  - AI-driven decision-making corrects printing errors in real time
- **Data speeds**
  - propriety algorithms increase speed of data analysis x10
- **Distributed Global Automation**
  - co-ordinate multiple machines across a site or across the world
  - machines share learning with each other for immediate adjustments in production flow



GIS - Overview

- **Datapath Electronics**
  - Support wide range of printheads
  - Versatile – e.g. wide range of waveform ranges & slew rates
  - Power efficient
  - USB & Ethernet platforms

- **Software**
  - Hardware agnostic & increasingly modular
  - We provide configurable workflow and UI - and
  - Interfaces to 3rd party products
    - vision systems, other diagnostic systems
  - Atlas IQ® Tools for improving image quality

- **Ink / Fluid Delivery Systems**
  - Modular systems – from prototype to production
  - All flow modes supported
  - Diagnostics and fault tolerant
  - Longer life-expectancy & service intervals

Where are we?
Inkjet developers?
Inkjet investors?
Which segments?

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No growth, reduced demand and revenues, consolidation for survival, players exit

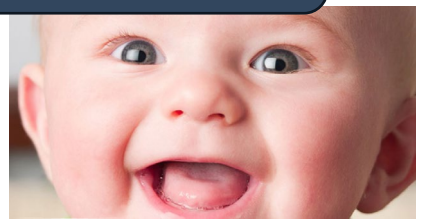
Decline

Cost reduction, consolidation, economies of scale, small players struggle

Maturity

Introduction

Fragmented, unclear



Value understood, growth, key players, R&D investment over profit, acquisitions

Growth

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Be mindful of exponential complexity

Set realistic expectations

DIY?
Make or buy?

Time & delay
total cost
compromise

Tier 1
long-term OEM relationships
often share development &
cost targets

Automotive OEMs
don't reinvent
wheels

Custom-design optimised for printer design, using existing, state-of-the-art, functional modules

Industrial Inkjet is not getting old, but the parents who fund it are
- a good time for industrial inkjet to mature and focus on ROI

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Talk to us…