**ADVANCED SORTATION & DIGITALISATION OF WASTE INDUSTRY: KEY REQUIREMENTS TO MEET PACKAGING CIRCULAR ECONOMY AMBITIONS DIGITAL WATERMARKS INITIATIVE – HOLYGRAIL 2.0**

**Presentation to Roto4All**
**By HolyGrail 2.0 Project Manager Jan 't Hart**

10/03/2023

- Short intro to HolyGrail 2.0

- Digital Watermark Technology

- Update HG2.0 Initiative
  - Phase I –II – III

- Business case (Roland Berger study)

- after HG2.0?
  - Pilot in France

# HOLYGRAIL 2.0 Membership

# CIRCULAR ECONOMY

FACING THE NEW
CIRCULAR REALITY

Eliminate problematic
or unnecessary
**single-use
plastics**
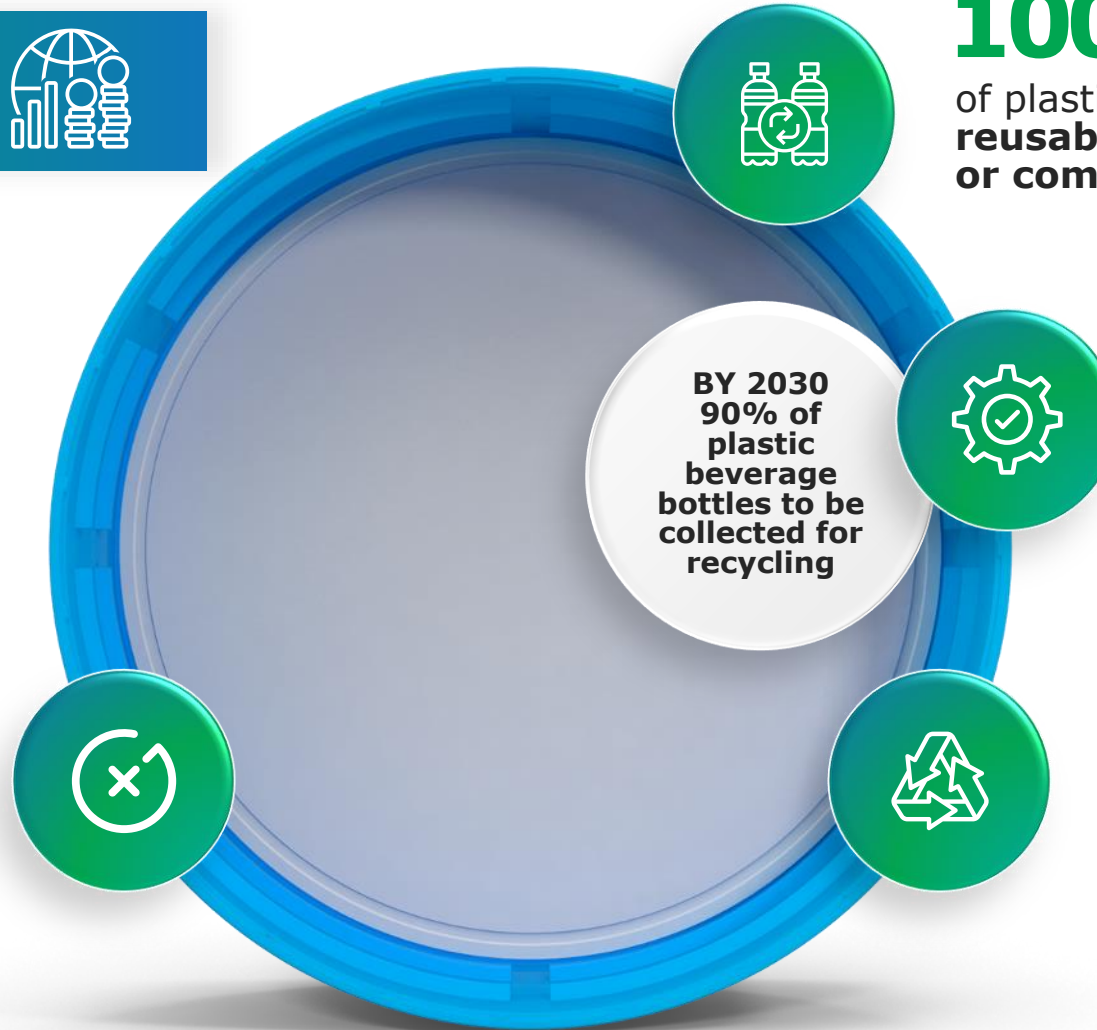
BY 2030
**100**%
of plastic packaging to be
**reusable, easily recyclable,
or compostable**

BY 2030
**55**%
of plastic packaging
to be **effectively
recycled**

**BY 2030
90% of
plastic
beverage
bottles to be
collected for
recycling**

BY 2030
**30**%
**average recycled
content** across all
plastic beverage bottles

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BRANDS
ASSOCIATION

HolyGrail 2.0
Intelligent Sorting

ALLIANCE
TO END
PLASTIC
WASTE
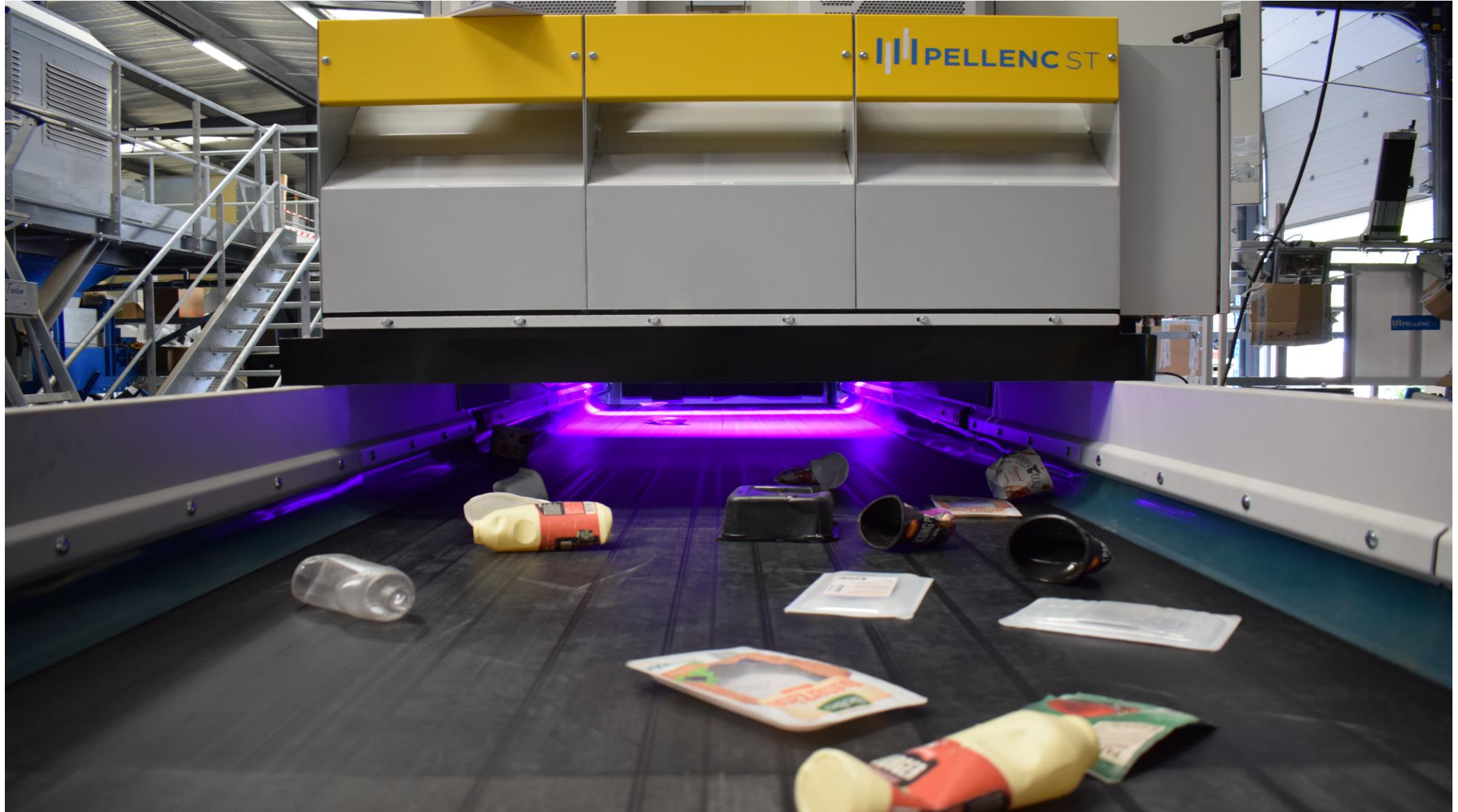
# HolyGrail 2.0 Objective

Prove the viability of digital watermarking technologies
for accurate sorting and the business case at large scale.

**Proving the <u>TECHNICAL</u> viability of digital watermarking technologies** (WP1-3), through e.g.:

- Validating of the prototype in three stages: 1° in an R&D centre (Phase 1 and Phase 2.1), 2° at a test facility on a semi-industrial scale (Phase 2.2), and 3° rolled out on a wider scale during real-time test runs in a commercial sorting and/or recycling facility (Phase 3)

- Ensuring the readability of the digital watermark embedded in print or in plastic, whilst taking into account esthetical and haptic aspects (e.g. shelf appeal)

**+**

**Proving the <u>ECONOMIC</u> viability of digital watermarking technologies** (WP4), through e.g.:

- Reviewing existing and new business models, in different stages, building on key learnings from each test phase

- Addressing main market barriers, and assessing similar state-of-the-art technologies

- Examining cost improvement potential of DW detection systems, as add-on, by retrofitting or new equipment

- Perform a full techno-economic analysis, incl. cost breakdown structure for the entire packaging value chain

# HOLYGRAIL 2.0

# Roadmap

| Q1 | Q2 | Q3 | Q4 |

**2020**

Official Launch

Start packaging concept dev.

| Q1 | Q2 | Q3 | Q4 | Q1 | Q2 |

**2021**

**2022**

**PHASE 1**
Developing detection unit prototypes

End Phase 1 testing for 1st prototype

**PHASE 2**
Brand owners and retailers are welcome to join with min. **2-3 SKUs** coded with digital watermarks

End Phase 2 semi-industrial testing for 1st prototype

End Phase 1 testing for 2nd prototype

| Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |

**2023**

**PHASE 3**
Brand owners and retailers that are operating in the chosen test markets are launching their enhanced packaging coded with digital watermarks into the three markets

End Phase 3 industrial testing on non-food PET bottles

End Phase 3 industrial testing on rigid packaging and PP flexibles

# DIGITAL WATERMARKS – A UNIQUE DIGITAL IDENTIFIER

- A digital identity is created through the integration of Digimarc Watermarks into printed artwork or plastic substrates.

- The watermark consists of two components – a Message Signal and Synchronisation Signal, which are combined to create a Signal Tile.
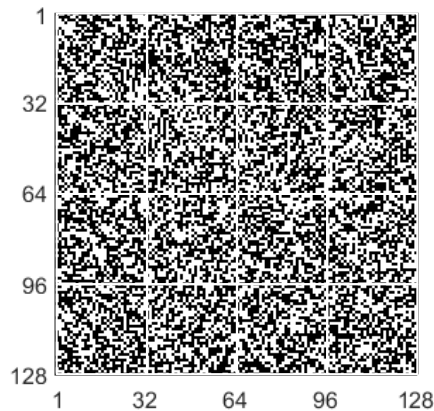


**Message Signal**

Contains redundantly coded Numeric Identifier, i.e., Code or "Payload"
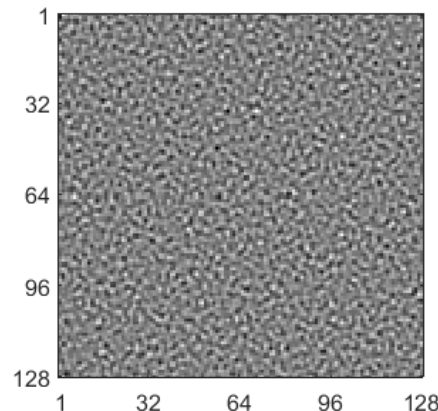
**Synchronisation Signal**

Tells us the relationship between the camera and the object, such as distance, skew angle or rotation
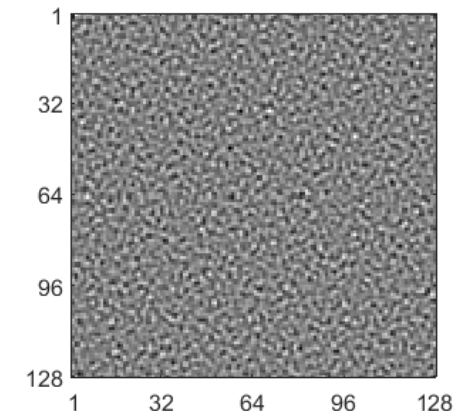
**Signal Tile**

Replicated throughout object with by subtle modulation of existing artwork / plastic

*All signals exaggerated here for illustration purposes*

# DIGIMARC WATERMARKS: APPLICATION IN PRINTED ARTWORK



Repeated Tile
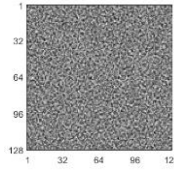
Pieces of multiple tiles can be combined to recover a Watermark

The encoder applies the tiles to graphics in a mosaic manner

Uses existing pixels. No special inks. No special printing process

*Exaggerated view for illustration purposes*

*Artwork*

- Imperceptible codes, the size of a postage stamp, covering the surface of a consumer goods packaging

- Able to carry a wide range of attributes (e.g. manufacturer, SKU, type of plastics used and composition for multilayer objects, food vs. non-food usage)

**... linked to a standardised database!**

## Looks Like This

## Performs Like This

*Images courtesy of P&G / Digimarc (barcodes for visualization purposes only)*

Watermarks are introduced in molds by 5-axis laser

Tested with heat-set as well as cold fill processes

Works for regular as well as lightweight bottle designs



Images courtesy of P&G / Digimarc/ Logoplaste



P&G Lenor
full body shrink sleeve
bottle

Watermark texture mimics traditional sandblasting texture

Texture on bottle induced by air bubbles forming Digimarc watermark

High resiliency to manufacturing process variations (pressure, temperature)

Debossed dots in plastic

Mold | PE

**Air Bubble**

Photo of surface texture

The concept of enhancement is the same as with print, only the Watermarks is created in 3D using the plastic substrate
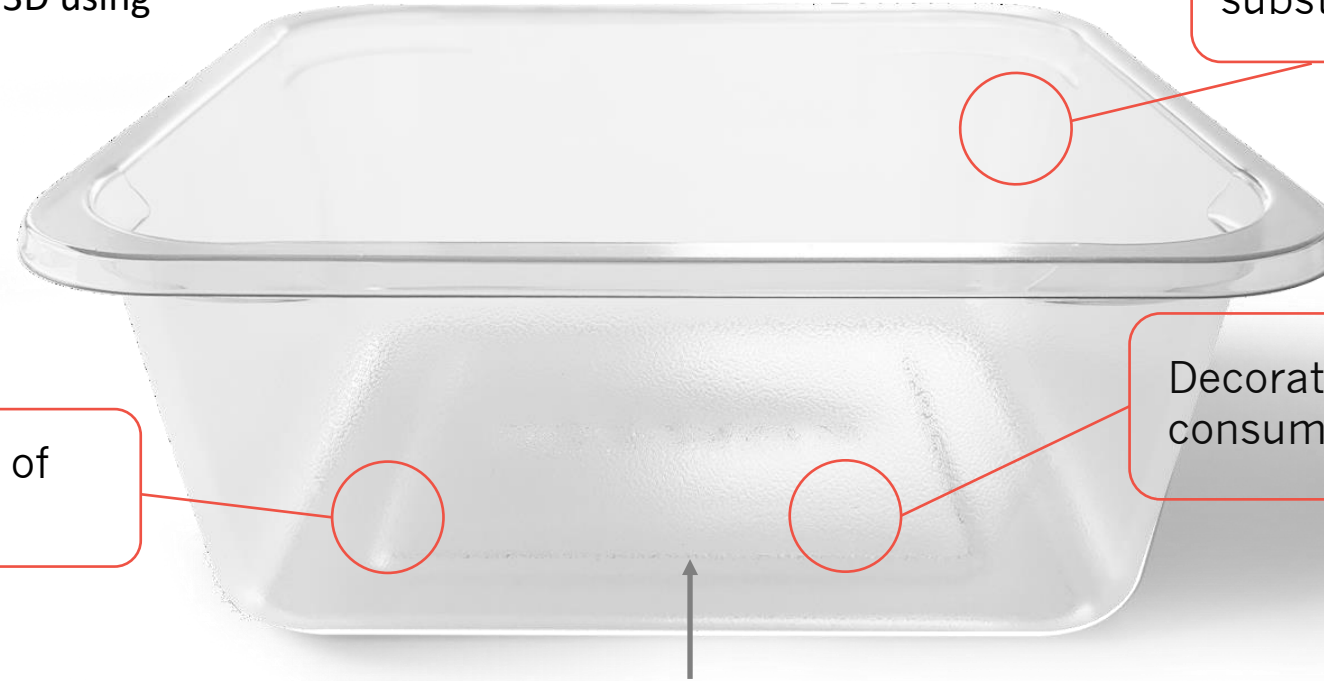
Micro-topological variations in substrate create signal tiles

Decorative embossing effect informs consumers of recyclability

Works in variety of mold types

**Imperceptible Digimarc Watermarks in PACCOR Thermoform Food Tray**

Image: Lebensmittel Zeitung, 22 October 21

# OPERATION OF DIGIMARC DETECTOR (CONCEPTUAL)

Digimarc-specified components can scan waste in recovery facilities, supplementing near-infrared detection
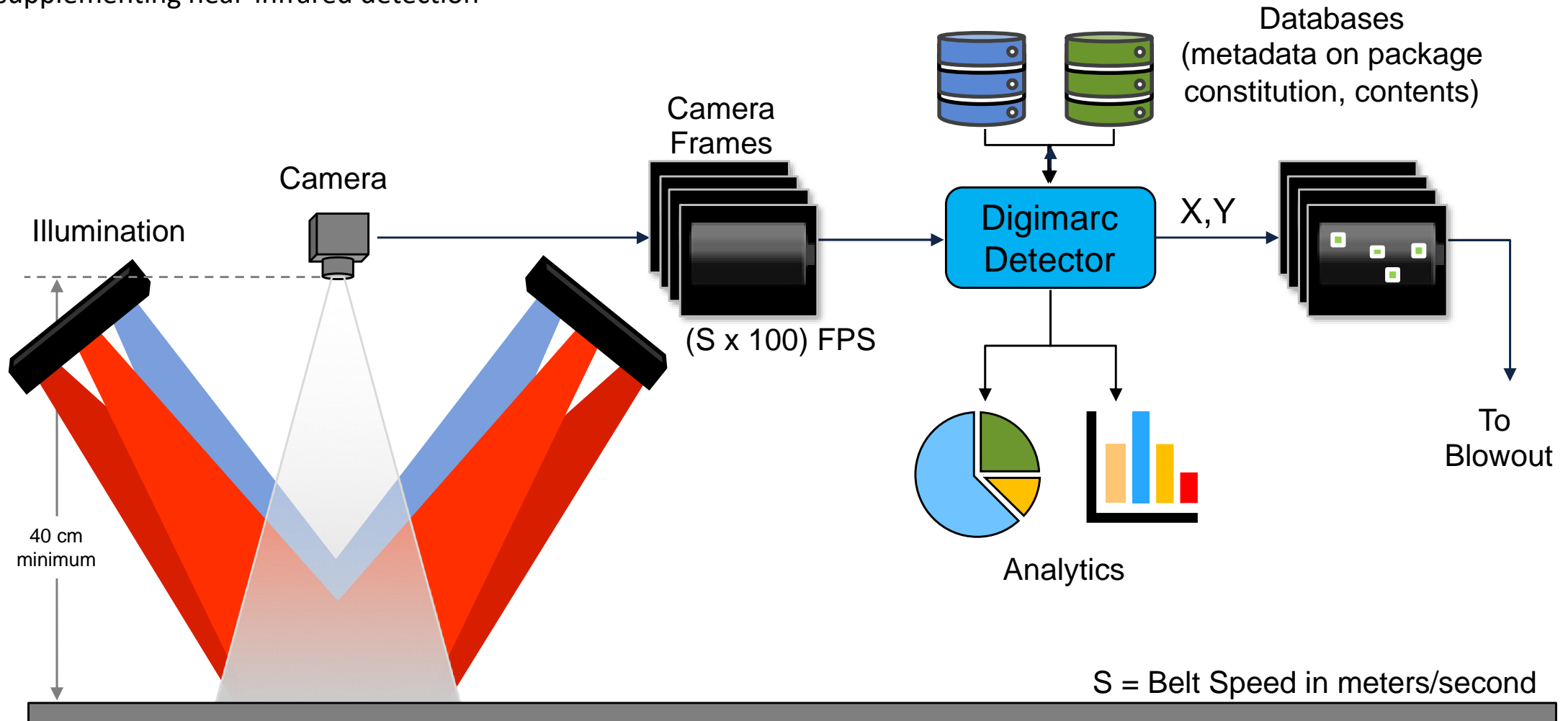
# VALUE THROUGHOUT THE PACKAGE JOURNEY
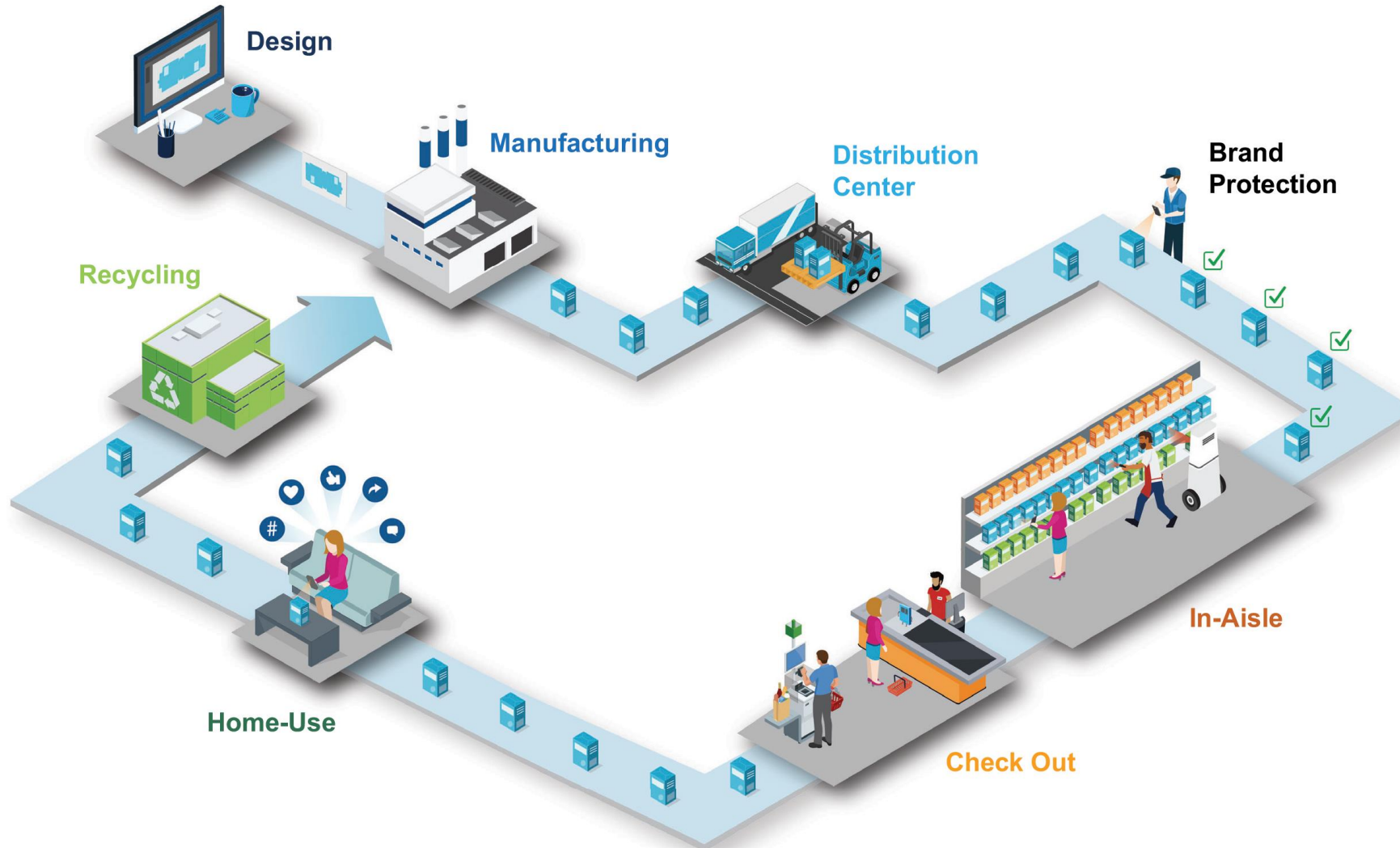
**Design**
- Incorporate barcode data into artwork
- Integrate codes and link to content

**Manufacturing**
- Improve in-line inspection

**Distribution Center**
- More reliable labels
- Print on corrugated packaging
- Scan readily from a distance
- Verify logistics and returns

**Brand Protection**
- Product authentication
- Identify counterfeits
- Product diversion

**In-Aisle**
- Price checks
- Manage planogram & availability (OSA)
- Data Analytics

**Check Out**
- Easily scan products & labels
- Improve first-pass read rate
- Reduce misreads and manual keying
- Improve customer experience

**Home-Use**
- Instructions for use
- Brand and social content
- Point and scan to buy now & reorder

**Recycling**
- Identify materials and substrates
- Improve sorting mechanisms

*Successfully Completed 2021*

*Successfully Completed 2022*

*We are here Throughout 2022/2023*

## Phase 1

- Develop a functional HG2.0 prototype as an add-on module to detect and separate the DW packaging from packaging waste, allowing category specific sorting.

## Phase 2

- HG2.0 prototype is tested for speed, accuracy and detection efficiency, and this for a category specific sorting based on DW detection – in combination with NIR and VIS.

## Phase 3

- HG2.0 prototype will be deployed in a large-scale pilot in a commercial sorting and/or recycling facility, under standard operation conditions.

AIM® EUROPEAN BRANDS ASSOCIATION — HolyGrail 2.0 Intelligent Sorting — ALLIANCE TO END PLASTIC WASTE — TOMRA — PELLENC ST — DIGIMARC

**PELLENC ST + DIGIMARC**

99% Detection rates
95% Ejection rates
95% Purity rates

**TOMRA + DIGIMARC**

99% Detection rates
96% Ejection rates
93% Purity rates



**Industrial conditions:**
- 3m/s belt speed
- 2,5 tons/hr rigids
- 0,5 tons/hr fexibles



More information: www.digitalwatermarks.eu/blog

# PHASE II

## SEMI-INDUSTRIAL TEST VALIDATION RESULTS OF PELLENC ST/DIGIMARC PROTOTYPE DETECTION SORTING UNIT

▶ Consistent high results across all tested categories of plastic packaging material of on average:

  - 99% detection rates

  - 95% ejection rates

  - 95% purity rates

demonstrated an impressive performance of the prototype.

## Results per packaging material

| Category | Detection Rate[1] (Estimate) | Ejection Rate[2] (By weight) | Purity[3] (By weight) |
|---|---|---|---|
| Rigid PP | 99% | 95% | 96% |
| Rigid PE | 98% | 96% | 99% |
| Rigid PET | 99% | 98% | 95% |
| Flexibles | 99% | 91% | 90% |
| LCBs | 99,95% | 98,85 | |
| Average across packaging materials | 99% | 95% | 95% |

*Table 1: Average single sort results from mixed packaging waste streams (watermarked samples + contamination (non-watermarked samples + other pack material classes)). Typical industrial process conditions have been used in these trials (belt speed of 3m/s; Loading: Rigids running at ~2.5 tonnes/hr; Flexibles at ~0.5 tonnes/hr). Success criteria (after 1st sort) for detection efficiency/ejection efficiency/purity are 95%/95%/92% for rigid packaging, 95%/87%/90% respectively for film packaging (in line with industrial specifications).*

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ALLIANCE TO END PLASTIC WASTE

# PHASE II

## SEMI-INDUSTRIAL TEST VALIDATION RESULTS OF TOMRA/DIGIMARC PROTOTYPE DETECTION SORTING UNIT

- High results across all tested categories of plastic packaging material of on average:

  - 99% detection rates

  - 96% ejection rates

  - 93% purity rates

demonstrated an impressive performance of the prototype.

Results per packaging material

| Category | Detection rate (by count) | Ejection rate (by weight) | Purity rate (by weight) |
|---|---|---|---|
| Average of rates for PP | 99,6% | 99,6% | 94,2% |
| Average of rates for PET | 99,1% | 95,7% | 92,6% |
| Average of rates for Fibre | 98,9% | 97% | 93,1% |
| Average of rates for PE flexibles | 97,6% | 92% | 90,8% |

AIM® EUROPEAN BRANDS ASSOCIATION  HolyGrail 2.0 Intelligent Sorting  ALLIANCE TO END PLASTIC WASTE

# Phase III

▶ Committed commercial enhanced samples from brand owners & retailers: **38,000 tons per year**

▶ Commercial enhanced pack materials launched in national markets **Denmark, France, Germany**

▶ **Locations for industrial tests:**
- 1 MRF and PRF – Hündgen Entsorgung:
  - MRF: test/capture all enhanced rigid packaging from Germany & Denmark
  - PRF: (input from MRF + on-going supply + spiked volumes): focus on granular sorting
- 2 recyclers (end to end recycling):
  - Wellman Indorama – Non-food rPET bottle grade: spiked volumes + on-going supply
  - Borealis – Food rPP film grade: spiked volumes + on-going supply
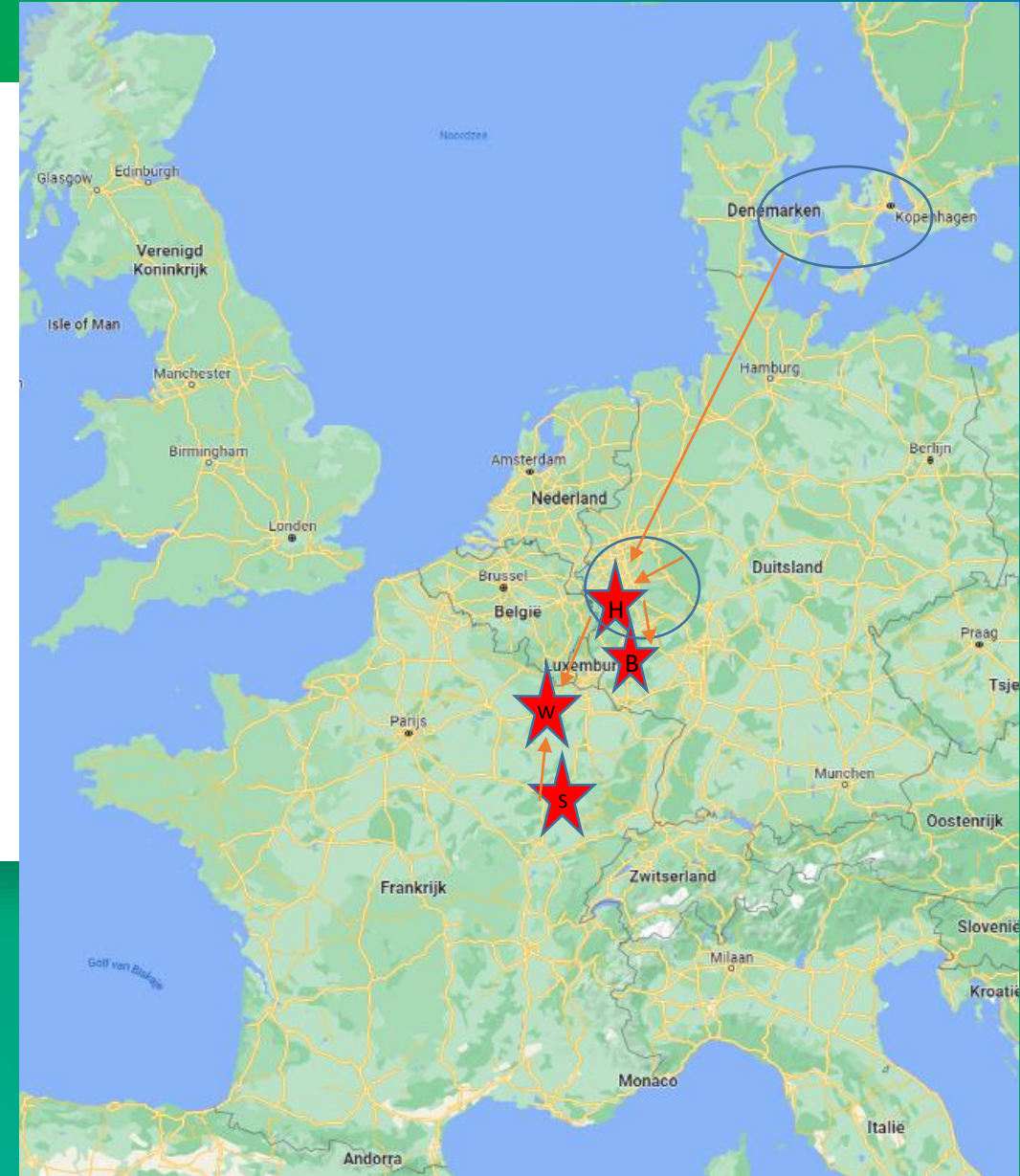
# MARKET ADOPTION STRATEGY (ROLAND BERGER STUDY)

Executive summary: HolyGrail market adoption strategy

This is an independent, objective, neutral report, designed for the entire waste management value chain. Some stakeholder categories will have opposing views, incl. to one another. This report is not customized to highlight different stakeholder category views.

## 1 Opportunity for value creation through digitalization

- **Household packaging waste** management value chain is battling structural problems, from **lack of high-quality recyclate**, to **limited transparency of waste volumes** and flow management, **heterogenous collection, limited sorting**
- A **transformational change** is required to **boost current recycling performance and mitigate rising system costs** (which transfers into higher EPR fees), thus **creating value for the entire value chain** – achievable also by **value chain digitalization**
- We focused on **advanced sorting digitalization** as this would increase quality of recycling feedstock and output value, as well as enhance **circularity of plastic packaging**

## 2 Digitalization technologies

- Sortation digitalization (highly needed due to slow progress of current solutions) can be achieved via **two emerging technologies which complement NIR**:
  – **Digital watermarking** is currently **the technology which could underpin all use cases for digitalization**, not only advanced sortation, and is it is likely to provide superior detection accuracy, in particular for flexible plastic packaging and more complex waste streams
  – **Object recognition** could be used successfully for a **number of sorting use cases**; however boundaries of effectiveness and overhead to manage flexible (and multi-layer) film are not yet fully known ; ability to sort multiple SKUs from complex streams not developed

## 3 Compelling case of digital watermarking

- **Direct (minimum) benefit** (from higher-quality/ more granular plastics streams and improving sorting efficiency) estimated at **EUR 0,5-0,9 bn/ year in 2030 (biggest potential for flexibles)**
- The **direct net (minimum) benefit** (total benefit minus costs in sorting stations and brand owners' costs for license fees and artwork changes) **estimated at EUR 0,2 - 0,5 bn/y in 2030** (25 price scenarios)

- **10-14% increase** in HH packaging **recycling rates** (required to meet 55% target)
- **0.5Mio tons/yr PCR** in addition
- **2.2Mio tons/yr PCR** sorted better

- Regain a portion of the up to **9 Mio tons/yr of household plastic packaging not collected in EU 27+3**

## 4 Next steps

- **Change momentum needs to start with brand owners and retailers,** as they are the ones who can derive value and need to meet their goals (recycling targets, mitigation of increasing EPR cost pressures)
- In the mid to long term adoption should happen at **European level** - This would be a complex multi-stakeholder effort, requiring a deliberate and intentional demonstration to validate value creation potential across all key stakeholders
- **France,** as pilot market, is recommended by project management team

## The detailed business case simulated for 1 country (France) and extrapolated for Europe indicates total net benefit for the system of EUR 0,2 – 0,5 bn/year by 2030

Summary of benefits of advanced sorting use case, per year in 2030 (assuming 55% DWM adoption rate)

| Plastic use cases | Benefit in 2030 (two price scenarios) | Sorting costs | Brand owners' costs | Net Benefit in 2030 | Improvement in sorted-for-recycling rates |
|---|---|---|---|---|---|
| PET bottles[1] | EUR 55-75 m | EUR 28 m | EUR 40 m | EUR -10-8 m | 2 p.p. |
| PET trays | EUR 120-180 m | EUR 40 m | EUR 55 m | EUR 25-85 m | 9 p.p. |
| HDPE bottles, trays | EUR 55-85 m | EUR 12 m | EUR 17 m | EUR 25-55 m | 4 p.p. |
| PP bottles, trays | EUR 90-140 m | EUR 21 m | EUR 30 m | EUR 40-90 m | 2 p.p. |
| LDPE films | EUR 180-370 m | EUR 47 m | EUR 66 m | EUR 70-250 m | 11 p.p. |
| PP films | EUR 20-45 m | EUR 6 m | EUR 8 m | EUR 10-30 m | 7 p.p. |
| | EUR 530-890 m/y | EUR 155 m/y | EUR 215 m/y | EUR 160-520 m/y | Ø 4 p.p. |

**Key take-aways**

- Overall benefit at **EUR 0.2-0.5 billion/ year**, just for advanced sorting uses cases, **all use cases positive in both price scenarios (except for PET in downside price scenario)**
- **60% of costs on the brand owners & retailers**, mainly for artwork (conservatively estimated) – Expected to decrease over time
- 4 p.p. addition to sorted-for-recycling volume does not seem much, but it is **11 p.p. for PE films and 7 p.p. for PP films** – Today PP films recycling rate stands at under 10%

1) PET volumes (mainly home-care and milk) in Europe after subtracting all beverage PET volumes, assuming a DRS system for PET beverage bottles across al EU27+3 countries
Source: Roland Berger

## Two technologies, DW and OR can complement existing sorting technologies (NIR): DW is currently the best placed technology, OR is developing rapidly

Comparison of digitalization technologies (based on information provided by novel technology providers)
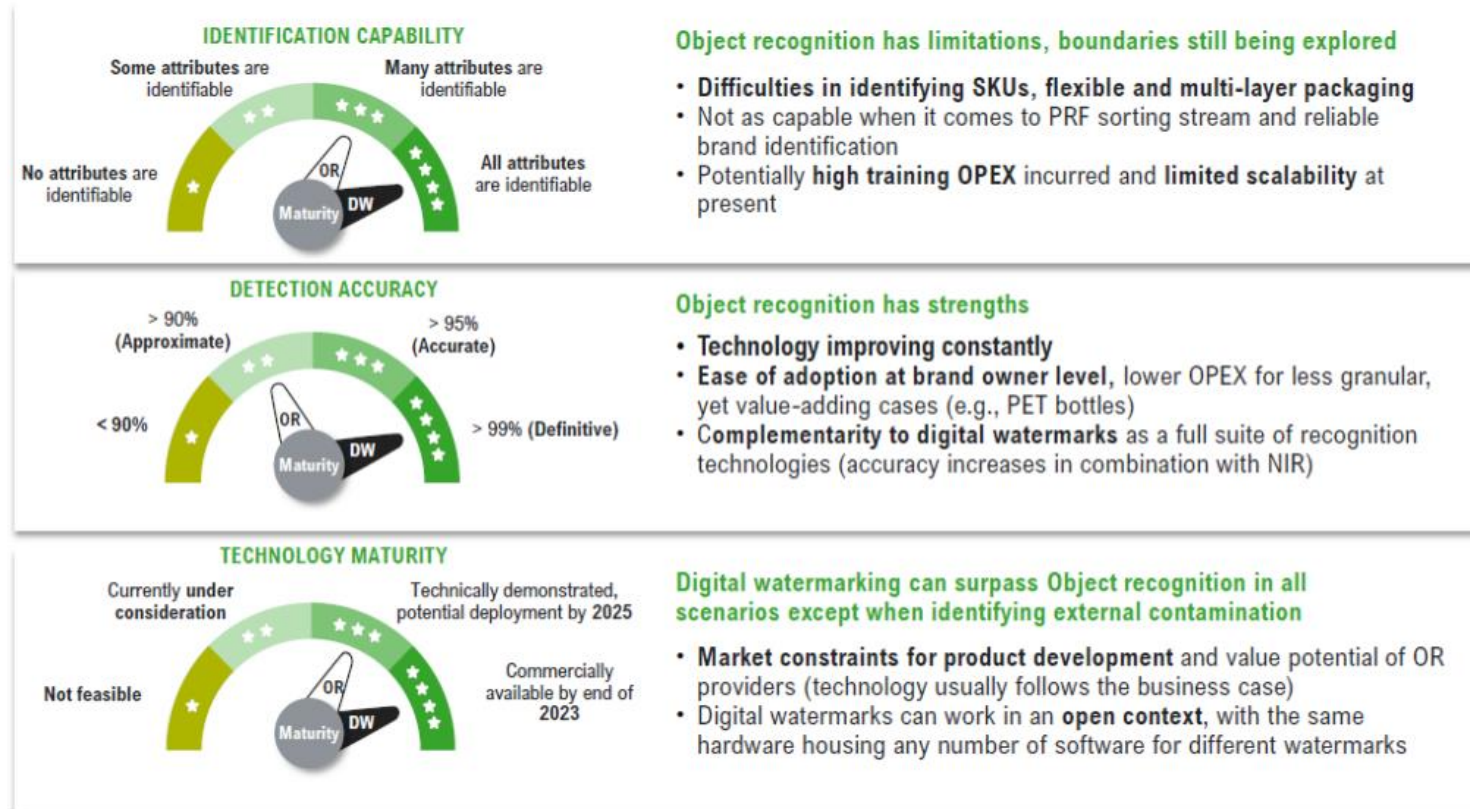
### Digital watermarks

- Nearly invisible marks on several locations on packaging/labels, to be recognized by add-on "readers" in a sorting/recycling context
- A "digital twin" for the product is created at SKU level, enabling a real-time database connection for detailed attributes of packaging

### Object recognition

- Machine enabled process of identifying objects present in camera's field of view, assigning them into categories
- Categorization process requires a learning algorithm (association of an object's shape, colour, branding and other identifying markers with the object's likely category)
- Lower entry barrier

☐ OR = object recognition   ■ DW = digital watermarks

**IDENTIFICATION CAPABILITY**

Some attributes are identifiable — Many attributes are identifiable
No attributes are identifiable — All attributes are identifiable
Maturity — OR / DW

**Object recognition has limitations, boundaries still being explored**

- **Difficulties in identifying SKUs, flexible and multi-layer packaging**
- Not as capable when it comes to PRF sorting stream and reliable brand identification
- Potentially **high training OPEX** incurred and **limited scalability** at present

**DETECTION ACCURACY**

> 90% (Approximate) — > 95% (Accurate)
< 90% — > 99% (Definitive)
Maturity — OR / DW

**Object recognition has strengths**

- **Technology improving constantly**
- **Ease of adoption at brand owner level**, lower OPEX for less granular, yet value-adding cases (e.g., PET bottles)
- **Complementarity to digital watermarks** as a full suite of recognition technologies (accuracy increases in combination with NIR)

**TECHNOLOGY MATURITY**

Currently **under consideration** — Technically demonstrated, potential deployment by 2025
Not feasible — Commercially available by end of 2023
Maturity — OR / DW

**Digital watermarking can surpass Object recognition in all scenarios except when identifying external contamination**

- **Market constraints for product development** and value potential of OR providers (technology usually follows the business case)
- Digital watermarks can work in an **open context**, with the same hardware housing any number of software for different watermarks

Source: Technology workshop, Roland Berger

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# WHAT AFTER HOLYGRAIL 2.0?

# LANDING STRIP FRANCE (CY 2024)

HolyGrail 2.0
Intelligent Sorting

Driven by    Powered by
AIM®         ALLIANCE
             TO END
             PLASTIC
             WASTE

- **External case for change is clear:** Roland Berger study confirms that Europe is off track to meet recycling 2030 goals. Status quo is not an option.

- **Intentionality Matters:** approach will help mobilise all key stakeholders and a public marketplace will *de facto* sort out critical questions around incremental value creation for DW platform vs. other possible alternatives.



Baseline forecast for plastic packaging waste in EU (27+3)[1] without digitalization impact[2]

Sorted-for-recycling household plastic packaging in scope, 2020 – 2030F [m tons]

- **France is a great choice for multiple reasons:**
  - Large number of players in LT present in France
  - Some willing to act (in principle)
  - Supportive and progressive PRO organisation
  - Strong political/legislative support (100% recycling for 2025), potential access to funding
  - Publicly announced investments in secondary sorting centres (ideal locations for DW modules installations)

- **Benefit / Risk ratio appears favourable**. Decision is fully reversible in case we fail to demonstrate positive value equation, with acceptable throwaway costs.

➢ If you are a brand owner / retailer / waste management operator with activities in France and want to become part of the movement, please reach out to AIM today: digitalwatermarks@aim.be

# CONTACT

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