

# ROTO4ALL

9 marzo 2023  
Sheraton Milano San Siro

## Advanced sortation & Digitalisation of waste industry: key requirements to meet packaging Circular Economy ambitions



### Presentation to Roto4All 9 March 2023

07/03/2023



## AGENDA

- 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

EASTMAN



wrap



DIGIMARC



METRO

L'ORÉAL

HALEON

ALPLA



Johnson & Johnson CONSUMER HEALTH



The Coca-Cola Company



suez

Reclay Group



kao



REYNDERS label printing

reproflex



Netto Marken-Discount



VALORLUX BE THE CHANGE



KESTREL VISION

Seeberger

KIEFEL TECHNOLOGIES A Member of Brückner Group



DAS STUDIO Trusted Brand Production



amazon

SUDPACK



Kraft Heinz



MARS

Unternehmensgruppe Theo Müller



Kellogg's



Mondelez International

KALYPSO A ROCKWELL AUTOMATION BUSINESS



ROSSMANN



SICK Sensor Intelligence.



WIPAK



greiner PACKAGING

INNTECH COFAPAK Omsur



Berry



Reifenhäuser



FERRERO SORREMARTEC

FOBOHA A business of BARNES GROUP INC



DNP Dai Nippon Printing



# CIRCULAR ECONOMY

## FOR PACKAGING



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

**30%**

**average recycled  
content** across all  
plastic beverage bottles

# HolyGrail 2.0 Objective

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

## Proving the **TECHNICAL** 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)



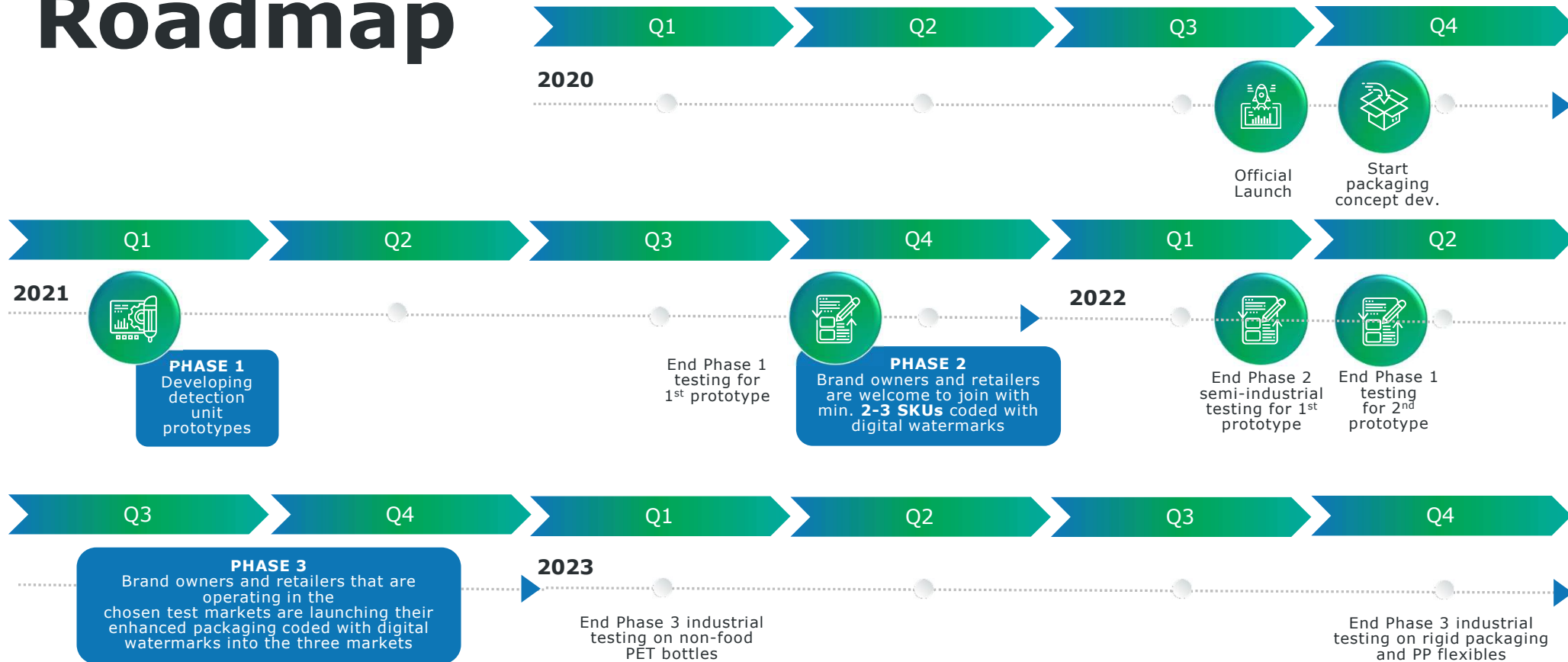
## Proving the **ECONOMIC** viability of digital watermarking technologies (WP4), through e.g.:

- ▶ 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

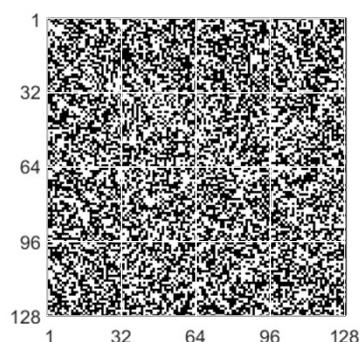
## Roadmap



# Digimarc Watermarks: A Unique Digital Identifier

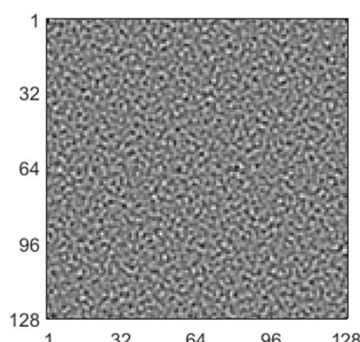
A digital identity is created through the integration of Digimarc Watermarks into printed artwork or plastic substrates.

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



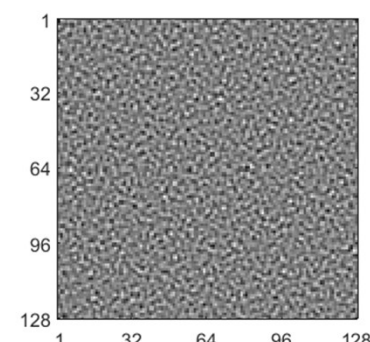
**Message Signal**

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**

2.2 cm x 2.2 cm

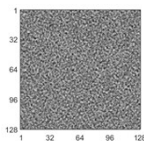
Replicated throughout object with by subtle modulation of existing artwork / plastic

*All signals exaggerated here for illustration purposes*



GRUPPO ITALIANO  
ROTOCALCO  
By Acimga

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*



## Intelligent Packaging Through Digital Watermarks

### 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 standardized database!



Looks Like This



Performs Like This

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

## 3D Watermarking for Stretch Blow Molding

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

By Acimga

## 3D Watermarking for Extrusion Blow Molding

Watermark texture mimics traditional sandblasting texture

Texture on bottle induced by air bubbles forming Digimarc watermark

High resiliency to manufacturing process variations (pressure, temperature)

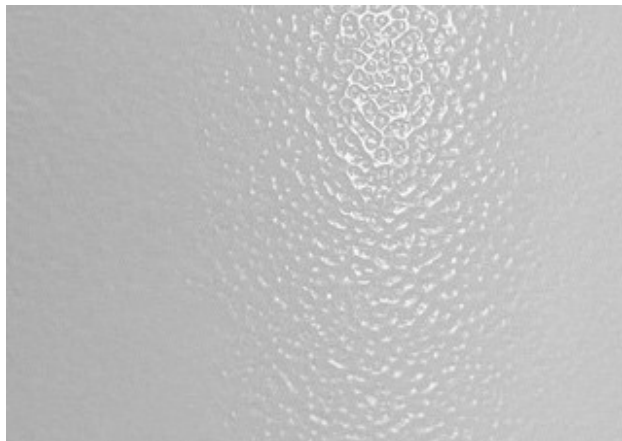
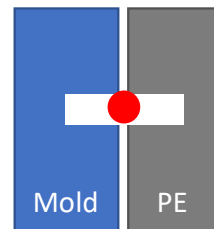


Photo of surface texture

Debossed dots  
in plastic

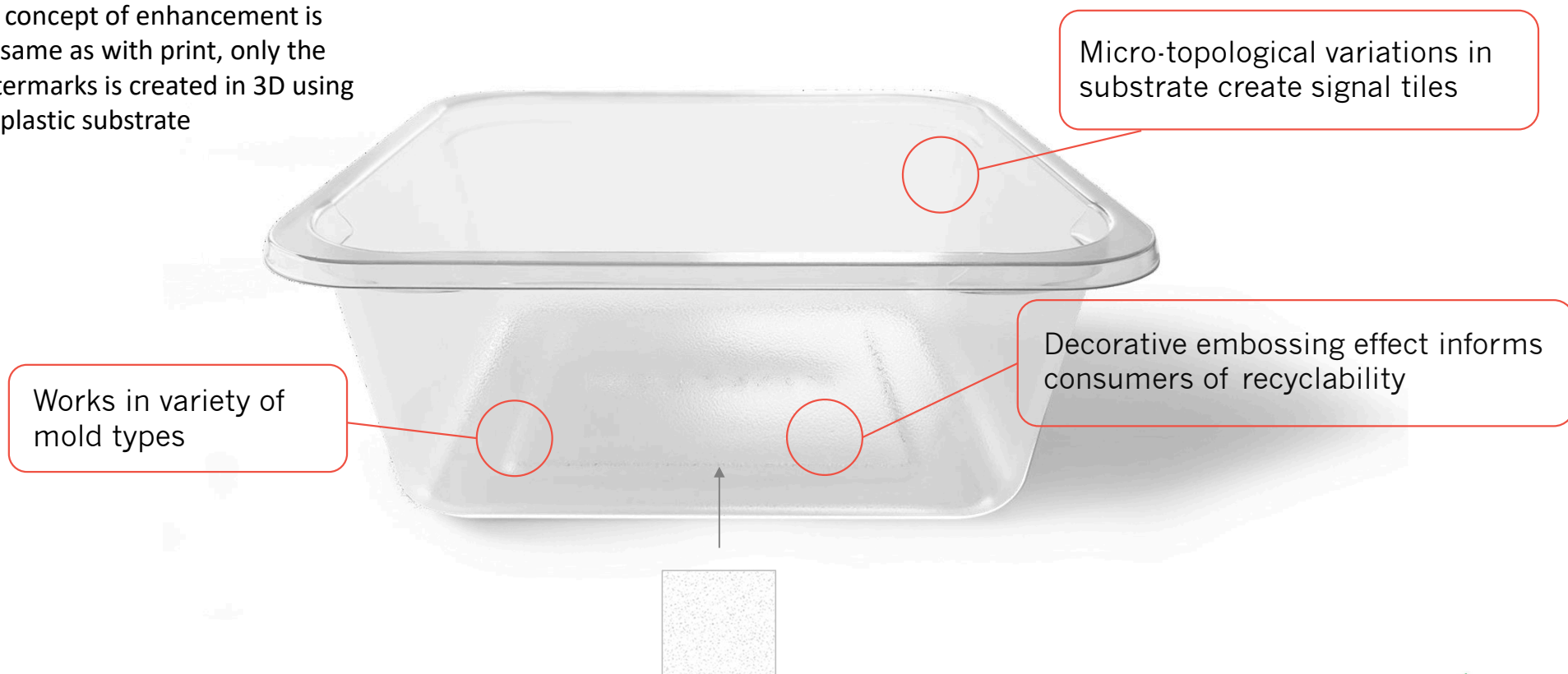


Air Bubble



The concept of enhancement is the same as with print, only the Watermarks is created in 3D using the plastic substrate

## Digimarc Watermarks: Applications in Plastic



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



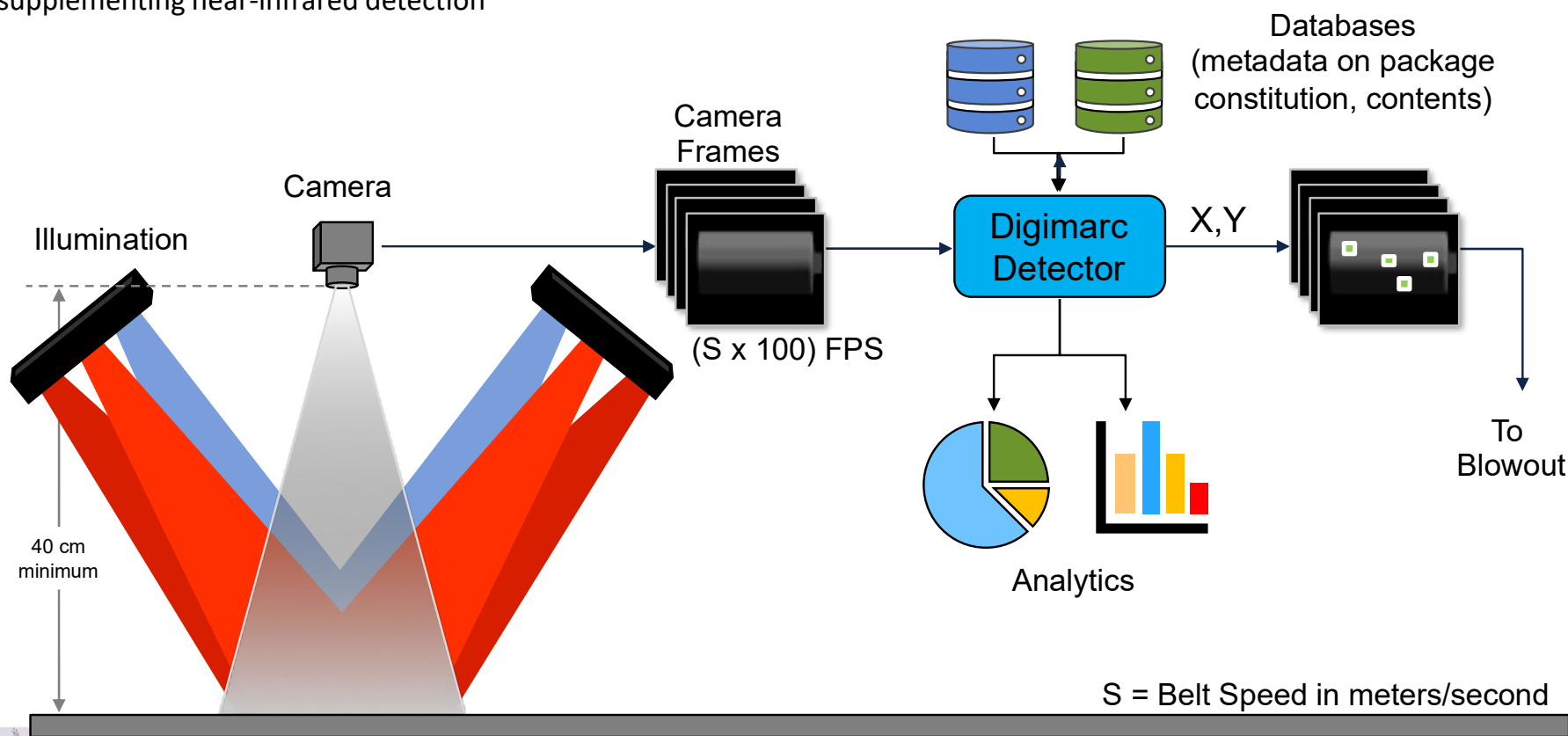
## Variety of Packages Tested as Part of HolyGrail 2.0



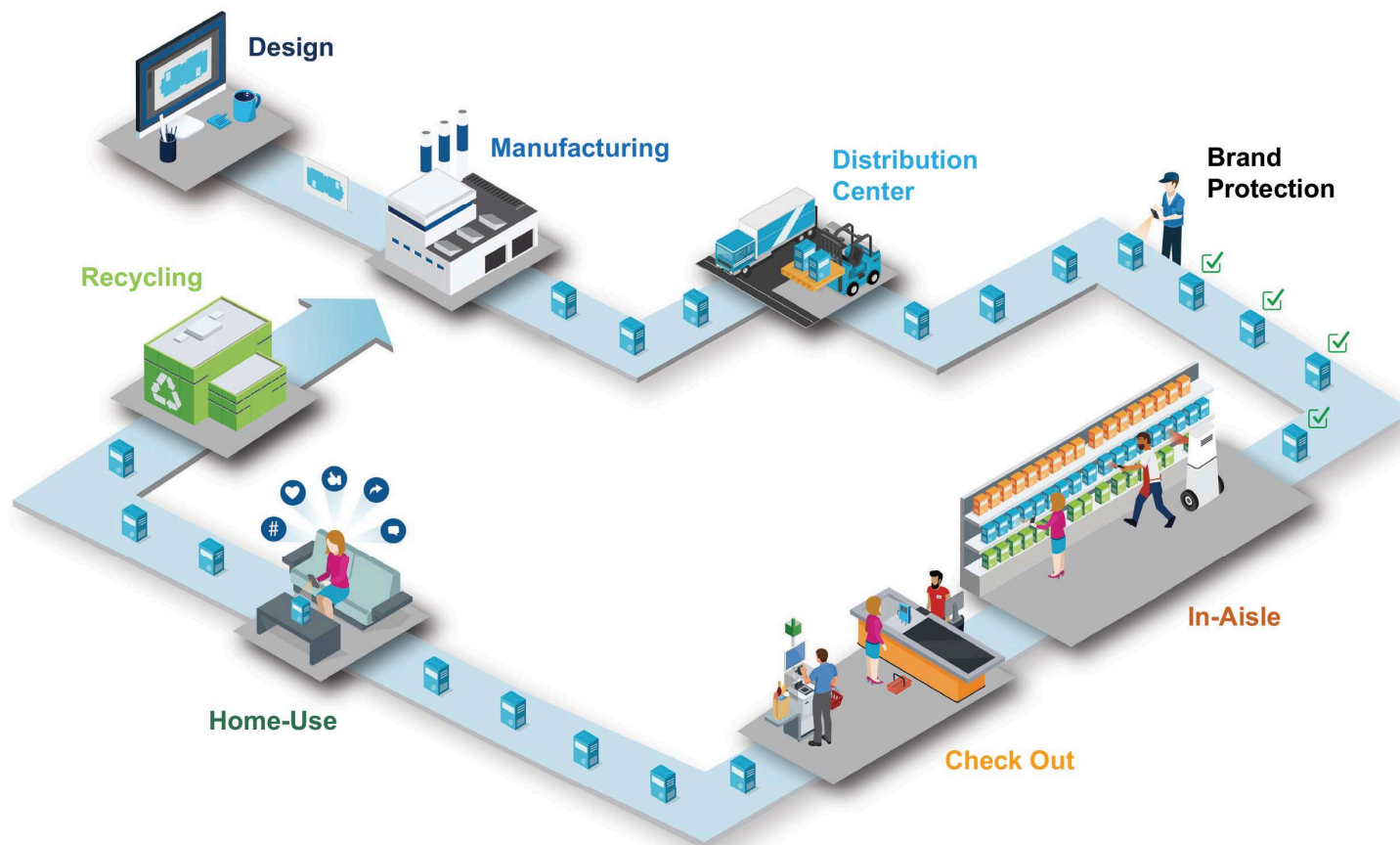


Digimarc-specified components can scan waste in recovery facilities, supplementing near-infrared detection

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## 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*

### Phase 1

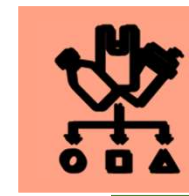
- Develop a functional HG2.0 prototype as an add-on module to detect and separate the DW packaging from packaging waste, allowing category specific sorting.



*Successfully  
Completed 2022*

### 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.



*We are here  
Throughout 2022/2023*

### 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.

## DETECTION ADD-ON MODULES:

> 230 product SKUs (2D, 3D, combined)

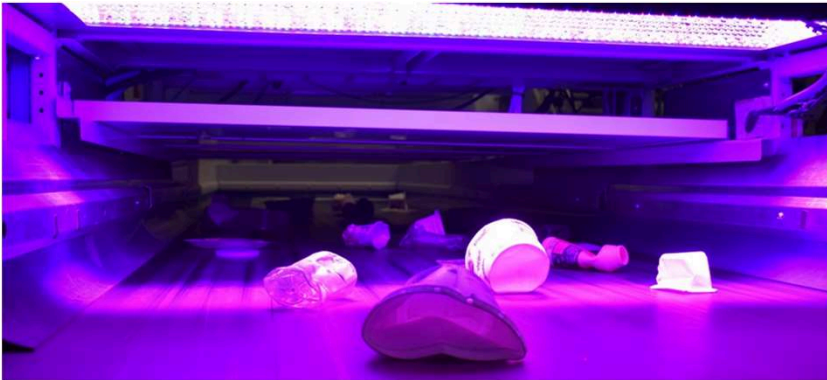


99% Detection rates  
95% Ejection rates  
95% Purity rates



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

*Average single sort numbers Rigid PP, Rigid PE, Rigid PET, PE Flexibles, LCBs (mixed packaging waste stream)*



### **Industrial conditions:**

- 3m/s belt speed
- 2,5 tons/hr Rigids
- 0,5 tons/hr Flexibles





# 1<sup>ST</sup> DETECTION ADD-ON MODULE: (Phase 2)



+



> 230 product SKUs (2D, 3D, combined)



## Digital Watermarks Initiative HolyGrail 2.0 achieves significant milestone with the successful semi-industrial validation of detection sorting unit

**Press release for immediate release – Brussels, 30 March 2022** – The Digital Watermarks Initiative [HolyGrail 2.0](#), driven by [AIM](#) – European Brands Association and powered by the [Alliance to End Plastic Waste](#), has achieved a significant milestone with the successful validation, after semi-industrial testing mimicking real-life conditions, of the prototype detection unit for digital watermarks. The results show that the digital watermark technology can achieve more granular sorting of packaging waste at scale, such as developing separate food and other new PCR streams that currently do not exist (e.g. for cosmetic or detergent applications). This would open up new recycling streams, effectively overcoming limitations of current near-infrared (NIR) sorting technologies, and drive a true circular economy for packaging. Consistent high results across all tested categories of plastic packaging material of 99% detection, 95% ejection and 95% purity rates, on average, demonstrate an impressive performance of the first prototype. Developed by the machine vendor [Pellenc ST](#) and the digital watermarks technology supplier [Digimarc](#), the detection unit is now ready for industrial-scale pilots, which are planned to start later this year. Details on industrial partners and packaging scope will be released at upcoming conferences.

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%
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).*

LCBs	99,95%	98,85%	
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[www.packagingeurope.com/news/holygrail-20-concludes-semi-industrial-trials-with-successful-validation/8056.article](http://www.packagingeurope.com/news/holygrail-20-concludes-semi-industrial-trials-with-successful-validation/8056.article)



## 2<sup>ND</sup> DETECTION ADD-ON MODULE: (Phase 2)



+



> 230 product SKUs (2D, 3D, combined)

Validation of second prototype machine takes HolyGrail 2.0 one step closer to industrial scale

**Brussels, 15 June 2022** – The Digital Watermarks Initiative [HolyGrail 2.0](#), driven by [AIM](#) – European Brands Association and powered by the [Alliance to End Plastic Waste](#), has achieved a new significant milestone with the successful semi-industrial validation of its second prototype detection unit combining digital watermarks and NIR detection. Developed by the machine vendor [Tomra](#) and the digital watermarks technology supplier [Digimarc](#), the detection unit demonstrated high results across all tested



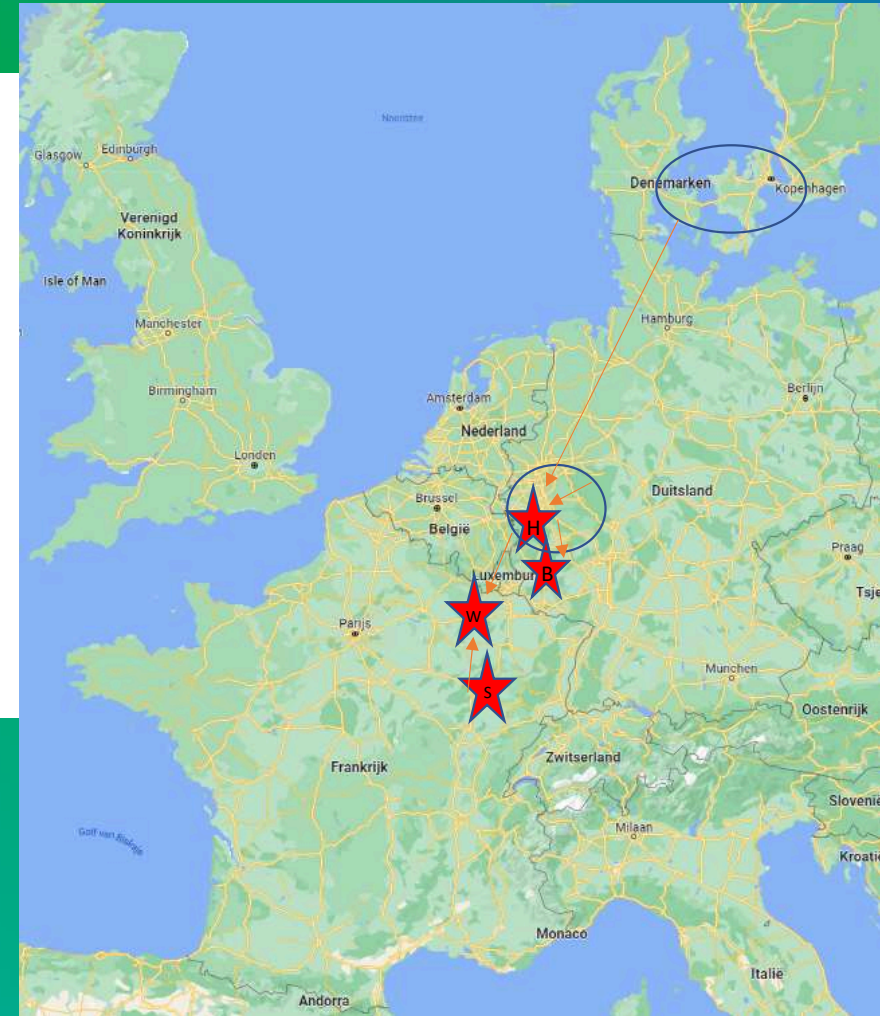
Category	Detection rate (by count)	Ejection rate (by weight)	Purity rate (by weight)
Average of rates for PP	99,6%	99,6%	94,2%
Average of rates for PET	99,1%	95,7%	92,6%
Average of rates for Fibre	98,9%	97%	93,1%
Average of rates for PE flexibles	97,6%	92%	90,8%



# Phase III

- ▶ Committed commercial enhanced samples from brand owners & retailers: **37 tons per year**
- ▶ Commercial enhanced pack materials launched in national markets **Denmark, France, Germany**
- ▶ **Locations for industrial tests:**
  - 1 MRF: test/capture all enhanced rigid packaging from Germany & Denmark)
  - 1 PRF (input from MRF + on-going supply + spiked volumes): focus on granular sorting
  - 2 recyclers (end to end recycling):
    - Non-food rPET bottle grade: spiked volumes + on-going supply
    - Food rPP film grade: spiked volumes + on-going supply

## Planned test locations & material



## Market adoption strategy (Roland Berger study)





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.

## Executive summary: HolyGrail market adoption strategy

### 1

#### Opportunity for value creation through digitalization

- Household packaging waste management value chain is battling structural problems, from **lack of high-quality recycle**, 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 <sup>1)</sup>	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%

<sup>1)</sup> PET volumes (mainly home-care and milk) in Europe after subtracting all beverage PET volumes, assuming a DRS system for PET beverage bottles across all 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

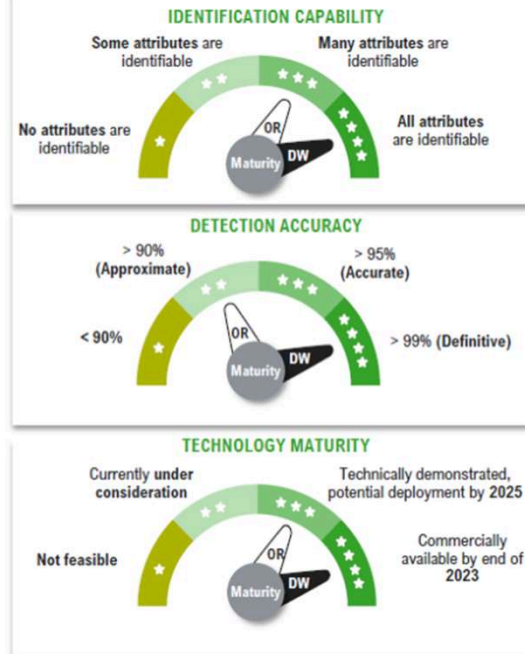
### Object recognition



- 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

Source: Technology workshop, Roland Berger



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

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)

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

# What after HolyGrail 2.0?

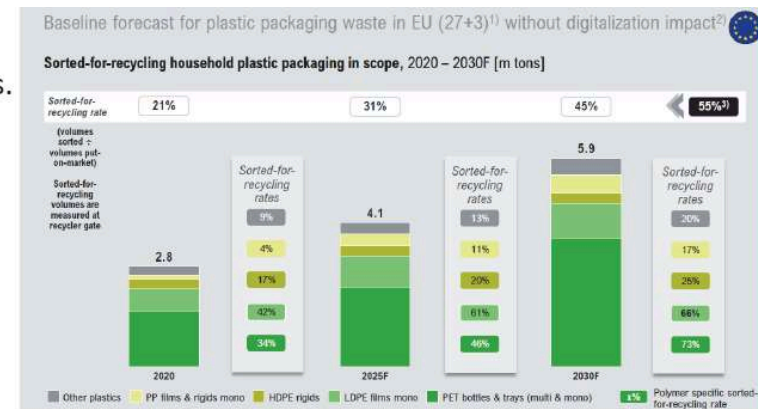
## Landing strip France (CY 2024)



## Sheraton Milano San Siro

- 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.
- 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 favorable** (Decision is fully reversible in case we fail to demonstrate positive value equation, with acceptable throwaway costs.

→ IF YOU ARE A BRAND OWNER, RETAILER AND/OR WASTE MANAGER WITH ACTIVITIES IN FRANCE AND WANT TO BECOME PART OF THE MOVEMENT, THEN PLEASE REACH OUT TO AIM TODAY!



# CONTACT

## Digital Watermarks Initiative – HolyGrail 2.0



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