AIM EUROPEAN BRANDS ASSOCIATION

HolyGrail 2.0 Intelligent Sorting

ALLIANCE TO END PLASTIC WASTE

PIONEERING DIGITAL WATERMARKS FOR SMART PACKAGING RECYCLING IN THE EU

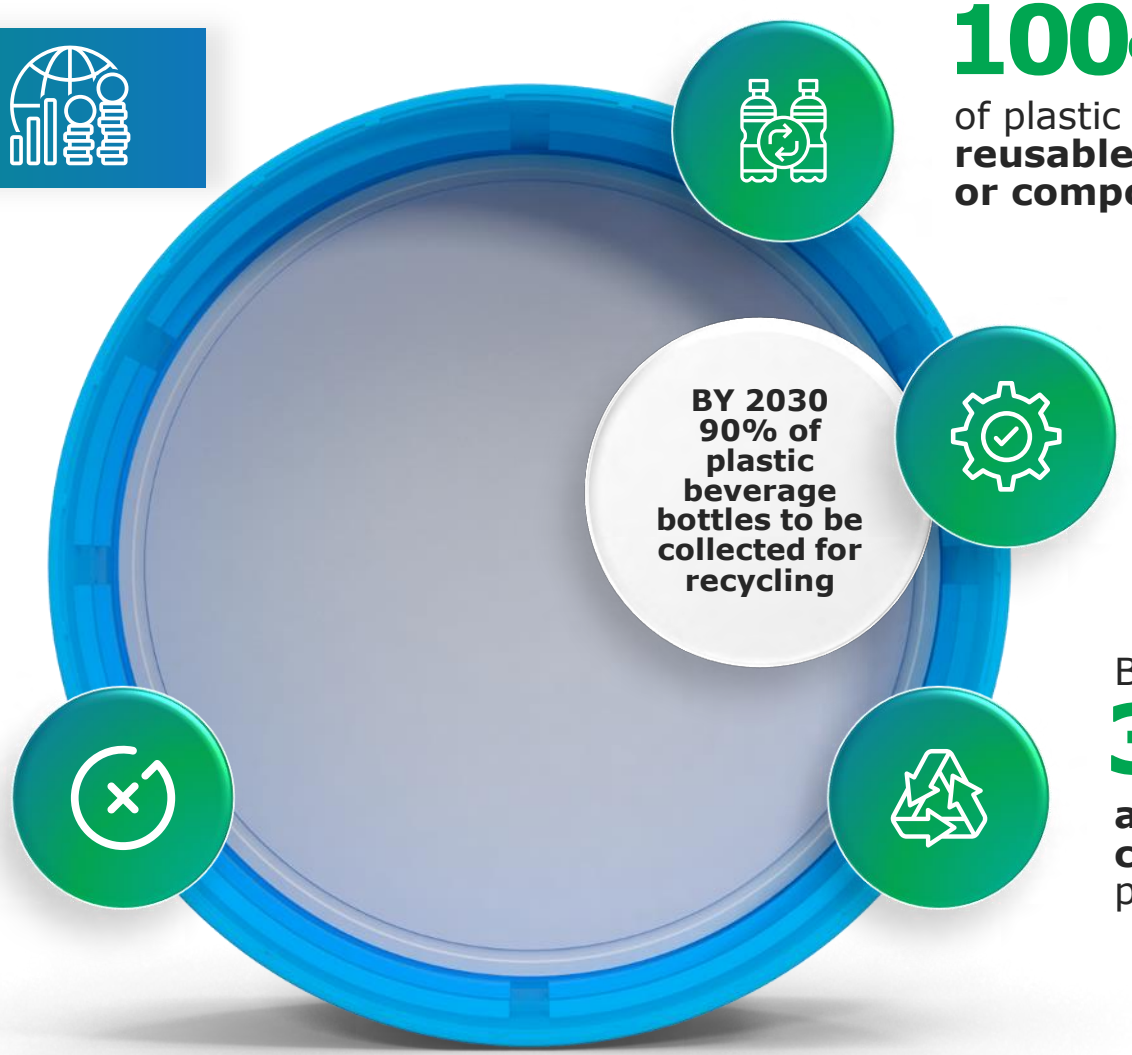
Digital Watermarks Initiative HolyGrail 2.0

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

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CIRCULAR ECONOMY

FOR PACKAGING

How can we achieve a Circular Economy for Packaging in the EU?

One of the biggest challenges is how to **maximize our resources** through optimal sorting and recycling

We need to **better sort our post-consumer waste in the EU waste management systems** by accurately identifying (plastics) packaging, resulting in more efficient and higher-quality recycling

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CIRCULAR ECONOMY

FOR PACKAGING

Digital watermarks for smart packaging to **revolutionise the way packaging is sorted**

Opens **new possibilities** currently not feasible with existing technologies

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CIRCULAR ECONOMY

FOR PACKAGING

September 2020: Under the auspices of AIM, European Brands Association, companies and organisations from the complete packaging value chain joined forces under the HolyGrail 2.0 project

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

Website: www.digitalwatermarks.eu

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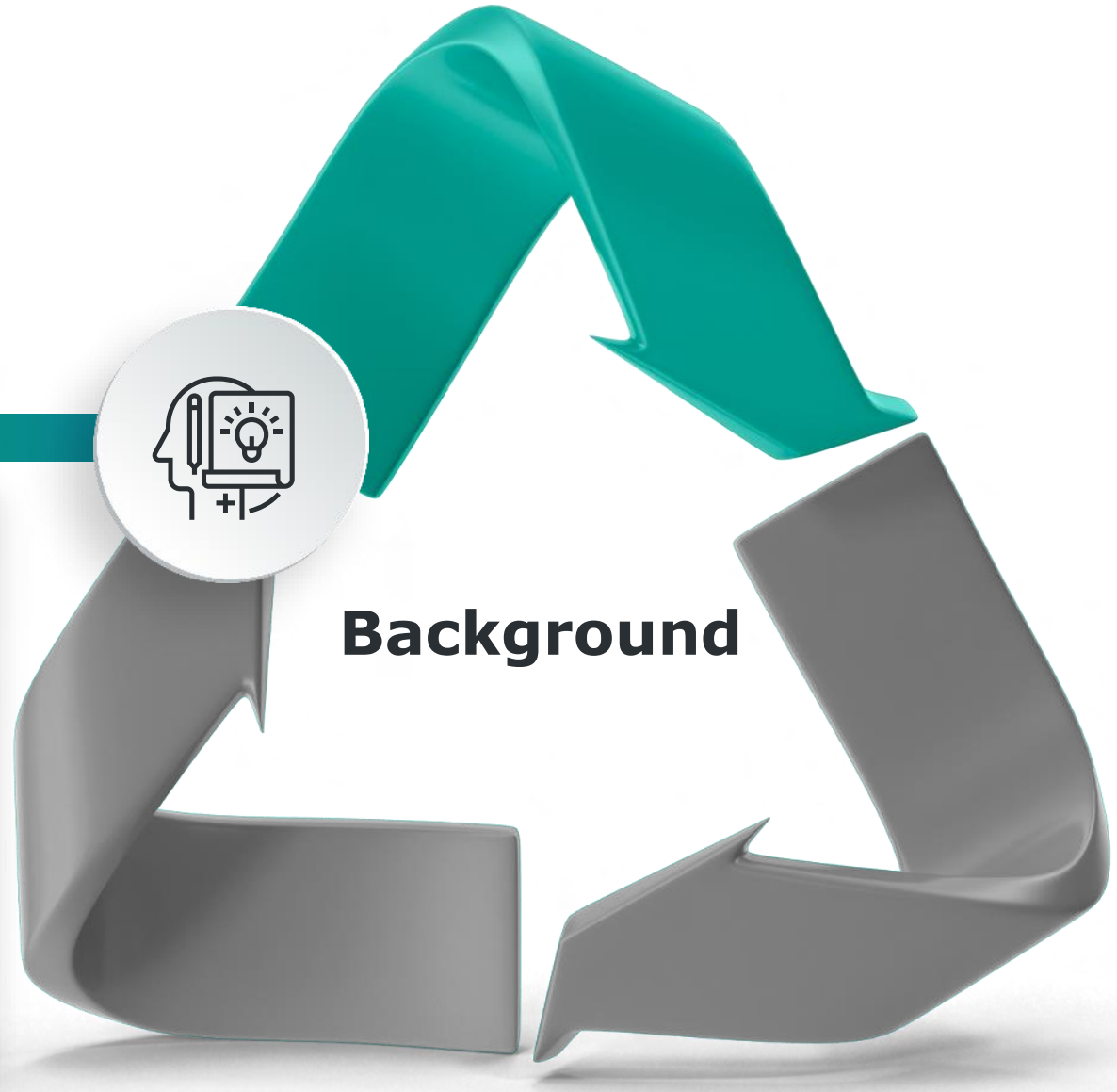
CIRCULAR ECONOMY

FOR PACKAGING



1st iteration of the **Pioneering Project HolyGrail 1.0** was led by the Ellen MacArthur Foundation 2016-2019

HolyGrail 1.0 investigated **different innovations to improve post-consumer recycling** (digital watermarks & chemical tracers)

Digital watermarks were found to be **the most promising technology,** gathering support among the majority of stakeholders and passing a basic proof of concept on a test sorting line

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Revolutionising Sorting and Recycling

by Intelligent Packaging containing Digital Watermarks

Digital Watermarks Initiative HolyGrail 2.0

Driven by AIM – European Brands Association

Powered by AEPW – Alliance to End Plastic Waste

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HAPPY COW
Fines Herbes
CREAM CHEESE
500g
Pioneering
DIGITAL
WATERMARKS
for smart packaging
recycling IN THE EU
Holy Grail 2.0
Intelligent Sorting
AIM®
EUROPEAN
BRANDS
ASSOCIATION

Welcome
to the world
of
DIGITAL
WATERMARKS

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HOLYGRAIL 2.0 Membership

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

WHAT ARE **Digital Watermarks?**

- 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)

LOOKS LIKE THIS

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WHAT ARE **Digital Watermarks?**

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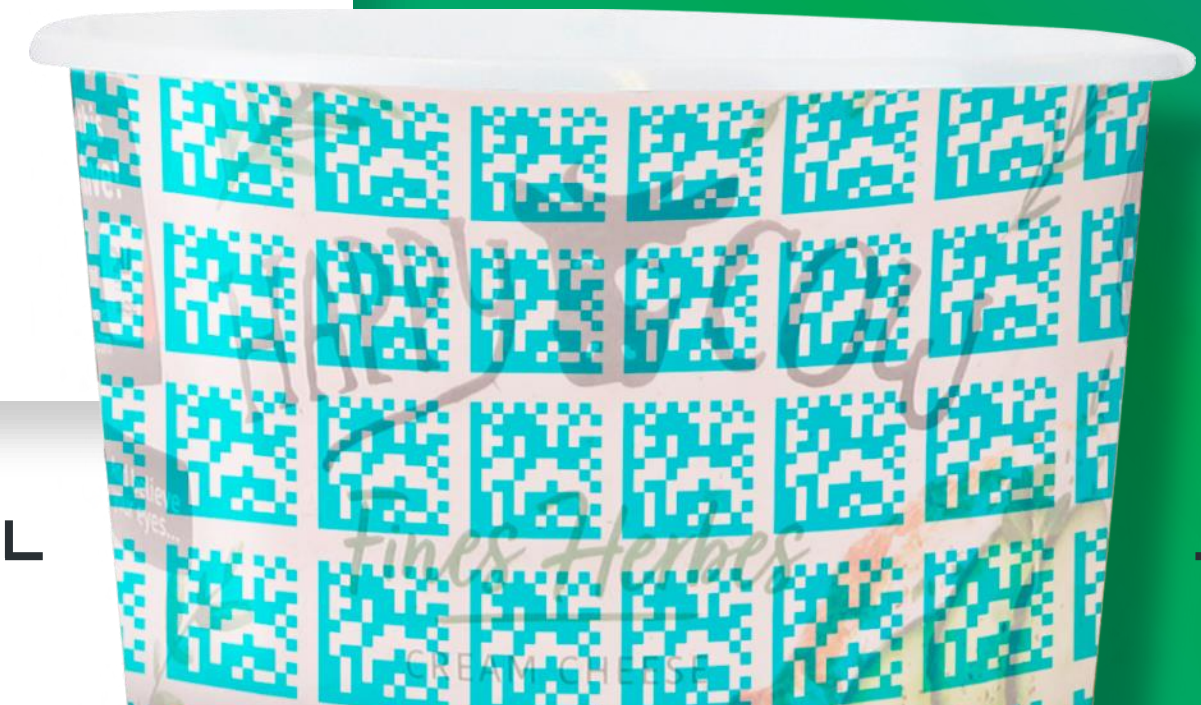
BEHAVES LIKE THIS



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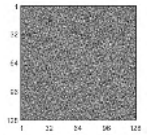
Digital Watermarks @work

FOR PRINT

01

Repeated Tile



02

Pieces of multiple tiles can be combined to recover a Barcode

03

The encoder applies the tiles to graphics in a mosaic manner

04

Uses existing pixels
No special inks
No special printing process

Exaggerated view for illustration purposes

Digital Watermarks @work

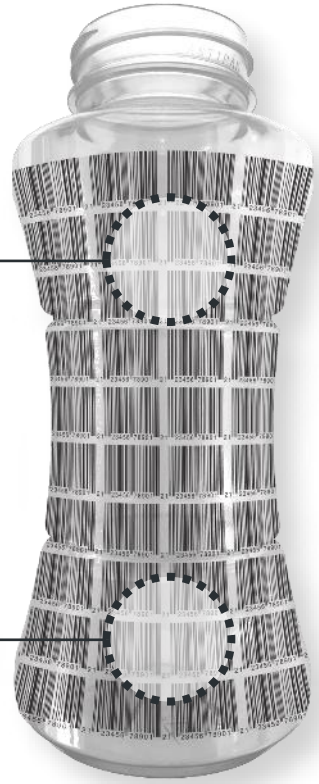
FOR MOLDS

01

Micro-topological variations in substrate create signal tiles

02

Works in variety of mold types



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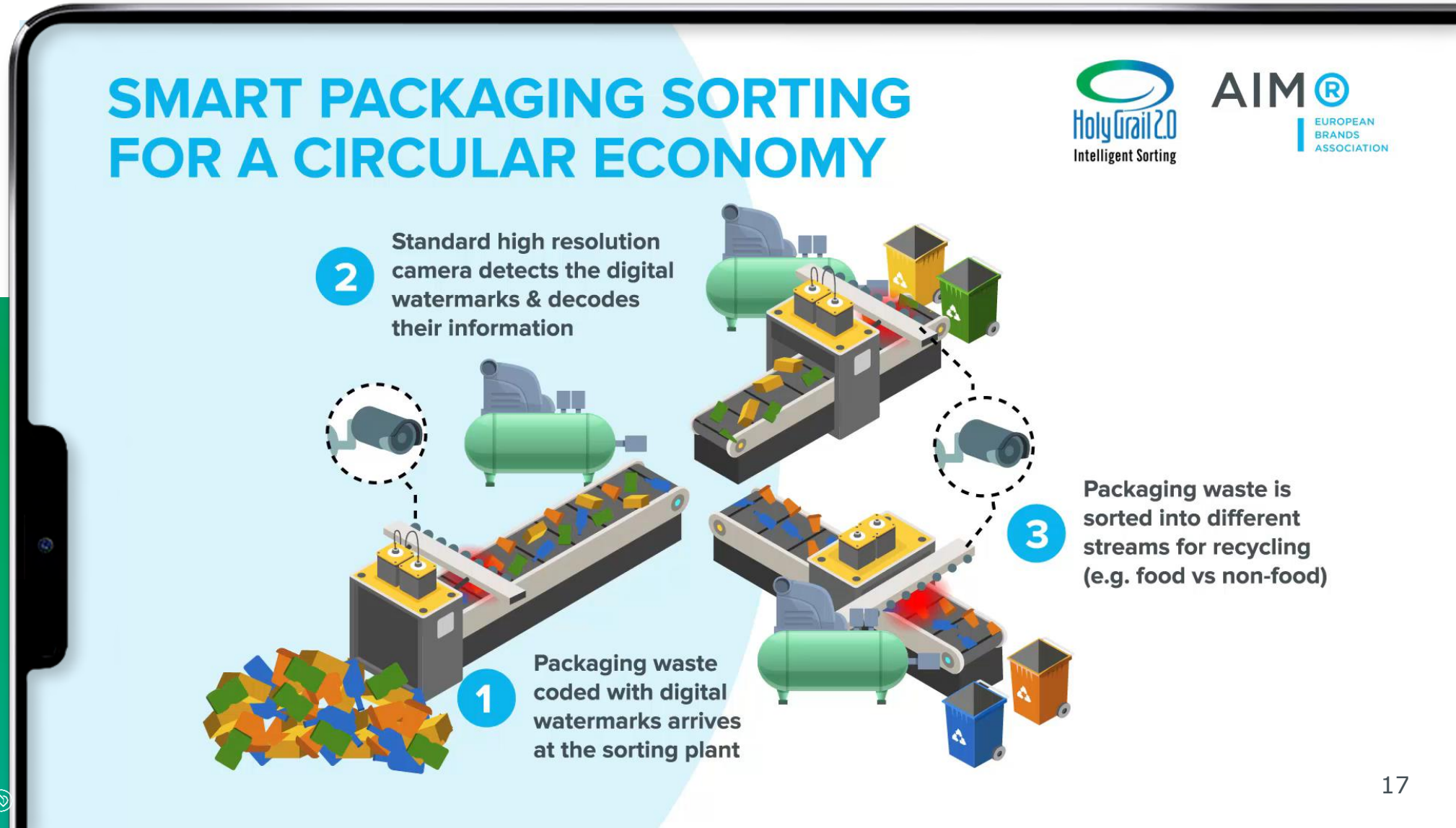
HOW DO DIGITAL WATERMARKS WORK ON A SORTING LINE?



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HOLY GRAIL 2.0

3 FOCUS AREAS

Reject
Add
Divide

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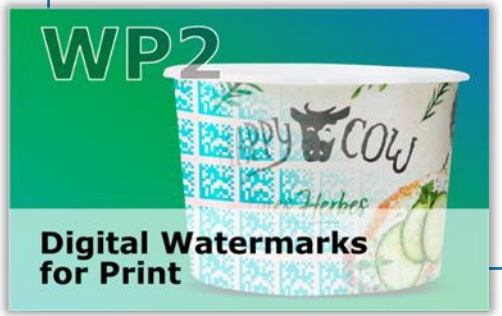
HOLY GRAIL 2.0

WORK PACKAGES



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POTENTIAL BENEFITS OF DIGITAL WATERMARKS

across the package life

01

Design

- Incorporate barcode data into artwork
- Integrate codes and link to content

02

Manufacturing

- Improve in-line inspection

03

Distribution Center

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

04

In-Aisle

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

05

Check Out

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

06

Home-Use

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

07

Recycling

- Identify material and substrates
- Improve sorting mechanisms

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Roadmap

2020

Q1 | Q2 | Q3 | Q4

- Official Launch
- Start packaging concept dev.

2021

Q1 | Q2 | Q3 | Q4

- **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

2022

Q1 | Q2

- End Phase 2 semi-industrial testing for 1st prototype
- End Phase 1 testing for 2nd prototype

Q3 | Q4

- **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

2023

Q1 | Q2 | Q3 | Q4

- End Phase 3 industrial testing on non-food PET bottles
- Phase 3 industrial testing on flexibles and rigid packaging

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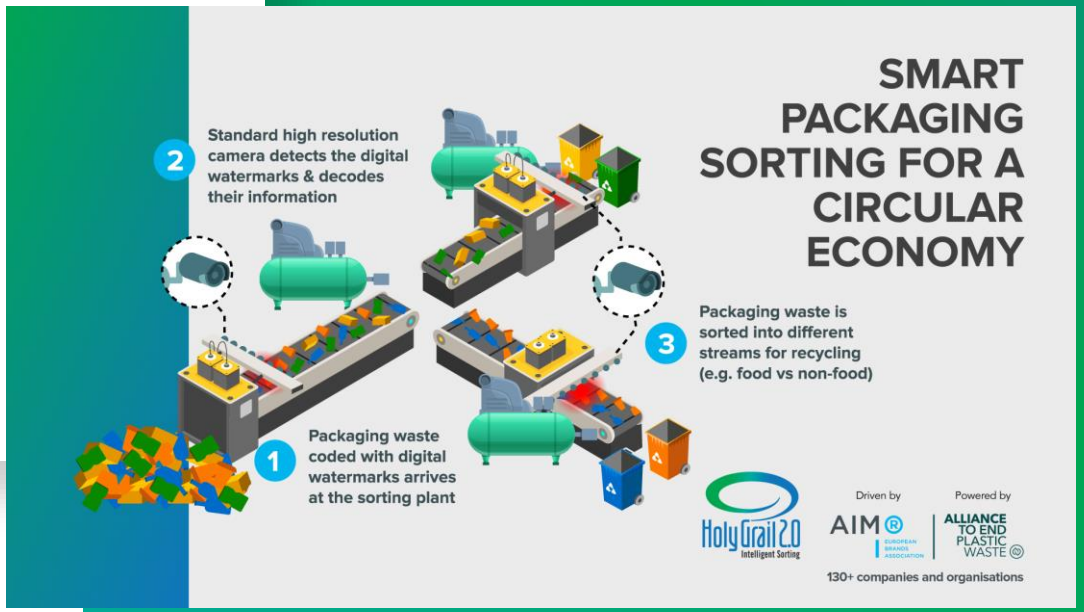
HolyGrail 2.0 Intelligent Sorting

Phase I

Prototype Development
Q1 2021 – Q1 2022

- Focus on **functional add-on module for the detection sorting unit** – combined with existing NIR sorters – developed by the machine vendors **Pellenc ST** and **Tomra**, in combination with **Digimarc** (digital watermarks technology provider).
- Success criteria: unit's ability to detect and sort digitally watermarked packaging of various sizes. The Technical Project Management overlooked and validated the prototypes.
- The prototypes will be used for the (semi-)industrial testing phase.
- Successful completion of Phase 1 brings the Technical Readiness Level (TRL) to TRL 6 – *technology demonstrated in relevant environment.*

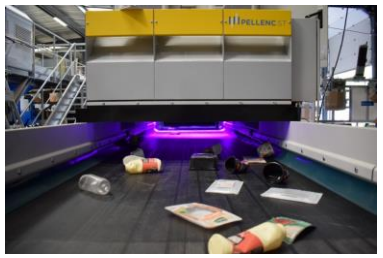


Digital Watermarks Initiative HolyGrail 2.0 reaches milestone with the validation of its first prototype detection sorting unit

Press release for immediate release – Brussels, 13 September 2021 – Following last week's partnership announcement, the Digital Watermarks Initiative HolyGrail 2.0 has reached its first milestone with the successful validation of the project's first prototype detection sorting unit.

Developed by the machine vendor Pellenc ST and the digital watermarks technology provider Digimarc, the prototype, which combines the digital watermarks technology and NIR/VIS infrared for sorting of packaging waste, achieved a >95% ejection rate. This sorter is now ready to be installed in the Amager Resource Centre (ARC) in Copenhagen to start the semi-industrial test phase. Over the next four months, trials and demonstrations with around 125.000 pieces of packaging representing up to 260 different stock-keeping units (SKUs), all prepared by HolyGrail 2.0 members, will be held in Copenhagen. Engineers will test for several parameters including the speed and accuracy of the system, to ensure its ability to withstand the pressures of full-scale industrial operations.

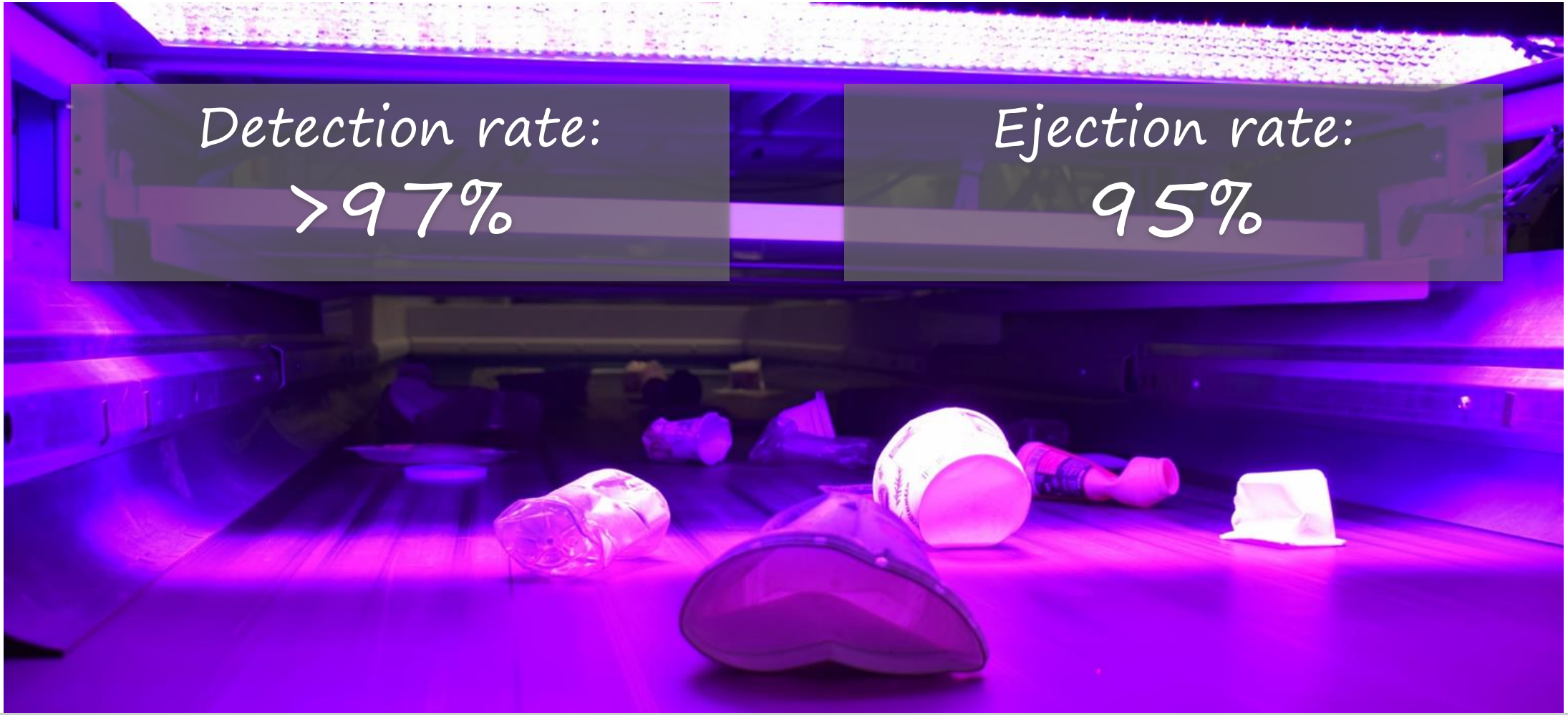
If successful, digitally watermarked products could be introduced to store shelves in Denmark, France and Germany by the first half of 2022 for in-market demonstrations and industrial-scale trials.



PHASE I

1st VALIDATED PROTOTYPE ADD-ON MODULE BY PELLENC ST, IN COOPERATION WITH DIGIMARC

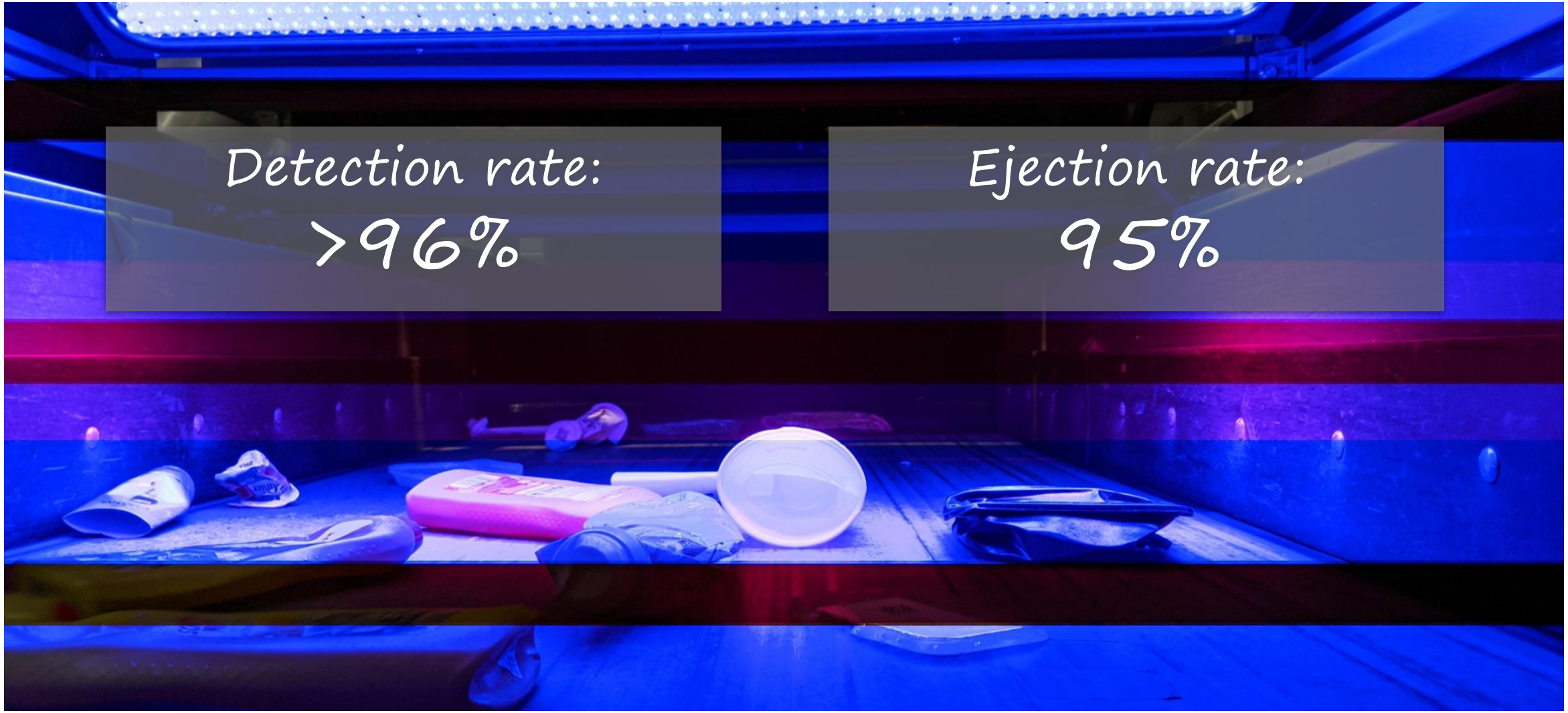
1ST DETECTION ADD-ON MODULE



PHASE I

2nd VALIDATED PROTOTYPE ADD-ON MODULE BY TOMRA, IN COOPERATION WITH DIGIMARC

2ND DETECTION ADD-ON MODULE



Phase II

Semi-industrial testing
Q3 2021 – Q2 2022

- **Software model & identification parameters are developed and tested** for sorting based on digital watermarks detection.
- System is tested for speed, accuracy, and detection efficiency.
- **2 test locations for semi-industrial trials** of the detection sorting units:
  - Pellenc ST/Digimarc module: Sep 2021 – Jan 2022 at the **Amager Resource Centre, Copenhagen** with **125.000 packaging samples coded with DW** (around 260 SKUs)
  - Tomra/Digimarc module: Q2 2022 in Germany
- Successful completion of Phase 2 brings the Technical Readiness Level (TRL) to TRL 7 – *system prototype demonstration in operational environment* and TRL 8 – *system complete and qualified.*

AIM - European Brands Association
and City of Copenhagen

INVITE TO

Open Houses

for a semi-industrial test demonstration of the Digital Watermarks Initiative HolyGrail 2.0

Amager Resource Centre, Copenhagen

19 October and 18 November 2021

Virtual tours for all interested stakeholders and on-site visits for HolyGrail 2.0 members only

PHASE II

SEMI-INDUSTRIAL TEST DEMONSTRATION AT AMAGER RESOURCE CENTRE IN COPENHAGEN

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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%
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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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%

Phase III

FULL SCALE validation
Industrial tests
2022-2023

- Functional prototypes now **deployed in commercial sorting and recycling facilities under normal operational conditions on a large-scale**.

  Locations in France and Germany, including 1 MRF, 1 PRF, 2 recycling plants

- Brand owners and retailers bring their **enhanced products commercially** to market in Denmark, France and Germany.
- Consumers can buy on-shelf products with digitally watermarked packaging, which will enter the waste stream after consumption.
- **Objective**: test system's reliability to ensure optimum performance.
- Successful completion of Phase 3 will bring the TRL to **TRL 9** – *actual system proven in operational environment*.

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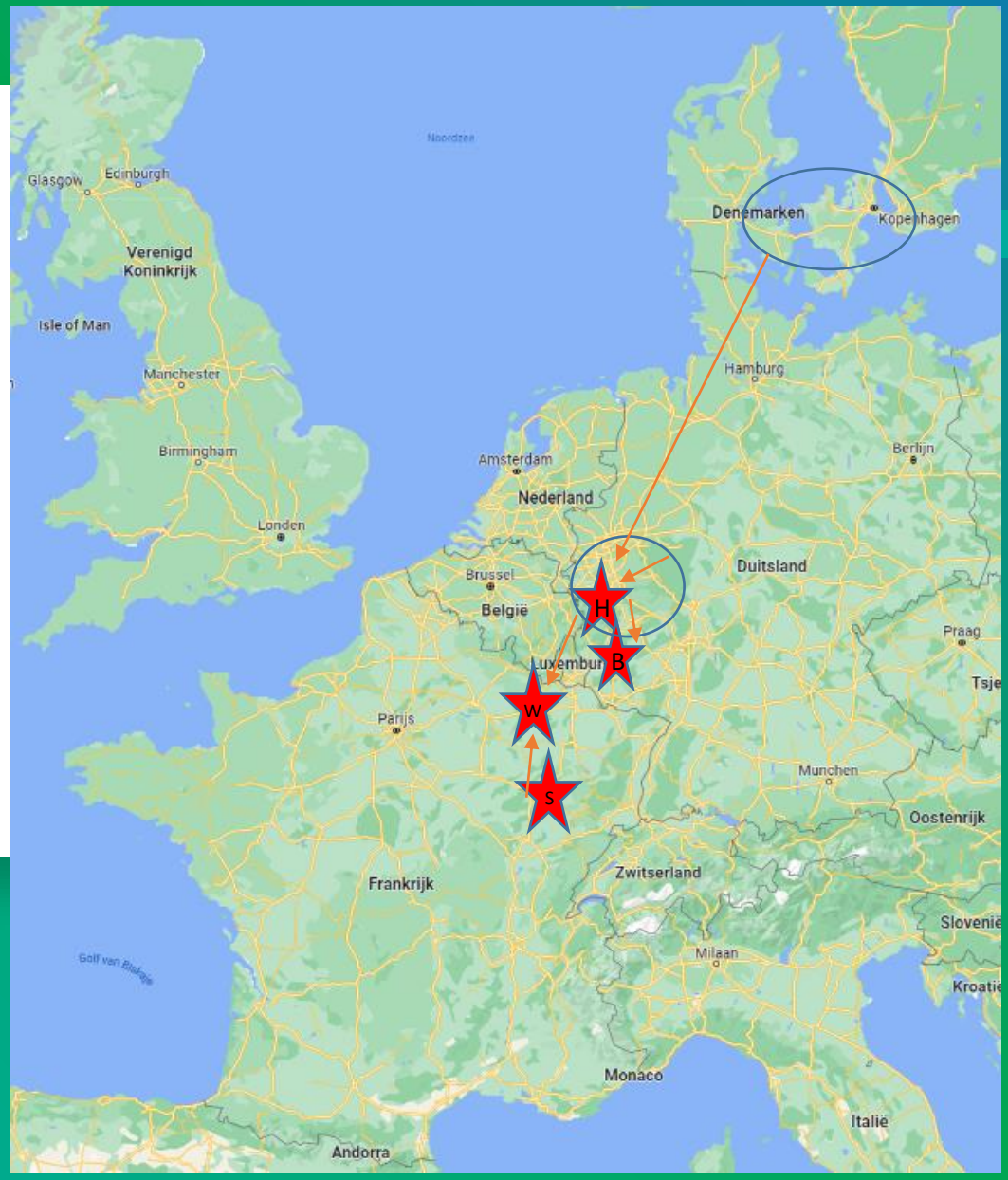
Phase III

Planned test locations & material

- 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



PHASE III – **PLAN** FOR 1ST 2023 TEST ON DEVELOPMENT OF NON-FOOD R-PET

- **SORTING**
  - Production of **10 tons of spiking volume** (~ 374k bottles)
  - **Mimic real-life conditions**: mix in at Suez MRF (France) and create 3 different blend volumes (food vs non-food PET bottle)
  - Run PET blends through Pellenc ST line (with add-on module) at Wellman Verdun to **characterise DW performance** (efficiency, purity and machine robustness)

- **Pre-assess non-food r-PET quality: SORPTION study of Household and Personal Care products (HPC) into PET**
  - Basis: **EFSA challenge test**
  - Involve research institute & recycle machine vendors: proof that **recycling process can remove HPC components**

INDORAMA VENTURES WELLMAN INTERNATIONAL LTD

suez

PELLENC ST

DIGIMARC

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PHASE III

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

- Two-passing sorting showed on average:
  - 96% detection rates
  - 95% ejection rates

  demonstrating an impressive performance of the prototype.

- Proven efficacy of HolyGrail 2.0 technology in
  - separating with **high granularity**, and
  - **reducing impurities** in food-grade PET output streams

  in recycling plants at industrial scale

Results of food/non-food PET bottles separation

Fraction	Detection Efficiency (%)	Sorting Efficiency (%)
5% (single-pass sorting)	93.6	91.5
10% (single-pass sorting)	91.3	86.8
20% (single-pass sorting)	91.3	86.7
Average (single-pass)	**92.1**	**88.3**
10% (two-pass sorting)	96.0	95.6
20% (two-pass sorting)	95.7	94.6
Average (two-pass)	**95.9**	**95.1**

Full Press Release here

PHASE III – **PLAN** FOR ADDITIONAL TESTS IN 2023

- **MRF Germany (Hündgen):** with 2 add-on units 1m20 and 2m80 for 3 months testing
  - Purpose: capture **all** enhanced Rigids from Germany/Denmark including PET rigids (bottles incl SSL + trays), PP rigids, PE rigids, liquid carton boards, paper cups
  - Granular sorting in dedicated stream including non-food PET bottles and surface printed mono-material PP films

- **Recycler (Wellman):**
  - Run **washing test** at Wellman Verdun
  - **Solid stating/pelletizing** at Wellman
  - Assess non-food r-PET **quality** (incl FFU)

- **Recycler (Borealis)**: trials on rigid and flexible PO, with key focus on development of food-grade r-PP film

HolyGrail 2.0 Partners

PARTNERSHIPS FOR HG2.0 (SEMI-) INDUSTRIAL TRIALS

Alliance to End Plastic Waste

City of Copenhagen

- More information in our press release here

HolyGrail 2.0 Structure

HG2.0 STRUCTURE BASED ON **HOLYGRAIL 2.0 CHARTER** UNDER THE AUSPICES OF AIM, EUROPEAN BRANDS ASSOCIATION:

MEMBERSHIP

HG2.0 Membership
Associate & Full Initiative Members

Technical Work Packages:

Involvement of all members based on expertise and knowledge

WG leaders appointed

Under supervision of Technical Project Management

Leadership Team:

= Core members representing each of the sectors engaged in the initiative

Leads, coordinates and manages the activities of the initiative

Ensures effective use of membership fees and involvement of member companies

Overlooks the activities and decides on the set-up of technical work packages

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HOLY GRAIL 2.0

LEADERSHIP TEAM

Brand manufacturers (4/4)

Retailers (2/4)

MRFs: Materials Recovery Facilities (2/2)

Converters (2/2)

Extended Producer Responsibility Organisations (2/2)

Recyclers (2/2)

LT Chair: Gian De Belder, P&G

HolyGrail 2.0 Structure

HG2.0 STRUCTURE BASED ON **HOLYGRAIL 2.0 CHARTER** UNDER THE AUSPICES OF AIM, EUROPEAN BRANDS ASSOCIATION:

MANAGEMENT

- **Secretariat – AIM as Initiative Facilitator:**
  - Overall management of initiative
  - Contact point for members & external stakeholders
  - Ensuring regular updates / information flow to all HG2.0 members
- **Technical Project Management:**
  - Drafting technical test plans
  - Coordinating the different technical working groups
  - Overseeing the work on the test sorting lines
  - Supporting members with technical expertise & in their work with technology suppliers
- **Legal Counsel:**
  - Present at all meetings of Leadership Team and HG2.0 members

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HolyGrail 2.0 Structure

HG2.0 ADVISORY GROUP STRUCTURE BASED ON **HOLYGRAIL 2.0 ADVISORY GROUP CHARTER**:

ADVICE

- **Advisory Group:**

  Panel for dialogue, exchange and input into both the operational implementation of key activities and the overall strategy of HG2.0.

  Provides advice to HG2.0 Leadership Team, constituting the public and policy complement to the cross-value chain initiative HolyGrail 2.0.

  Comprised of key stakeholders in the Circular Economy debate, including representatives from NGOs, Media, European and national public agencies, European and national policy-makers, other key stakeholders

PACKAGING EUROPE · ELLEN MACARTHUR FOUNDATION · ALLIANCE TO END PLASTIC WASTE · AGVU Arbeitsgemeinschaft Verpackung + Umwelt · WWF

AIM European Brands Association · HolyGrail 2.0 Intelligent Sorting · ALLIANCE TO END PLASTIC WASTE

Innovation, sustainability and **digital** are the **3 key ingredients** we are combining with smart packaging through **digital watermarks** to achieve the objective of the **Green Deal** towards a **clean**, **circular** and **climate neutral economy**.

MICHELLE GIBBONS
DIRECTOR GENERAL, AIM

AIM® EUROPEAN BRANDS ASSOCIATION
HolyGrail 2.0 Intelligent Sorting

Digital Watermarks Initiative HolyGrail 2.0

The Digital Watermarks Initiative HolyGrail 2.0 – driven by AIM, the **European Brands Association** and powered by the Alliance to End Plastic Waste – is a pilot project with the objective to prove the **technical viability** of digital watermarks for accurate sorting of packaging waste as well as the **economic viability** of the business case at large scale.

Digital watermarks are **imperceptible codes**, the size of a **postage stamp**, covering the surface of a consumer goods **packaging** and carrying a wide range of attributes. The aim is that once the packaging has entered into a **waste sorting facility**, the digital watermark can be detected and decoded by a **standard high resolution camera** on the sorting line, which then – based on the transferred attributes (e.g. food vs. non-food) – is able to sort the packaging in corresponding streams. This would result in better and more accurate sorting streams, thus consequently in **higher-quality recyclates benefiting the complete packaging value chain.**

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CONTACT

Digital Watermarks Initiative HolyGrail 2.0

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EU Transparency register ID no.:
1074382679-01

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