

The Road to Realizing the Circular Economy

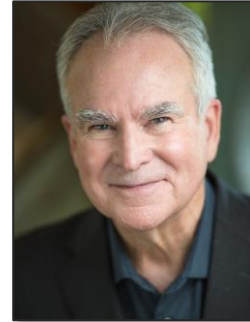
HolyGrail 2.0 Update on Digital Watermark Technology



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Chair for HG Leadership Team



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Leader of WP1:
Intelligent Sorting



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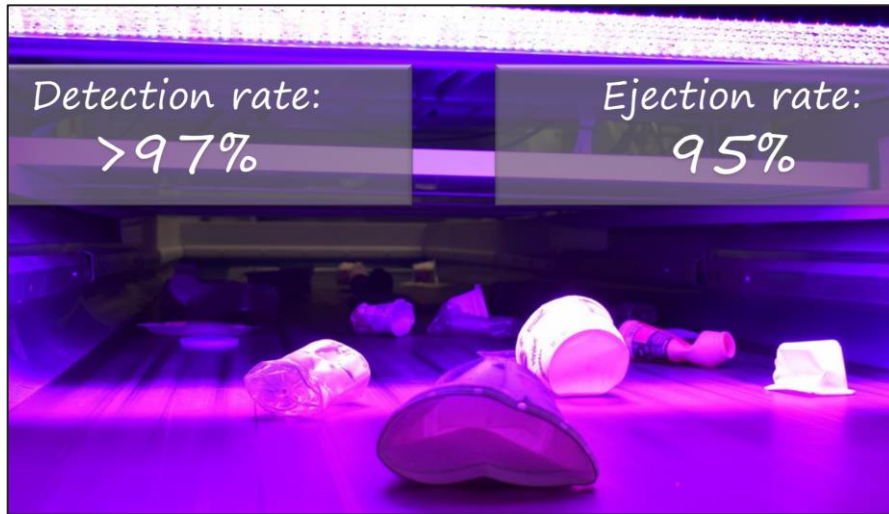
HOLYGRAIL 2.0 Membership



Phase 1 – Development of Functional Prototype

Test location at Pellenc's facility in Pertuis, France with Digimarc add-on module

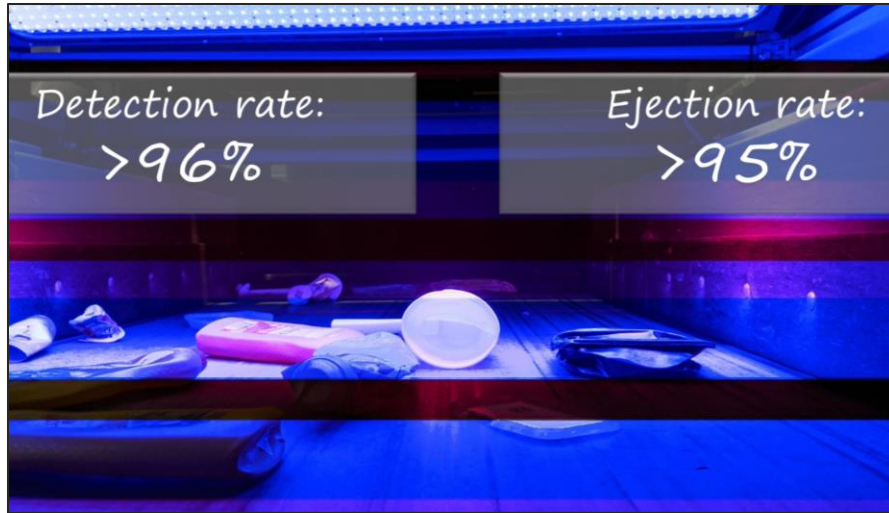
- Technical Readiness Level (TRL) of “6” (technology demonstrated in relevant environment)



Phase 1 – Development of Functional Prototype

Test location at TOMRA's facility in Mülheim-Kärlich, Germany with Digimarc module

- Technical Readiness Level (TRL) of “6” (technology demonstrated in relevant environment)



Phase 2

Semi-Industrial Test

Amager Resource Centre / Copenhagen

Open Houses

5 Sessions – 550 participants

20 Private sessions
200 participants

Pellenc ST Mistral+ with Digimarc add-on module



Non-ejected products Ejected products
Output Bins

Multiple test conditions

125,000
packaging samples encoded

260 SKUs, 3 tons

Samples including PET, PP,
HDPE bottles and thermoforms
with 2D labels and in 3D plastics,
and flexibles

TOMRA utilizes same samples



Two detection systems:

Digimarc DW

Improved Camera/Optics

Additional Illuminants

Pellenc ST NIR/VIS

Focused NIR lighting
High Speed spectrometer

Pellenc ST Mistral+ Connect with Digimarc add-on module



Phase 2

Functional Pellenc ST Prototype

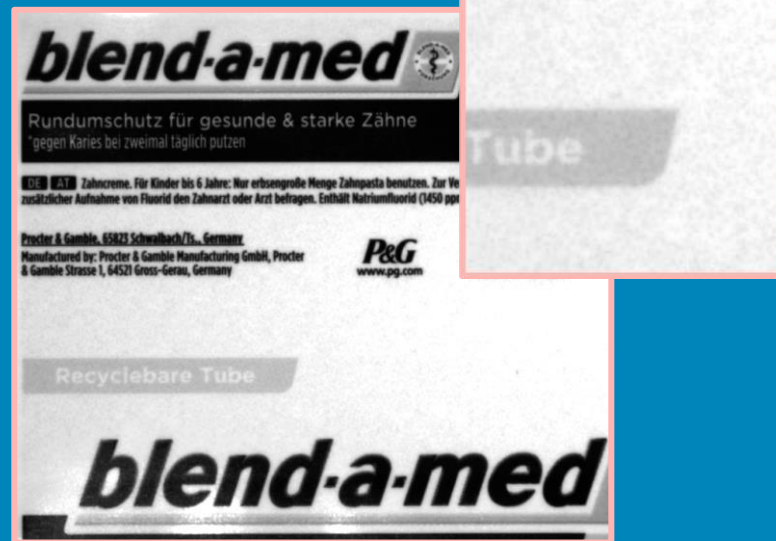
Detector Advancements – Illuminants & Camera

Camera system is able to detect subtle contrast that humans cannot

Human eye



Red light



Further Validations at Copenhagen, January 2022

Validate sorting performance in stressed conditions

Speed	Iso performance at 4.5 m/s belt speed
Soiled	Iso performance with soiled products
Ejection	Enhanced ejection performance with NIR/ VIS & DW combination



Advantages of Combining NIR/VS & DW Detection

Target highest sorting efficiency

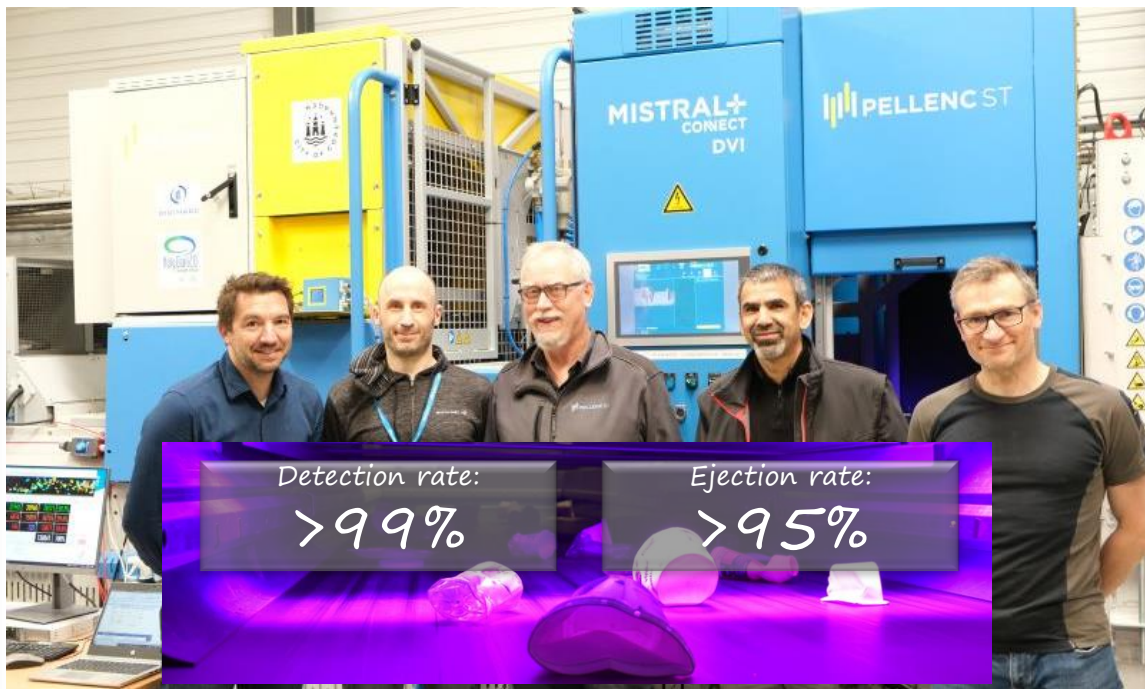
Complete	the unmarked or dirty portions of the object
Reject	encoding errors
Allow	mixed sorting of marked & unmarked objects
Optimize	object borders for a purer sorting



Press release March 30th, 2022

PHASE II Performance validation

PELENC ST
NIR + DW COMBINATION



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%



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Deploy prototypes in
commercial sorting and
recycling facilities

6 locations in France & Germany

3 MRFs, 1 PRF, 2 recycling plants

Brand Owners introduce marked
packaging into retail

Used packaging enters the regular
post consumer waste stream



Phase 3

**Industrial Demonstration to
Test System Reliability**

**Successful completion
brings TRL to 9**

Advancements in Digimarc 2D and 3D Watermarks

Advancements in White – No Ink or Only White Ink

Several new options now for white or no ink designs, in collaboration with our partners

Historical

PANTONE 9520



Today

PANTONE 9120



White ink on white



Varnish



2x white, enhance 1 white



Advancements in Black

Several new options now for black ink, in collaboration with our partners

Historical

PANTONE 2356 Holes in Black



Today

Varnish



Screened holes



Black on clear



PANTONE 275



Advancements in Spots, Transparent & Metallic Substrates

Several new options now available, significantly improving aesthetics/strength

Historical

Dots of white



Today

Refined white



Spot direct



Screened cyan



Varnish



Spot on spot



PANTONE 9520



Black on red



Black on blue



Advances in 3D Watermarking

Thermoforming



Cups, pots, trays (including ribbed designs) and clamshells

Clear and opaque (black) PET / rPET and PP

Watermark readable from contact and non-contact side

Extrusion Blow Molding



Texture mimics traditional sandblasting texture

Air bubbles in texture form watermark

High resiliency to manufacturing process variations

Injection Molding



Shiny and matte surfaces of margarine tub, lid and shampoo cap

3D watermark is readable through IML label

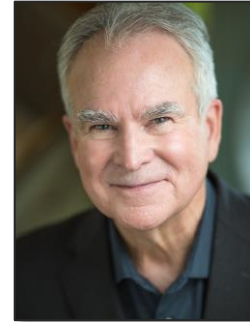
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