# State of the art of automated sorting and disassembly technologies for textiles and footwear in Europe

Re_fashion

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Report written by REFASHION & CETIA, based on the work carried out by CETIA.

# GLOSSARY

**Clippings:** Textile cut pieces of controlled size (in cm), often square, obtained after cutting textile articles.
**Delamination:** Process of separating the different layers of materials of a multilayered product.
**Densimetric separation/sorting:** Dry or wet separation process according to the relative density, i.e. the ratio of the density of one element to the density of another element taken as reference.
**Disassembly / dismantling:** Operation of separating the different components of shoes (uppers, soles, foams, plastics…) through delamination, tearing or cutting.
**DPP - Digital product passport[1] :** Digital identity card for products, components and materials.
**Hyperspectral:** Imaging technique enabling to obtain detailed spectral information for each pixel of an image.
**Second hand**: Any operation enabling post-consumer textiles & footwear to be reused for the same product application (before or after sorting).
**Shreds / grinds:** Pieces of controlled size (mm to cm), obtained after shredding / grinding.
**Tearing / fibre opening:** Industrial mechanical process involving successive drawing of textiles to recover their fibres. Main applications include nonwovens & spinning; recovered long fibres can be used for yarn spinning.
**Trim removal:** Process of removing all or part of a garment's external disruptors to recycling (hard points such as buttons, rivets, zippers; labels, patches…).

# ACRONYMS & ABBREVIATIONS

| | |
|---|---|
| **ABS** | Acrylonitrile Butadiene Styrene |
| **AI** | Artificial intelligence |
| **CHF** | Clothing, Household linen and Footwear |
| **$CO_2$** | Carbon dioxyde |
| **DPP** | Digital Product Passport |
| **EM** | Electromagnetic |
| **EPDM** | Ethylene Propylene Diene Monomer |
| **ERP** | Enterprise Resource Planning |
| **EVA** | Ethylene Vinyl Acetate |
| **HSI** | Hyperspectral Imaging |
| **MIR** | Mid Infrared |
| **NFC** | Near Field Communication |
| **NIR** | Near Infrared |
| **NR** | Natural Rubber |
| **PA** | Polyamide |
| **PA6 / PA66** | Polyamide 6 / Polyamide 66 |
| **PET** | Polyethylene Terephtalate |
| **PLA** | Polylactic Acid |
| **PP** | Polypropylene |
| **PPE** | Personal Protective Equipment |
| **PU** | Polyurethane |
| **PVC** | Polyvinyle Chloride |
| **RFID** | Radio Frequency Identification |
| **RGB** | Red Green Blue |
| **RUB** | Rubber |
| **SBR** | Styrene Butadiene Rubber |
| **SWIR** | Short Wave Infrared |
| **TPU** | Thermoplastic Polyurethane |
| **TRL** | Technology Readiness Level |
| **VIS** | Visible |
| **XR** | X-rays |

[1] https://eur-lex.europa.eu/EN/legal-content/summary/ecodesign-requirements-for-sustainable-products.html

# INTRODUCTION

This study was carried out as part of the update and enhancement of the state-of-the-art of European technologies for optical sorting, material recognition and preprocessing of textiles, published in 2023. Interviews were conducted with industry stakeholders at the end of 2025 and the beginning of 2026 in order to gather information on the latest innovations and discuss the limitations of the technologies currently in use.

The objectives of this update are as follows:

- To provide an updated overview of the technologies and industrial solutions used for the automated sorting and material preprocessing of textiles and footwear;
- To map industry stakeholders and European projects.

This report is structured around four major sections:

- **Material (and colour) sorting of textiles and footwear**, to direct them to the appropriate recycling streams, also known as **sorting for recycling**;
- **Textiles trims removal**, enabling the removal of external disruptors to recycling[2];
- **Footwear disassembly**, aimed at separating the different shoe components for recycling;
- **Sorting for second-hand**, presenting the technologies and solutions designed to identify items and reintroduce them into second-hand channels.

Each section first presents the existing principles and technologies, then provides an overview of European solutions, operational lines and identified projects. Other solutions exist worldwide; this study focuses on solutions available in Europe.

# 1. Sorting for recycling

Sorting of post-consumer non-reusable textiles and footwear for recycling, also known as **sorting for recycling**, is a key step in the recycling chain. In particular, it aims to identify materials used in textiles and footwear so that they can be directed to the appropriate recycling streams.

This section presents the state of the art of material recognition technologies, followed by an overview of industrial solutions and existing projects in Europe.

## 1.1. The different sorting-for-recycling technologies

### The stages of automated sorting for recycling:

Sorting for recycling is based on three main successive stages which can be more or less automated:

1. **Feeding textiles or footwear in the form of full items, clippings or shredded material**;
2. **Identifying material, colour** and other characteristics (using spectroscopy, RGB camera, etc.);
3. **Physically separating the items** on the basis of the classification made during the identification stage, using an ejection system.

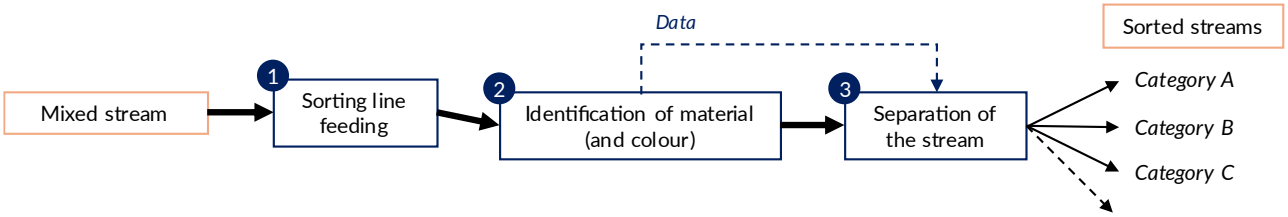


**Figure 1 – Stages of automated sorting for recycling**

The stage concerning the identification is expWoold here after.

[2] Study on recycling disruptors and facilitators in Textiles and Footwear, Refashion, February 2025

## Material identification using spectroscopy

Today, material identification is mainly carried out using spectroscopy technologies.

Spectroscopy (or spectrometry) is a non-destructive analytical technique that consists of illuminating a sample with an electromagnetic wave (1) and measuring the reflected or transmitted light (2). Each material has a specific spectral signature (3) related to its chemical composition. By comparing this signature with a database of reference spectra, it is possible to identify the material making up the textile or the component being analysed.

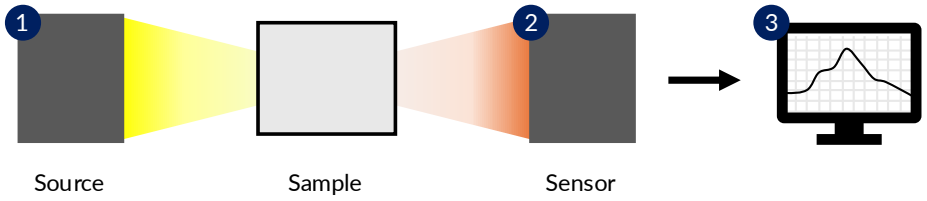


**Figure 2 : Functioning principle of spectroscopy**

There are several electromagnetic spectrum domains: visible, infrared (IR), ultraviolet (UV), X-rays, etc. Each one is characterised by a frequency (Hz) or wavelength (m) and corresponds to a wave–matter interaction and a specific physical phenomenon.

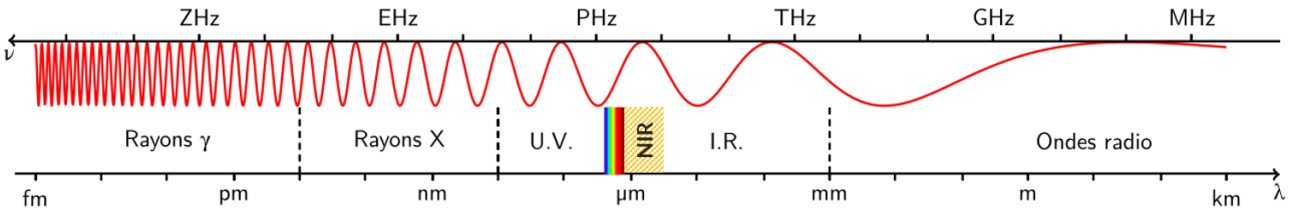


**Figure 3 - Electromagnetic spectrum domains (Source : Wikipedia)**

### Near infrared (NIR):

Near-infrared spectroscopy (NIR) is the most widely used material recognition technology and operates within a wavelength range of 780 to 2,500 nanometres.

### Examples of textile materials NIR spectra

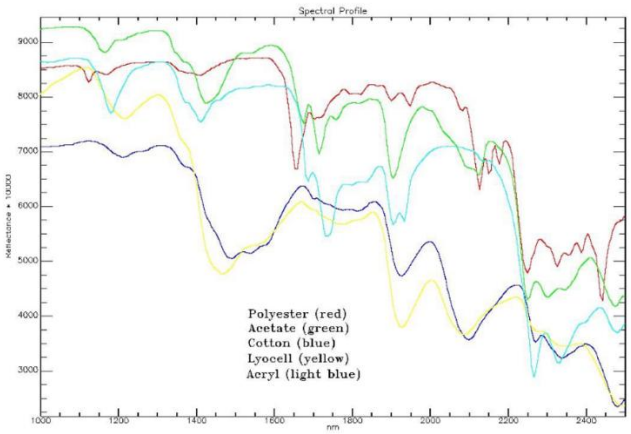


**Figure 5 – Spectra of different pure materials**
(Source : SPECIM. Esko Herrala)

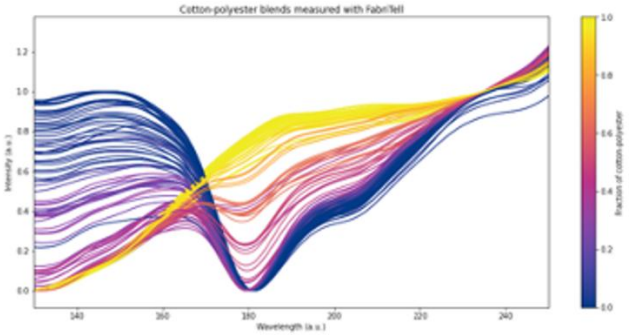


**Figure 4 – Spectra of cotton/polyester blends**
(Source : Matoha. Introduction to near-infrared spectroscopy)

NIR spectroscopy is used with **point sensors** (measuring at one or more points). One variant of point-based NIR measurement consists in using a **hyperspectral camera (HSI)** or a multispectral camera, which can simultaneously capture images and spectral information. Unlike a point-based NIR sensor, these cameras acquire a spectrum for each pixel in the image. This makes it possible to produce a 2D image of the material composition across all or part of the item's surface. The same principle can also be implemented using a multitude of individual NIR sensors positioned so as to cover the entire analysis field, thereby reconstructing spatial information equivalent to a hyperspectral image.

This feature is particularly important for textiles, as it allows to detect the composition of textile blends and determine whether they consist of intimate blends (two or more different fibres blended within the same yarn) or yarns made of different material compositions in a fabric (woven or knitted). It also makes it possible to detect a non-uniform composition on the surface, for example a flock print or an embroidery applied to a textile.

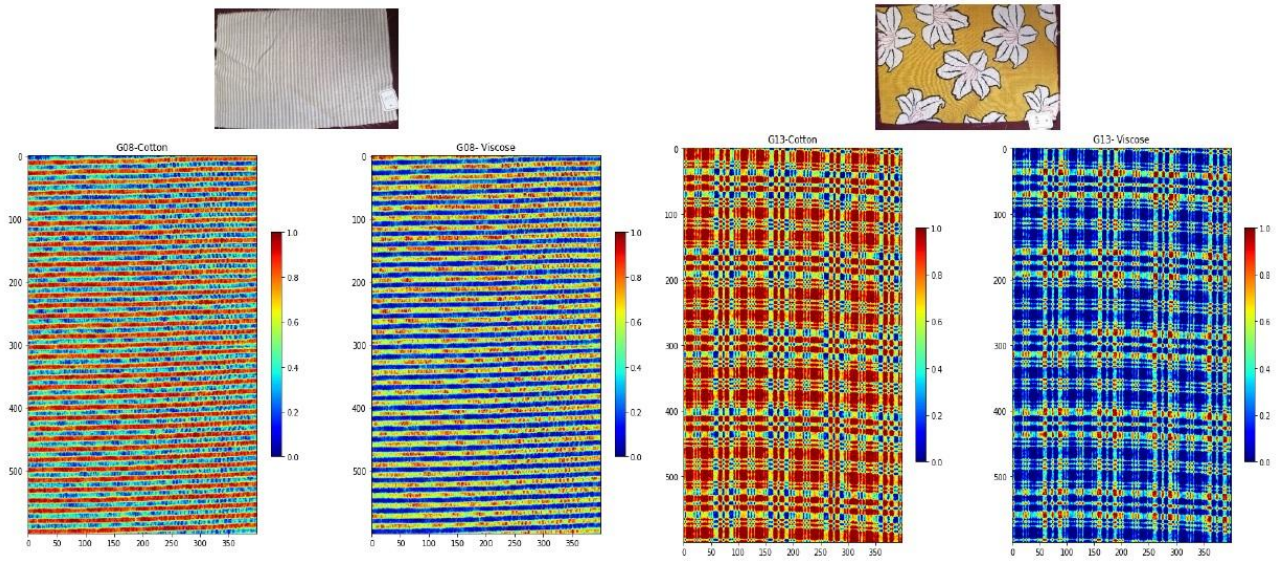


**Figure 6: Sample hyperspectral images of two cotton/viscose fabrics : woven on the left, and printed on the right**
(Source : Plateforme d'Imagerie Multi Spectrale (PIMS) - CEA DNAQ)

**NIR technology performance:**

The **performance** of a spectrometric material recognition system depends on:

- The **quality of the measuring equipment** *(hardware)*: optical system, light source, resolution, spectra reproducibility, etc.
- The **reference database** *(library)*: the number and representativeness of the materials available in the database.
- The **classification algorithm** *(software)*: model used, configuration, etc.

**If any one of these aspects is deficient, the material identification system will fail to deliver the expected performance.**

One of the main challenges in spectroscopy remains the creation of a reliable and substantial database to enable the identification of a large number of materials. It is with this objective in mind that Refashion developed the Refashion textile materials Library, to help technology suppliers calibrate their equipment using samples with certified material compositions.

**Limitations of NIR technology:**

Despite its maturity and widespread industrial use, near-infrared (NIR) spectroscopy presents several technical limitations regarding textiles and footwear sorting. These limitations were confirmed during interviews conducted with several equipment suppliers and developers.

- **Surface analysis**: spectroscopy remains a surface-detection technology and only measures the light reflected or transmitted by the visible surface of the sample. Non-homogeneous surfaces, such as gimped yarns, double-sided fabrics, multilayered items, surface treatments (coatings, finishes, dyes, waterproofing, etc.), are therefore problematic, as the technology cannot detect the underlying materials;
- **Wet items**: following the same principle, wet items interfere with light scattering and consequently with the correct identification of the materials;
- **Blended materials** (with two or more different materials): the precise determination of proportions, even in the case of two materials, is subject to a variable margin of error depending on: the type of blend, the spectrometer and the textile structure. Nevertheless, improvements to the databases make it possible to achieve notable progress in the identification of two-material blends and, in some cases, three-material blends (e.g. cotton / polyester / elastane);
- **Materials present in small proportions**: accuracy and reliability decrease when a material is present in a very small proportion or depending on the nature of the blend (e.g. elastane often less than 5%);
- **Chemically similar materials**: materials with similar chemical structures (e.g. cotton and viscose, two cellulosic fibres; or TPU and PU) may be difficult to differentiate;
- **Dark colours**: some pigments, particularly carbon black used to dye synthetic or man-made materials, strongly absorb near-infrared radiation, making detection impossible or highly noisy. This phenomenon is less pronounced in textiles than in plastics, and most black textile materials remain detectable using NIR.

### Other types of spectroscopies:

Other spectroscopy technologies exist, such as **SWIR** (Short-Wave Infrared, with wavelengths ranging from 1,000 to 2,500 nm) and **MIR** (Mid Infrared, with wavelengths ranging from 2.5 to 25 µm). These technologies can be used alongside NIR to analyse complex textiles and footwear, as tested during the CEA MISTERY project[3]. **Raman spectroscopy**, which uses a laser beam as a light source, was also explored during the CRTX.ai project (Germany) to differentiate chemically similar fibres. However, due to the high costs involved and the sensors sensitivity, these technologies have not been industrially developed for textile or footwear applications.

New approaches are also emerging, with companies such as *PLAS'TRI* and *IRIS*, seeking to increase detection depth and overcome the surface-limited nature of NIR. This work explores other spectral ranges and innovative measurement geometries, paving the way for more precise recognition of thick, coated or multilayered materials.

### Material recognition using a digital identifier:

Product identification can also be based on information embedded when the product is placed on the market, through the creation of a unique identifier associated with a digital product record describing the item's main characteristics (composition, colour, presence of disruptors, recycling instructions, etc.). Several technologies can be used to embed this digital identifier.

**Table 1 – Digital identifiers solutions**

| Medium | Principle | Advantages / limits | Examples of solutions |
|---|---|---|---|
| Product information label | Information printed on textile | Simple but often missing or illegible after many washes | |
| QR Code | Optical reading of the identifier linked to a database | Cheap but requires visibility and cleanliness | |

[3] Refashion 2021 Innovation Challenge winning project

| | | | |
|---|---|---|---|
| **RFID (Radio Frequency Identification)** | Remote radiofrequency reading of an embedded chip | Automatable, fast, but cost and recyclability to be managed | Primo1D (RFID thread), cf. Decathlon 4RFID project |
| **NFC (Near Field Communication)** | Short-range variant of RFID, readable via smartphone | Easy to use, but limited range (≈ 10 cm) and still high cost | |
| **Chemical marker** | Reading a chemical marker (e.g. DNA, fluorescent) | Need for a specific sensor but ensures material traceability, not widespread yet | SMX<br>FibreTrace<br>Haelixa |

## Complementary technologies to material sorting

Automated sorting equipment is not limited to material identification alone. Many machines incorporate additional modules, such as an optical or RGB camera for colour sorting, or combine several sensors (NIR, cameras, X-rays) to cross-reference data on the composition, structure or density of the materials. Magnetic and Eddy-Current separators, as well as inductive sensors, can also be integrated to detect the presence of ferrous and non-ferrous metals. These additional features can enrich the information collected and improve the quality of sorted streams.

## Material identification applied to footwear

Automated footwear sorting is advancing, driven by the adaptation of spectroscopy technologies already used for plastics and textiles. Current sensors can analyse the polymers and elastomers making up soles and other footwear components.
Until recently, the main obstacle to the development of these solutions was not the technology itself, but the lack of spectral databases specific to the wide range of materials used in shoe soles (EVA, PU, TPU, natural or synthetic rubber, formulations containing fillers or additives).

To address this challenge, Refashion developed a footwear materials Library, consisting of characterised samples (soles). This database provides an essential foundation for training classification algorithms and making material identification more reliable for these complex components.

## Types of sorting-for-recycling equipment

NIR technologies are available in a wide range of equipment, from handheld spectrometers and NIR sorting tables to automated lines for industrial sorting for recycling.

### Automated sorting lines

Two main types of automated sorting lines are currently used or being developed to sort high-volume streams. These lines can incorporate different sensors and cameras to identify material compositions, colours and other features (fabric structure, metal components, etc.).

- **Binary or ternary sorting machine:** The stream is separated into two or three categories (for example: cotton, polyester, other materials). These machines operate at high speeds (several metres per second) and can process a large number of items. They are particularly well suited to continuous or high-throughput sorting processes, and they work more efficiently with a pre-sorted input stream.

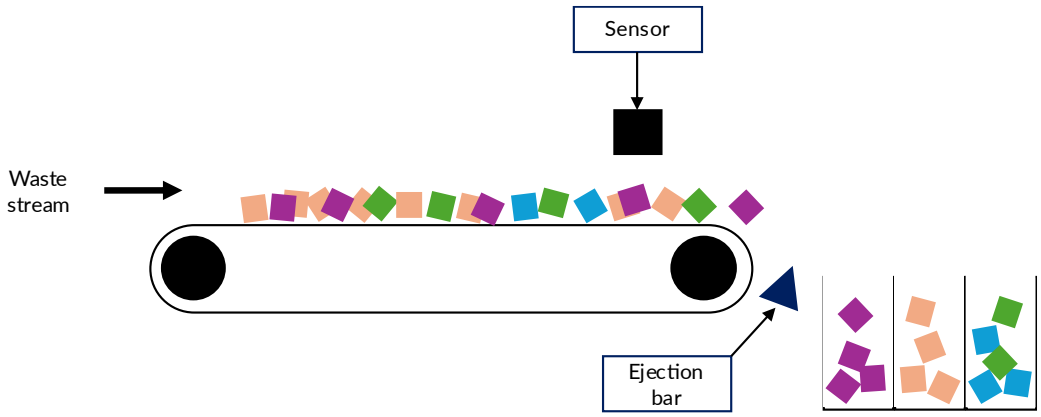


**Figure 7 : Ternary sorting line operating diagram**

- **Multi-category sorting machine**: The line can separate items into a larger number of categories (up to several dozen), but at a lower throughput (approximately one item per second). The stream travels along a long conveyor, where sorted items get separated by pneumatic ejection (air nozzles), mechanical or robotic systems.


**Figure 8: Multi-category sorting line operating diagram**

**Handheld spectrometers:**

Handheld spectrometers are compact and lightweight devices that allow for easy analysis of a sample's material composition. They can be used at manual workstations to assist operators with material recognition of the items intended for recycling, or for quality control.

**NIR sorting tables:**

NIR sorting tables are tables equipped with integrated NIR sensors, combined with AI algorithms. They are designed to facilitate material sorting operations for low- and medium-throughput streams.

Handheld spectrometers and NIR sorting tables are more versatile types of equipment that only enable material recognition (NIR sensor only). Colour sorting or the detection of other surface characteristics are not possible with this equipment that does not incorporate an RGB camera or any other module.

## Costs of the solutions:

The acquisition costs of the various automated sorting solutions vary significantly:

- Handheld spectrometer: €2,000 to €15,000.
- NIR sorting tables: €9,000 to €25,000.
- Automated sorting lines: €100,000 to €1,000,000, depending on the capacity and the complexity of the line (available options).

## 1.2. Automated sorting machine suppliers – Textiles

# Industrial solutions

### 1.2.1. NewRetex (Denmark)

| Equipment | NewRetex range |
|---|---|
| Detection (technology) | Materials (NIR) + Colours (VIS) + Disruptors (XR) + Typology (AI) |
| Sorting | Multi-category |
| Application | Textiles |
| Input format | Whole items |
| Maturity | Industrial solution |

**Figure 9 : NewRetex line in Denmark**
Source : NewRetex

NewRetex, a Danish company founded in 2020, develops automated sorting and traceability solutions combining robotics, sensors and AI, and operates a sorting facility (>3,000 t/year) in Bjerringbro, Denmark. Its lines are adopted from the industrial laundry sector, they use conveyors for ejection (replacing air nozzles) and integrate modules such as the THOR feeding robot, the MIMIR NIR sensor for material recognition, the HEIMDAL camera for colour and the ODIN X-ray solution for the detection of external disruptors to recycling. AI models are open and customizable, and allow for automatic sorting of re-use as well as recycling.

**Performance:**

For blends, 59 categories with predefined material composition percentages are available. Detection of minority materials is possible from 1 to 2%, with slightly reduced accuracy at these very low rates. NewRetex specifies that it is also possible to add new categories of materials on request, and to be able to detect wet textiles.

| Line type | Feeding | Sensors | Capacity |
|---|---|---|---|
| **Semi-automatic** | Manual (3–5 operators) | MIMIR + HEIMDAL | 2,200 pieces/h (≈1,300 t/year/shift) |
| **Single automatic** | 2 THOR robot | MIMIR + HEIMDAL + ODIN | 2,200 pieces/h |
| **Dual automatic** | 4 THOR robots | 2× MIMIR + 2× HEIMDAL + 2× ODIN | 4,400 pieces/h (≈2,600 t/year/shift) |

| Recognized materials | |
|---|---|
| **Pure** | Acetate, Acrylic, Cotton, Elastane, Lyocell, Polyamide (PA6 & PA66), Polyester, Silk, Viscose, Wool |
| **Blends** | 2 fibres: Cotton / Elastane, Cotton / Polyester, Polyester / Elastane, Wool / Acrylic...<br>3 fibres: Cotton / Polyester / Elastane |

**Locations:**

| Testing centre | Examples of equipped facilities |
|---|---|
| Bjerringbro (Denmark) | NewRetex A/S (Denmark)<br>5 European sites in planning |

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Andreas LEHMANN ENEVOLDSEN – Ingénieur Développement – ale@newretex.com

### 1.2.2. PELLENC ST (France)

| | |
|---|---|
| **Equipment** | **MISTRAL+ CONNECT and MULTITEX** |
| **Detection (technology)** | **Materials (NIR) + Colours (VIS)** |
| **Sorting** | **Binary or ternary Multi-category** |
| **Application** | **Textiles** |
| **Input format** | **Whole items, clippings, shreds** |
| **Maturity** | **Solutions industrielles** |

Pellenc ST is a global leader offering automated optical sorting solutions for different recycling streams. Since 2022, Pellenc ST offers the **MISTRAL+ CONNECT** dedicated to textile sorting, combining NIR spectroscopy with photodiodes and colour vision (VIS). The MISTRAL+ CONNECT can sort full garments, clippings or shreds (grinds) (via manual feeding or automated feeding – ANDRITZ integration).
Developed in collaboration with ANDRITZ, a **new multi-category version MULTITEX** is available since beginning of 2026.

#### Performance:

The claimed industrial performance for the MISTRAL+ CONNECT is: 95% sorting efficiency on most categories et >95% mass purity (accuracy) after purity sorting performed on clippings.

For a 100% automated process, its nominal speed varies from 4 to 8 t/h for full garments sorting, and from 2 to 3 t/h for clippings sorting. The MISTRAL+ CONNECT exists in several widths: 800-1200-1600-2000-2400-2800mm.

The MULTITEX has a rate of 1,3t/h.

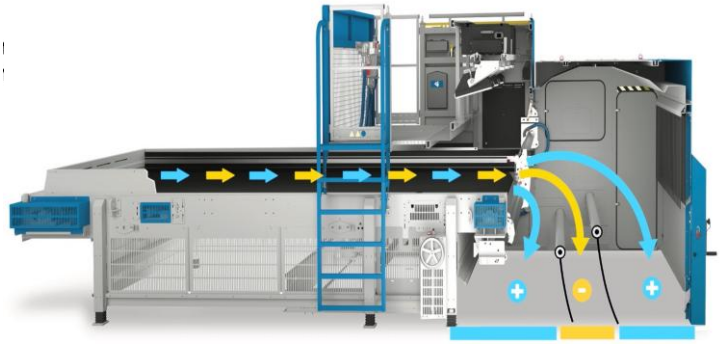


**Figure 10 : MISTRAL+ CONNECT**
Source : Pellenc ST

| Recognized materials | |
|---|---|
| **Pure** | Acrylic, Cotton, Polyamide, Polyester, Silk, Viscose, Wool |
| **Blends*** | Cotton/Elastane, Cotton/Viscose, Polycotton (80%/20% – 60%/40% – 40%/60% – 20%/80% + 90%/10% or 95%/5% variants), Polyester/Elastane, Polyester/Polyamide, Wool/Acrylic, Wool/Polyester… |

**Detection of a minority material possible from 5%, including elastane in blends with cotton or polyester*

Detected colours cover a wide spectrum (yellow, red, blue, black, white) with recognition of light to dark shades.

#### Available options:

- **Turbosorter system** for stabilising clippings on the conveyor
- **Aerolight module** enabling to regulate the air flow in order to improve accuracy at ejection
- **Inductive sensor** to extract metallic hard points
- **BrAIn AI option** on spectral database to enhance contaminant materials detection (e.g. elastane)

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| **Nouvelles Fibres Textiles (France)**<br>Pertuis (France) | Nouvelles Fibres Textiles (France)<br>Insertega (Spain) |

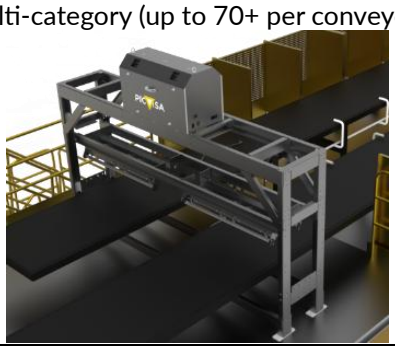
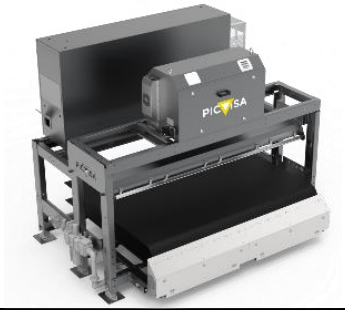
**Contacts:** Raphael JOSSELIN VERDIER – Project Manager – r.josselin@pellencst.com
Sylvain BAUMAS – Responsable commercial France – s.baumas@pellencst.com

### 1.2.3. PICVISA (Spain)

| | |
|---|---|
| **Equipment** | **ECOSORT TEXTIL and ECOCLIP** |
| **Detection (technology)** | **Materials (NIR-HSI) + Colours (VIS / RGB) + Fabric structure + Item typology + Hard points (VIS+AI)** |
| **Sorting** | **Multi-category Binary or ternary** |
| **Application** | **Textiles** |
| **Input format** | **Whole items, clippings** |
| **Maturity** | **Industrial solutions** |

PICVISA is a Spanish company specializing in the development of optical sorting systems combining spectroscopy, computer vision and AI. Since 2019, PICVISA has been offering equipment with hyperspectral cameras for textiles automated sorting: **ECOSORT TEXTIL** (multi-category) and **ECOCLIP** (binary or ternary). Feeding is automatic (by conveyor) on the ECOCLIP, and automatic (robot) or manual on the ECOSORT TEXTIL. The latest versions include improved AI models for material detection on black/dark textiles and can also recognize fabric structure.

**Performance:**

| Machines | ECOSORT TEXTIL | ECOCLIP |
|---|---|---|
| **Sorting** | Multi-category (up to 70+ per conveyor)*  | Binary or ternary  |
| **Features** | Materials + Colours + Fabric structure (woven/knit) + Item typology | Materials + Colours + Hard points |
| **Input format** | Full garments | Clippings or full garments |
| **Capacity** | Up to 1 t/h per conveyor (3 conveyors possible) | Up to 2-3 t/h (depending on feedstock format) |
| **Recognized Materials**** | Pure: Acetate, Acrylic, Cotton, Elastane, Polyamide, Polyester, Silk, Viscose, Wool<br>Blends: Cotton/Polyester, Wool/Polyamide, Wool/Polyester... | |
| **Accuracy** | Claimed average accuracy of more than 90% under standard conditions | |
| **Options** | Inductive sensor for metal detection | |

**Number of categories can be custom made. // **The reference database includes more than 20 textile families and is continuously updated. Detection of a minority material possible from 5%.*

**Current developments:**

Current developments mainly focus on the ECOSORT TEXTIL, with the integration of **new visual recognition functionalities for 2nd hand**. The system already allows the identification of garment typologies and aims to integrate an automated garment condition assessment.

**Locations:**

| Testing centre | Examples of equipped facilities (ECOSORT TEXTIL) |
|---|---|
| Calaf (Spain) | Fratelli Esposito (Italy) / Essaimons (France)<br>Lipor (Portugal) / Textile House (Slovakia)<br>+ 15 additional confidential references |

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### 1.2.4. BT-Systems GmbH, competence centre REDWAVE (Austria)

| | |
|---|---|
| Equipment | REDWAVE TEX range and REDWAVE TEX 2i & QI |
| Detection (technology) | Materials (NIR-HSI) + Colours (VIS) + Metals (inductive sensor) |
| Sorting | Binary/ternary<br>Multi-category |
| Application | Textiles, Footwear |
| Input format | Whole items, clippings<br>Shreds |
| Maturity | Industrial solutions |


**Figure 11 : REDWAVE TEX**
Source : REDWAVE

REDWAVE, the technology brand of BT-Systems GmbH, is an Austrian manufacturer specialising in multi-materials optical sorting equipment including textiles and plastics. The **REDWAVE TEX** range is the result of the transfer of its proven sorting technologies (hyperspectral + high speed prism linescan cameras) to the textile sector. REDWAVE TEX equipment can identify materials, colours and metal disruptors. Textiles are analysed on a conveyor belt and then directed by compressed air nozzles to different flows according to their classification. REDWAVE also offers REDWAVE TEX 2i equipment for the sorting of shreds (including from footwear).

#### Performance:

| Machines | REDWAVE TEX | REDWAVE TEX 2i | REDWAVE TEX QI |
|---|---|---|---|
| Sorting | Multi-category<br>(4 to 20 outputs) | Binary/ternary<br>(2 to 3 or 4 to 6 outputs) | Automatic analyser for quality monitoring or process control, no sorting |
| Features | Materials + Colours + Metals | | |
| Application | Full garments<br>(100 – 1000 mm) | Garments and clippings<br>(40 – 500 mm)<br>Shredded materials (> 3 mm) | Determination of material composition streams on belt conveyors |
| Capacity | Up to 4 t/h | Up to 16 t/h | Up to 4 t/h |
| Recognized materials* | Textiles: Acrylic, Cotton, Elastane, Polyamide, Polyester, Viscose, Wool… & 2-material blends<br>Footwear: ABS, EVA, PC, PU, PVC, RUBBER, SBR, TPU… | | |

**Possibility of adding new material categories*

#### Current developments:

- Extension of the material database
- Improved detection of black textiles
- Fine detection of elastane
- Integration of article typologies recognition

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Eggersdorf bei Graz (Austria) | Facilities in Germany and Benelux |

**Contact:** office.redwave@bt-systems.at

### 1.2.5. TOMRA (Norway)

| | |
|---|---|
| **Equipment** | **AUTOSORT™** |
| **Detection (technology)** | **Materials (NIR) + Colours (VIS) + Metals (EM)** |
| **Sorting** | **Binary or ternary** |
| **Application** | **Textiles** |
| **Input format** | **Whole items, clippings (>30mm)** |
| **Maturity** | **Industrial solution** |

TOMRA is a global leader in optical sorting and advanced detection solutions for various waste streams. Active in textile sorting since 2015, TOMRA has adapted its technologies for plastics and household waste sorting to textiles and complex materials recognition. The **AUTOSORT™** solution, the latest generation of the range, allows to identify textile fibres and colours. Feeding can be automatic or manual.

The equipment incorporates several exclusive TOMRA technologies:

- **FLYING BEAM™**, a patented system for homogenous illumination ensuring instant classification of all materials over the conveyor belt width;
- **DEEP LAISER™**, an object recognition system for advanced decision making and identifying **textiles containing carbon black** to keep them out of the flow.


**Figure 12 : AUTOSORT™ 5 (new generation) – TOMRA**
Source : TOMRA

#### Performance:

The AUTOSORT™ can be configured for binary or ternary sorting, with a modular belt width of up to 2.8 meters and a speed of up to 4.5 t/h with a 3m/s conveyor belt. Multiple machines can be cascaded to increase the number of outputs.

| Recognized materials | |
|---|---|
| **Pure** | Acrylic, Cotton, Polyamide, Polyester, Silk, Viscose, Wool |
| **Blends** | Polycotton, blends of pure fibres with elastane (>2%) |

*TOMRA can adapt its training models on request, provided that a representative reference batch is available.*

The VIS analysis makes it possible to distinguish main textile shades, including specific shades (e.g. denim blue) and their light or dark shades. The system is also capable of sorting cut or shredded textiles and eliminating unwanted fabrics, metal, pieces with seams or PU or PVC coatings, that are recycling disruptors.

#### Options:

- **Metal detection module (EM)** (detecting presence of metal FE&NE)
- **DEEP LAISER™** (advanced data-driven decision making – e.g. pattern detection)

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Mülheim-Kärlich near Koblenz (Germany) | SYSAV (Sweden) (*for sale)*<br>IGERS (Italy) |

**Contact:** Lea Höll – Business Development – lea.hoell@tomra.com

### 1.2.6. VALVAN (Belgium)

| | |
|---|---|
| **Equipment** | **Fibersort**<br>**Manual Fibersort** |
| **Detection (technology)** | **Materials (NIR) + Colours (VIS)** |
| **Sorting** | **Multi-category**<br>**Scanning table** |
| **Application** | **Textiles** |
| **Input format** | **Whole items** |
| **Maturity** | **Industrial solutions** |

**Figure 13 : Fibersort**
Source : Valvan

Valvan is a Belgian manufacturer specialising in the design of machines for textiles sorting. The company develops automated solutions integrating NIR spectroscopy, vision and AI.

Continuously optimized since its launch in 2019, the **Fibersort** is a multi-category sorting machine, capable of recognizing multiple textile materials and colours by combining AI, NIR and colour sensors, and 2D & 3D cameras. Detected colours cover a wide spectrum and can be defined by the operator. It is also possible to recognize the fabric structure (woven or knitted), using an additional camera.

The ejection system works by compressed air. Feeding can be automatic (with a robot) or manual. In continuous mode, the machine can process up to 3,600 items per hour.

Valvan also offers the **Manual Fibersort** which consists in a table with an integrated NIR device (without colour sorting).

#### Performance:

The claimed average accuracy of the Fibersort is 99% for pure fibres identification and 95% on 2-fibre blends. With blends of 3 fibres or more, the accuracy tends to drop, mainly due to the fabric structure and the fact that NIR only scans the fabric surface.

To ensure good material detection, Valvan recommends sorting dry textiles (< 8% moisture).

| Recognized materials | |
|---|---|
| **Pure** | Acrylic, Cotton, Elastane (> 1%), Polyamide (PA6 and PA66), Polyester, Silk, Viscose, Wool |
| **Blends** | Blends of pure materials (2 or 3 materials) |

#### Current developments:

- Extension of the material database;
- Multi-layered items detection.

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Menen (Belgium) | 13 facilities in Europe including:<br>Wieland Textiles (Netherlands)<br>KOOPERA (Spain)<br>Formacio i Treball (Spain)<br>CETIA (France)<br>SATCol (UK) |

**Contact:** Jean-François GRYSPEERT – Sales & Development Manager – jfg@valvan.com

### 1.2.7. Wastex (Spain)

| | |
|---|---|
| Equipment | SORTER R |
| Detection (technology) | Materials (NIR) + Colours (VIS) |
| Sorting | Multi-category |
| Application | Textiles |
| Input format | Whole items |

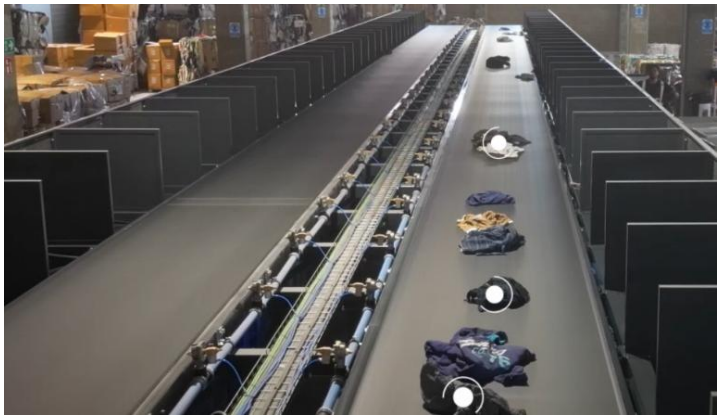

**Figure 14 : SORTER R sorting line**
Source : Wastex

Wastex (technology division of COLEO) is a Spanish company specialising in optical sorting and textile traceability, combining spectral detection and AI.

Wastex has developed the **SORTER R** equipment that identifies textiles' material composition and colour via a NIR hyperspectral camera, before automatically ejecting them via compressed air. Sorting can be organized into several parallel lines (up to 4 conveyors connected to the same detection module). Depending on the configuration, the line can reach speeds of several tonnes per hour. Feeding can be manual or semi-automated.

#### Performance:

The purity level mainly depends on calibration and on the detection limit set during adjustments. The spectral database, continuously enhanced thanks to feedback from connected partner sorting facilities, gradually increases the accuracy for the recognition of complex blends.

| Recognized materials | |
|---|---|
| **Pure** | 14 fibres including: Acrylic, Cotton, Elastane, Polyamide, Polyester, Viscose, Wool |
| **Blends** | Blends of pure materials |

*Limits on the detection of fibres in very small proportions, notably elastane < 3%.*

#### Option:

- RGB camera for identifying item typologies and for detecting defects (stains and holes)

#### Current developments:

- Developments on the recognition of complex and black materials;
- Optimized speed and classification reliability.
- Shape recognition and cleaning of non-textile fractions from waste streams.
- Fabric structure recognition (woven and knitted)
- Sorting for reuse to identify various attributes of the item and evaluate its resale value in the 2nd hand market
- Hard points scanner.

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Barcelona (Spain) | 2 partner sorting facilities in Spain (COLEO)<br>Recyclocal Textiles (France)<br>1 project in Eastern France |

**Contacts:** Harmonie KOCH – Business Developer – harmonie.koch@coleo.es
Axel PLAZA – Directeur Wastex – axel.plaza@coleo.es

# Sensors for industrial sorting lines

## 1.2.8. LLA Instruments GmbH (Germany)

| | |
|---|---|
| **Equipment** | **KUSTA-System** |
| **Detection (technology)** | **Materials (SWIR) + in option: Colours (VIS)** |
| **Sorting** | **System for binary/ternary line** |
| **Application** | **Textiles** |
| **Input format** | **Whole items, clippings** |
| **Maturity** | **Industrial solutions** |

**Figure 15 : KUSTA-System**
Source : LLA Instruments

LLA Instruments GmbH, a specialist in hyperspectral imaging for more than 30 years, offers optical detection and sorting solutions for textiles. Its **KUSTA** range, including the **KUSTA-System** industrial unit (based on SWIR spectroscopy) **can be integrated on binary/ternary sorting lines** with a maximum width of 2.8 metres and a speed of 3 m/s.

### Performance:

| Recognized Materials – KUSTA-System | |
|---|---|
| **Pure** | Acetate, Acrylic, Cotton, Lyocell, Polyamide, Polyester, Polypropylene, PU-based prints, Silk, Viscose, Wool |
| **Blends** | **Cotton/Polyester, Cotton/Elastane, Polyester/ Elastane**, **Cotton/Polyester/Elastane**, Cotton/Acrylic, Polyamide/Elastane, Acrylic/Polyamide, Polyester/Polyamide, Viscose/Elastane, Wool/Acetate, Polyester/Acrylic |

***For the first 4 blends**, the average standard detection error varies between 1.5% and 8%, with a limit of detection ranging from 5% to 10%. LLA has also created subclasses for these common blends in textiles:*

- Polycotton blends: subclasses for each ten percent,
- Two subclasses for cotton/elastane (EA) blends: EA <5% and EA >5%,
- Three subclasses for polyester/elastane and cotton/polyester/elastane blends: EA ≤5%, 5% ≤EA ≤ 10% and EA >10%.

### Current developments:

- Wool blends recognition
- Improved performance on dark textiles
- Optimized accuracy on low elastane content (<5%)

### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Berlin (Germany) | Equipment used on automated lines in multiple European sorting facilities *(incl. prev. SOEX in Germany, closed early 2025)* |

**Contact:** Nika HOLUB – Inside Sales Representative – n.holub@lla.de

# Pilots / demonstrators

## 1.2.9. Looper Textile Co. (Sweden)

| | |
|---|---|
| Equipment | Looper automated sorting line |
| Detection (technology) | Material (NIR) + Colour (VIS) + Metal parts (metal sensor) |
| Equipment type | Multicategory |
| Application | Textiles |
| Input format | Whole items |
| Maturity | Industrial pilot |

Looper Textile Co. is a Swedish independent company owned 50% by H&M Group and 50% by REMONDIS. Looper Textile Co. has developed a proprietary automated sorting line, combining NIR, optical and metal sensors, for sorting post-consumer textiles by material type, colour and metal content. The line has been active since September 2023.

Textiles are manually fed onto the conveyor and automatically sorted by lateral air nozzles into (currently) eight different categories.

**Figure 16 : Looper Textile automated sorting line in Polch, Germany**
Source : Looper Textile Co.

### Performance:

The line can process up to 500 kg/h (about 2,000 items/h).

Up to 20 different material compositions can be detected. The claimed accuracy of textile material recognition reaches 95% for pure materials and 92% on blends.

| Recognised materials | |
|---|---|
| **Pure** | Acetate, Acrylic, Cotton, Polyamide, Polyester, Silk, Viscose, Wool |
| **Blends** | Any 2-fibre blend of recognised pure materials |

### Current developments:

- Working on fabric structure detection with high resolution camera
- Working on automatic feeding of textiles (using robotic solutions) to increase throughput

### Locations:

| Testing centre | Equipped plant |
|---|---|
| N/A | Polch, Germany |

**Contact:** Felix Hoelzer – COO Looper Textile Co. – hoelzer.felix@loopertextile.com

### 1.2.10. CETIA (France)

| | |
|---|---|
| Equipment | SensorHUB |
| Detection (technology) | Materials (NIR) + Colours (VIS) + Typology (VIS) + Hard points (XR) |
| Sorting | Multi-category |
| Application | Textiles, Footwear |
| Input format | Whole items |
| Maturity | Demonstrator |

CETIA, a technical centre based in Hendaye, develops innovative solutions for sorting and dismantling textiles and footwear, combining robotics, vision and AI.

Its **SensorHUB solution** is a smart and modular sorting cell for textiles and footwear combining:

- BRUSTIA X-ray module to detect hard points (buttons, hidden rivets, objects inside pockets, etc.);
- 3D and 2D vision for colours;
- Hyperspectral camera and NIR sensor for materials;
- AI algorithms designed and trained by CETIA.

The SensorHUB can be tested at CETIA in Hendaye.


**Figure 17 : SensorHUB cell**
Source : CETIA

**Contact:** Pauline ARROUASSE – Sales Manager – pauline.arrouasse@cetia.tech

### 1.2.11. IRIS Technology Solutions (Spain)


**Figure 18 : Solution developed by IRIS Technology Solutions**
Source : WhiteCycle

IRIS Technology Solutions, based in Barcelona, develops optical solutions for material recognition and spectral analysis (NIR, Raman, hyperspectral) coupled with AI, since 2007.

The European WhiteCycle project, coordinated by Michelin and launched in 2022 with 15 partners, aims to develop an industrial solution capable of recycling complex polyester-rich waste, including multilayered textiles, pipes and tyres. One of the project's objectives is the development of innovative sorting technologies for identifying and separating multilayered textiles.

In this context, IRIS Technology Solutions plays a key role in developing a **solution combining its Visum HSI™ technology with AI to detect presence of polyester and classify PET multilayered textiles into 3 categories** (≥ 90% PET, < 90% PET, 0% PET).

**Contact:** Jose Ortega – Sales & Marketing Manager – jortega@iris-eng.com

### 1.2.12. SPECIM (Finland)

| | |
|---|---|
| **Equipment** | **Specim RETEX** |
| **Detection (technology)** | **Materials (NIR-HSI) + Colours (VIS)** |
| **Application** | **Textiles** |
| **Input format** | **Whole items, clippings** |

**Figure 19 : Specim RETEX test portal**
Source : KONICA MINOLTA (Youtube)

Specim, a KONICA MINOLTA company, offers Specim RETEX, a solution resulting from the HYPER RETEX project, consisting of a detector integrating a SPECIM FX17 hyperspectral camera (material composition), a line-scanning camera (colours and textile surface characteristics), with a software designed in Italy. Launched in April 2026.

**The sorting system is not included, Specim RETEX is designed to work on binary/ternary or multi-category sorting lines.**

| Recognized materials | |
|---|---|
| **Pure** | Acrylic, Cotton, Elastane, Polyamide (PA6 & PA66), Polyester, Silk, Viscose, Wool |
| **Blends** | 2-fibre blends of pure materials |

The claimed average accuracy varies from 95% to 99% depending on the material.

**Current developments:** Recognition of new blends and of fabric structure.

| Testing centre | Examples of equipped facilities |
|---|---|
| Rome (Italy) | MagnoLab consortium site (Italy) + other customers |

**Contact:** Federico Faina – Technical Product Owner - federico.faina@konicaminolta.it

### 1.2.13. 3U Vision – Next Waste (France)

| | |
|---|---|
| **Equipment** | **ScanTex** |
| **Detection (technology)** | **Materials (NIR-HSI) + disruptors (AI)** |
| **Sorting** | **Multi-category** |
| **Application** | **Textiles** |
| **Input format** | **Whole items, clippings** |

3UVision, in partnership with NextWaste, offers **ScanTex**, a textile material detection solution integrating a hyperspectral camera (NIR-HSI) with real-time restitution of results. The system maintains its performance up to 4 to 5 items/sec. Sorting after detection is also possible depending on the selected options. The ScanTex solution can be tested at the testing centre in Imola (Italy). Commercial launch in March 2026.

| Recognized materials | |
|---|---|
| **Pure** | Acrylic, Cotton, Elastane, Polyamide (PA6 & PA66), Polyester, Silk, Viscose, Wool |
| **Blends** | Polycotton, blends of pure material + elastane |

- Efficiency superior to 95 - 98%
- Error rate under 1 % for pure fibres
- Margin of error of less than 3% on estimated proportions within polycotton blends
- Possibility of adding new materials after training of the algorithms (developments in progress)
- Detection of recycling disruptors: buttons, metal, zippers…


**Figure 20 : ScanTex equipment**
(Source : 3U Vision - NextWaste)

**Contact:** Guillaume-Henri HUREL - NextWaste SAS - ghh@nextwaste.fr

## 1.3. Handheld spectrometers and NIR sorting tables suppliers - Textiles

### 1.3.1. MATOHA Instrumentation Ltd. (UK)

| Equipment | FabriTell range |
|---|---|
| Detection (technology) | Materials (NIR) |
| Application | Textiles |
| Input format | Whole items |
| Maturity | Industrial solution |


**Figure 21 : FabriTell Bench**
Source : Matoha

MATOHA is a British company founded in 2018 specializing in the detection and rapid analysis of materials. Matoha designs NIR spectroscopy solutions for the textile and plastics industries. For textiles, its solution is the **FabriTell** range.

The **FabriTell** is available in different formats:

- **Desktop** (benchtop version),
- **Bench** (NIR sorting table),
- **Handheld** (handheld version).

Matoha also offers the **sensor on its own**, which can be integrated onto automated or semi-automated lines.

#### Performance:

FabriTell devices have an accuracy of ± 5% on pure materials and ± 10% on binary blends. Detection of elastane becomes uncertain below 5%.

The measurement is completed in less than a second.

| Recognized materials | |
|---|---|
| **Pure** | Acetate, Acrylic, Cotton, Elastane, Polyamide, Polyester, Polypropylene, Silk, Viscose, Wool |
| **Blends** | Cotton/Acrylic, Cotton/Elastane, Cotton/Polyamide, Cotton/Polyester, Cotton/Viscose, Polyamide/Elastane, Polyamide/Wool, Polyester/Acrylic, Polyester/Elastane, Polyester/Viscose, Viscose/Elastane, Wool/Acrylic, Wool/Polyester |

#### Current developments:

- Bench solution with additional sensors to improve recognition
- Automation project

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| London (United Kingdom) | Presence in 60 countries, about 950 units sold (FabriTell + PlasTell) |

**Contact:** Chris NEWTON – Chief Commercial Officer – chris@matoha.com

### 1.3.2. TrinamiX (Germany)

| | |
|---|---|
| Equipment | PAL One & PAL Two |
| Detection (technology) | Materials (NIR) |
| Application | Textiles |
| Input format | Whole items, clippings, shreds |
| Maturity | Industrial solution |

**Figure 22 : TrinamiX PAL Two**
Source : TrinamiX

TrinamiX GmbH, a subsidiary of the BASF group, is a German company specializing in NIR spectroscopy and materials analysis. Active in the textile sector since 2022, it develops portable spectrometers integrating advanced recognition algorithms for rapid identification of pure fibres and blends.

The **trinamiX** spectrometers combine a NIR optical sensor (1,300–2,350 nm) with cloud-based algorithmic processing. They are mainly used for quality control, R&D or assisted manual sorting.

The **trinamiX PAL Two**, marketed since October 2025, is more ergonomic than its previous version (**trinamiX PAL One**), and integrates a screen and an intuitive interface.

**Performance:**

The solution delivers a complete result in less than two seconds. The claimed average accuracy is ±7% on blends, with a reliable detection of minority materials from 5%.

| Recognized Materials – trinamiX Pal Two | |
|---|---|
| Pure | Acrylic, Cotton, Elastane, Polyamide, Polyester (PET and PTT), Polypropylene, Silk, Viscose, Wool |
| Blends | 21 blends in total, 15 with identified material percentages, including: Cotton/Polyester, Cotton/Viscose, Polyester/Acrylic, Viscose/Polyester… |

**Locations:**

| Testing centre | Examples of equipped facilities |
|---|---|
| Equipment rental only (short term (1 month) possible) | Undisclosed |

**Contact:** Adrian VOGEL – Segment Lead Circular Economy – adrian.vogel@trinamix.de

### 1.3.3. Spectral Engines – m-u-t (Allemagne)

**Figure 23 : NIRONE S**
Source : Spectral Engines – m-u-t

Spectral Engines - m-u-t, a German company specializing in the development of NIR portable sensors, partnered with Bosch and LSJH (Finland) in 2019 on a project dedicated to textile recognition via NIR spectroscopy. The project led to the creation of the **NIRONE S** device in 2021. The scan is carried out by simple contact with the textile surface (full garments) for about a second. Data is transmitted to a cloud platform. The sensor can be integrated into a sorting table (1 set-up at ERDOTEX in the Netherlands) and be tested at the testing centre in Frankfurt (Germany). Spectral Engines – m-u-t does not own a material database, LSJH has kept the database developed during the project.

**Contact:** Gregoire SAGET – Sales Manager - gregoire.saget@spectralengines.com

## 1.4. Other textile sorting for recycling solutions

Other solutions have been identified in Europe (below), and outside Europe (see Appendix).

### 1.4.1.HySpex (Norway)

HySpex by NEO, a Norwegian company, offers hyperspectral cameras and advanced imaging solutions for sorting. In collaboration with Norsk Tekstilgjenvinning (NTG) and Steco Miljø, NEO has developed an automated sorting line demonstrator with **HySpex** hyperspectral technology able of automatically classifying textiles according to 4 to more than 100 fibre types/blends.

### 1.4.2. KAPDAA (UK)

Kapdaa, a British company, has developed Ai4FIBRES, an automated textile sorting and recognition solution in a mobile version (solar energy), which can process up to 10t of post-consumer textiles / week. The system, equipped with UV light to kill bacteria, uses hyperspectral analysis and computer vision to identify material composition (16 materials and blends (supplier claim)), garment typology and colour, and nature and positioning of trims (closures, buttons, labels).

### 1.4.3. Next Technology Tecnotessile (Italy)

**Figure 24 : DAEDALUS system**
Source : Next Technology Tecnotessile

Next Technology Tecnotessile, an Italian textile research and innovation centre based in Prato, has developed DAEDALUS, a semi-automatic sorting machine designed for sorting post-consumer garments or clippings (>60 garments/min).

The equipment combines a hyperspectral camera (NIR) and a visible camera (VIS) with an artificial intelligence system capable of analysing material composition, colour and fabric structure, as well as garment condition.

Once recognition has been carried out, textiles are directed to modular unloading modules arranged along a conveyor belt. Classification is then carried out by compressed air nozzles or other ejection systems depending on the chosen configuration.

### 1.4.4. STEINERT (Germany)

STEINERT is a German manufacturer specializing in magnetic separation and sensor detection separation, applied to both metals and plastics. Steinert has recently been applying its optical and physical sorting technologies to textiles.

Their **UniSort PR EVO 5.0®** machine is used to test material sorting on textile clippings via a hyperspectral camera. Efficiency depends on calibration (lower efficiency on ≤ 40mm clippings) and homogeneous distribution of clippings on the conveyor belt. Currently recognized materials include cotton and polyester. Other materials may be recognized, but tests must be carried out at their testing centre in Cologne.

**Current developments:** Tests and calibration on textile materials, MIR adaptation for dark materials.

**Contact:** Florian GAUDRON - Sales Manager - florian.gaudron@steinert.de

## 1.5. Automated sorting machine suppliers – Footwear

# Industrial solutions

### 1.5.1. PICVISA (Spain)

| | |
|---|---|
| Equipment | ECOFLAKE range |
| Detection (technology) | Materials (NIR-HSI) + Colours (VIS / RGB) |
| Sorting | Binary |
| Application | Footwear |
| Input format | Shredded shoe soles (> 6mm) |
| Maturity | Industrial solution |

PICVISA is a Spanish company specializing in the development of optical sorting systems combining spectroscopy, computer vision and AI. PICVISA offers an automated sorting solution for shredded shoe soles with its ECOFLAKE range. This solution is composed of a hyperspectral camera to identify material composition (binary sorting) of shoe sole shreds, a high-resolution camera for colour, and an innovative belt feeding system, enabling enhanced stability of shreds and their efficient separation at ejection (via blowing).

**Performance:**

The ECOFLAKE can process shreds larger than 6mm, at a rate varying from 0.4 t/hour to 2 t/hour, depending on the model chosen (x600 or x1,200) and the input bulk density. The claimed average accuracy is more than 90% under standard conditions.

| Recognized materials (specific to footwear) | |
|---|---|
| **Pure** | ABS, EVA, Leather, PA, PC, PU*, PVC, RUB (rubber), TPU* |

**Difficulties in differentiating PU and TPU*

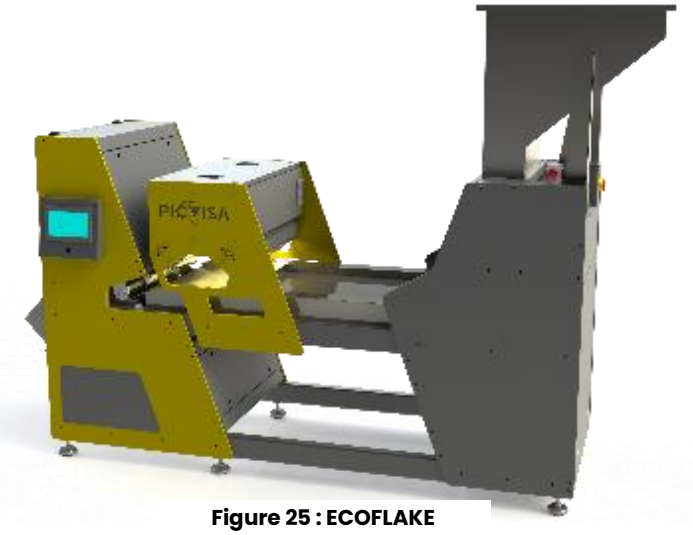


**Figure 25 : ECOFLAKE**
Source : PICVISA

**Current developments:**

- Sorting of shredded shoe soles composed of blended materials (Rubber/EVA)
- Reinforced software and higher resolution camera for maximizing accuracy

**Locations:**

| Testing centre | Examples of equipped facilities |
|---|---|
| Calaf (Spain) | Undisclosed |

**Contact:** Silvia GREGORINI – Business Development – sgregorini@picvisa.com

# Pilots / demonstrators

## 1.5.2. Plas'tri (France)

| | |
|---|---|
| Equipment | HyperID |
| Detection (technology) | Materials (NIR-HSI) |
| Sorting | Binary or ternary<br>Multi-category |
| Application | Footwear |
| Input format | Shoe soles |
| Maturity | Pilot |

Plas'tri is a French company resulting from applied research in spectroscopy and AI, specializing in the characterization of complex polymer materials.

In 2023, Plas'tri implemented an automated solution, **HyperID**, for the sorting of shoe soles via a hyperspectral camera. The system can be **integrated to binary, ternary or multi-category sorting lines** according to customer needs.

**Figure 26 : HyperID**
Source : Plas'tri

### Performance:

The claimed average accuracy of HyperID is more than 99%. The error rate is monitored, and control tools are integrated into the hyperspectral camera.

| Recognized materials (specific to footwear) | |
|---|---|
| **Pure** | Shoe soles: ABS, EPDM, EVA, PU, PVC, RUBBER (NR), SBR, TPU<br>Shoe uppers: Cotton, Polyamides (PA6 or PA66 / PA11 or PA12), Polyester, PP, Viscose, Wool |

*This is a non-exhaustive list that is continuously enriched according to customer needs.*

### Current developments:

- Adding new polymers;
- Plas'tri is developing a new technology[4] based on radiative transfer to:
  - Identify materials containing carbon black;
  - Identify multi-materials and multilayers through in-depth measurement;
  - Identify the proportions of materials (including additives).

### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Saint-Etienne (France) | ReValorem (France) |

**Contacts:** Clara SPETEBROODT – CEO – clara.spetebroodt@plastri.fr
Nicolas GILIBERT – Commercial - nicolas.gilibert@plastri.fr

[4] Project supported by Refashion as part of the 2024 Innovation Challenge

### 1.5.3. CETIA (France)

| | |
|---|---|
| Equipment | IDSHOES |
| Detection (technology) | Typology (VIS) |
| Sorting | Articles |
| Application | Footwear |
| Input format | Whole items |
| Maturity | Pilot / Demonstrator |


**Figure 27 : IDSHOES unit**
Source : CETIA

CETIA, a technical centre based in Hendaye, develops innovative solutions for sorting and dismantling textiles and footwear, combining robotics, vision and AI.

CETIA has developed **IDSHOES**, an intelligent detection cell capable of automatically recognising the different typologies of shoes: running shoes, high-top shoe, Cupsole, wedge/open/closed heels, espadrilles, boots, etc. IDSHOES was also trained to recognize post-consumer shoe references from Decathlon, the ERAM group and Salomon to associate each shoe with its digital product passport (DPP), providing access to key information on its composition, its assembly and its recycling potential.

The solution developed by CETIA is a pilot line that can process 720 shoes/hour. CETIA aims to deploy IDSHOES in various sorting facilities in 2026.

**Current developments:** Brand detection and system speed improvement.

**Contact:** Pauline ARROUASSE – Sales Manager – pauline.arrouasse@cetia.tech

## 1.6. Fournisseurs de spectromètres portatifs – Chaussures

### 1.6.1. MATOHA Instrumentation Ltd. (UK)

| | |
|---|---|
| **Equipment** | **ShoeTell (prototype)** |
| **Detection (technology)** | **Materials (NIR)** |
| **Application** | **Footwear** |
| **Input format** | **Whole items** |
| **Maturity** | **Prototype phase** |

**Figure 28: ShoeTell prototype**
Source : Matoha

MATOHA is a British company founded in 2018 specializing in the detection and rapid analysis of materials. It designs near-infrared spectroscopy (NIR) solutions for the textile, plastics and flooring industries.

For plastics, its solution is the **PlasTell** range. Different formats are available:

- **Desktop** (benchtop version),
- **Bench** (sorting for recycling table),
- **Handheld** (handheld version).

Matoha also offers the **sensor on its own**, which can be integrated onto (semi-)automated systems.

The **ShoeTell** prototype is based on their PlasTell device, with a material database that has been trained with the **Refashion footwear materials Library to include further shoe sole materials. The ShoeTell prototype has only been built in a handheld version.**

#### Performance:

The measurement is completed in less than a second. It is also possible to add new materials via Matoha's application (web or smartphone).

| Recognized materials (specific to footwear) | |
|---|---|
| **Pure** | Shoe soles: ABS, EVA, PU, PVC, RUB*, RUB-SBR**, SBR, SBS, TPU<br>Shoe uppers: Cotton***, Leather, Polyamide***, Polyester***, Polypropylene, Viscose***, Wool*** |

**RUBBER ("NR/IR": Natural Rubber/Isoprene Rubber): Natural and synthetic rubber blend*

***RUBBER-SBR (NR/IR=SBR): Natural Rubber/Isoprene Rubber and Styrene Butadiene Rubber in equivalent quantities*

****Trained with the Refashion textile materials Library*

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| London (United Kingdom) | Re-Shoes in-line sensor at CETIA (France)<br>Presence in 60 countries, about 950 units sold (FabriTell + PlasTell) |

**Contact:** Chris NEWTON – Chief Commercial Officer – chris@matoha.com

### 1.6.2. Plas'tri (France)

| | |
|---|---|
| **Equipment** | **Tri'Scan** |
| **Detection (technology)** | **Materials (NIR)** |
| **Application** | **Footwear** |
| **Input format** | **Whole items** |
| **Maturity** | **Industrial solution** |

Plas'tri is a French company resulting from applied research in spectroscopy and artificial intelligence, specializing in the characterization of complex polymer materials.

Plas'tri marketed its first tool in 2021: **Tri'Scan**, a portable scanner that can identify more than 20 polymers. 3 different modes can be selected on the device: plastics, textiles and elastomers.

**Performance:**

| Recognized materials (specific to footwear) | |
|---|---|
| **Pure** | Shoe soles: ABS, EPDM, EVA, PU, PVC, RUBBER (NR), SBR, TPU<br>Shoe uppers: Cotton, Polyamides (PA6 or PA66 / PA11 or PA12), Polyester, PP, Viscose, Wool |

*Non-exhaustive list that is continuously enriched according to customer needs.*


**Figure 29 : Tri'Scan**
Source : Plas'tri

**Locations:**

| Testing centre | Examples of equipped facilities |
|---|---|
| Saint-Etienne (France) | ReValorem (France) |

**Contacts:** Clara SPETEBROODT – CEO – clara.spetebroodt@plastri.fr
Nicolas GILIBERT – Commercial - nicolas.gilibert@plastri.fr

### 1.6.3. TrinamiX (Allemagne)

| | |
|---|---|
| **Equipment** | **TrinamiX PAL Two** |
| **Detection (technology)** | **Materials (NIR)** |
| **Application** | **Footwear** |
| **Input format** | **Whole items** |
| **Maturity** | **Industrial solution** |

TrinamiX GmbH, a subsidiary of the BASF Group, is a German company specializing in near-infrared spectroscopy (NIR) and materials analysis.

The **trinamiX PAL Two** spectrometer combines NIR illumination (1,300–2,350 nm) and cloud-based algorithmic processing for the detection of materials (shoe sole and upper).

**Figure 30 : TrinamiX PAL Two**
Source : TrinamiX

**Performance:**

| Recognized materials (specific to footwear) | |
|---|---|
| **Pure** | Shoe soles: EVA, Leather, PEBA, PU*, PVC, SBR<br>Shoe uppers: Cotton, Leather, Polyamide, Polyester, Wool |

** TPU is detected as PU*

**Locations:**

| Testing centre | Examples of equipped facilities |
|---|---|
| Equipment rental only | Undisclosed |

**Contact:** Adrian VOGEL – Segment Lead Circular Economy – adrian.vogel@trinamix.de

## 1.7. Overview of automated material sorting or identification equipment

### Automated sorting machines – Textiles 1/2

| Supplier | Equipment | Maturity | Sorting | Possibility of automated feeding | Detection (technology) | Application & formats | Recognised materials (supplier claims) | Capacity / Speed (Data in t/h depend on the stream) | Type of ejection | Supplier nationality |
|---|---|---|---|---|---|---|---|---|---|---|
| **NewRetex** | **NewRetex** | Industrial | Multi-category | YES | Materials (NIR) + Colours (VIS) + Disruptors (XR) + Typology (AI) | Whole garments | Acetate, Acrylic, Cotton, Elastane, Lyocell, Polyamide (PA6 & PA66), Polyester, Silk, Viscose, Wool + Cotton/Polyester, Cotton/Elastane, Wool/Acrylic, Polyester/Elastane | 2,200 to 4,400 pieces/h | Conveyors | Denmark |
| **Pellenc ST** | **MISTRAL+ CONNECT** | Industrial | Binary-Ternary | YES | Materials (NIR) + Colours (VIS) | Whole garments, clippings, shreds | Acrylic, Cotton, Polyamide, Polyester, Silk, Viscose, Wool + Cotton/Elastane, Cotton/Viscose, Polycotton (80%/20% – 60%/40% – 40%/60% – 20%/80% + variants 90%/10% or 95%/5%), Polyester/Elastane, Polyester/Polyamide, Wool/Acrylic, Wool/Polyester… | 4 to 8 t/h | Ejection bar | France |
| | **MULTITEX** | Industrial | Multi-category | YES | Materials (NIR) + Colours (VIS) | Whole garments | | 1.3 t/h | Lateral nozzles | |
| **PICVISA** | **ECOSORT TEXTIL** | Industrial | Multi-category | YES | Materials (NIR-HSI) + Colours (VIS) + Fabric structure + Typology (VIS) | Whole garments | More than 20 categories incl.: Acetate, Acrylic, Cotton, Elastane, Polyamide, Polyester, Silk, Viscose, Wool + Cotton/Polyester, Wool/Polyamide, Wool/Polyester… | 1 t/h | Lateral nozzles | Spain |
| | **ECOCLIP** | Industrial | Binary-Ternary | YES | Materials (NIR-HSI) + Colours (VIS) + Hard points (VIS+IA) | Clippings or whole garments | | 2-3 t/h | Ejection bar | |
| **BT-Systems GmbH - REDWAVE** | **REDWAVE TEX** | Industrial | Multi-category | NO | Materials (NIR) + Colours (VIS) + Metals (induction) | Whole garments | Textiles: Acrylic, Cotton, Elastane, Polyamide, Polyester, Viscose, Wool … & bi-material blends Footwear: ABS, EVA, PVC, RUB, PC, PU, SBR, TPU… | 4 t/h | Lateral nozzles | Austria |
| | **REDWAVE TEX 2i** | Industrial | Binary-Ternary | NO | Materials (NIR) + Colours (VIS) + Metals (induction) | Whole garments, clippings, shreds | | 16 t/h | Lateral nozzles | |
| **TOMRA** | **AUTOSORT™** | Industrial | Binary-Ternary | YES | Materials (NIR) + Colours (VIS) | Whole garments and clippings | Acrylic, Cotton, Polyamide (PA6 & PA66), Polyester, Silk, Viscose, Wool + Polycotton, blends of pure fibres with elastane (>2%) | 4.5 t/h | Ejection bar | Norway |
| **VALVAN** | **Fibersort** | Industrial | Multi-category | YES | Materials (NIR) + Colours (VIS) | Whole garments | Acrylic, Cotton, Elastane (> 1%), Polyamide (PA6 et PA66), Polyester, Silk, Viscose, Wool + Blends of 2 or 3 of pure materials | 3,600 pieces/h | Lateral nozzles | Belgium |

## Automated sorting machines – Textiles 2/2

| Supplier | Equipment | Maturity | Sorting | Possibility of automated feeding | Detection (technology) | Application & formats | Recognised materials (supplier claims) | Capacity / Speed (Data in t/h depend on the stream) | Type of ejection | Supplier nationality |
|---|---|---|---|---|---|---|---|---|---|---|
| **Wastex** | **SORTER R** | Industrial | Multi-category | YES | Materials (NIR-HSI) + Colours (VIS) | Whole garments | 14 fibres incl.: Acrylic, Cotton, Elastane, Polyamide, Polyester, Viscose, Wool + Bi-material blends of pure materials | Several t/h | Lateral ejection | Spain |
| **LLA Instruments** | **KUSTA MPL** | Industrial (sensor only) | System for binary-ternary line | NO | Materials (SWIR-HSI) + optional: Colours (VIS) | Whole garments and clippings | Acetate, Acrylic, Cotton, Elastane, Lyocell, Polyamide, Polyester, Polypropylene, , PU-based prints, Silk, Viscose, Wool + Cotton/Elastane, Cotton/Polyester, Cotton/Polyester/Elastane, Polyester/Elastane, Acrylic/Polyamide, Cotton/Acrylic, Polyamide/Elastane, Polyester/Acrylic, Polyester/Polyamide, Viscose/Elastane, Wool/Acetate | 3 m/s | Depending on needs | Germany |
| **Looper Textile Co.** | **Looper automated sorting line** | Industrial pilot | Multi-category | NO | Materials (NIR) + Colours (VIS) + Metals (metal detector) | Whole garments | Acetate, Acrylic, Cotton, Polyamide, Polyester, Silk, Viscose, Wool + Bi-material blends of recognised pure materials | 2,000 pieces/h | Lateral nozzles | Sweden |
| **CETIA** | **SensorHUB** | Pilot | Multi-category | NO | Materials (NIR-HSI) + Colours (VIS) + Typology (VIS) + Hard points (XR) | Whole garments or shoes | In development | - | Lateral nozzles and ejection bar | France |
| **IRIS Technology Solutions** | **VISUM range** | Pilot | Ternary | NO | Materials (NIR) | Whole garments and clippings | Polyester | - | Depending on needs | Spain |
| **SPECIM** | **Specim RETEX** | Pilot | System for binary, ternary or multi-category line | NO | Materials (NIR-HSI) + Colours (VIS) | Whole garments and clippings | Acrylic, Cotton, Elastane, Polyamide (PA6 & PA66), Polyester, Silk, Viscose, Wool + Blends of 2 pure materials | - | - | Finland |
| **3U Vision – Next Waste** | **ScanTex** | Pilot | Multi-category | NO | Materials (NIR-HSI) + disruptors (AI) | Whole garments and clippings | Acrylic, Cotton, Elastane, Polyamide (PA6 & PA66), Polyester, Silk, Viscose, Wool + Polycotton, Blends of pure material + elastane | 5 pieces/s | NC | France |

**Table 2 : Overview of automated sorting machines – Textiles**

***PLEASE NOTE: For all solutions presented, technology suppliers recommend discussing first to better understand customers' needs.***

## NIR sorting tables - Textiles

| Supplier | Equipment | Technology | Sensor type | Application & formats | Recognised materials (supplier claims) | Measurement time | PC software / Mobile app | Supplier nationality |
|---|---|---|---|---|---|---|---|---|
| **MATOHA** | **FabriTell Bench** | NIR | Point | Whole garments | Acetate, Acrylic, Cotton, Elastane, Polyamide, Polyester, PP, Silk, Viscose, Wool + Cotton/Acrylic, Cotton/Elastane, Cotton/Polyamide, Cotton/Polyester, Cotton/Viscose, Polyamide/Elastane, Polyamide/Wool, Polyester/Acrylic, Polyester/Elastane, Polyester/Viscose, Viscose/Elastane, Wool/Acrylic, Wool/Polyester | 1s | Mobile app | UK |
| **Valvan** | **Manual Fibersort** | NIR | Point | Whole garments | Acrylic, Cotton, Elastane (> 1%), Polyamide (PA6 et PA66), Polyester, Silk, Viscose, Wool + Blends of 2 or 3 of pure materials | 1s | PC software | Belgium |

**Table 3 : Overview of NIR sorting tables – Textiles**

## Handheld spectrometers - Textiles

| Supplier | Equipment | Technology | Sensor type | Application & formats | Recognised materials (supplier claims) | Measurement time | PC software / Mobile app | Supplier nationality |
|---|---|---|---|---|---|---|---|---|
| **MATOHA** | **FabriTell Handheld & Desktop** | NIR | Point | Whole garments | Acetate, Acrylic, Cotton, Elastane, Polyamide, Polyester, PP, Silk, Viscose, Wool + Cotton/Acrylic, Cotton/Elastane, Cotton/Polyamide, Cotton/Polyester, Cotton/Viscose, Polyamide/Elastane, Polyamide/Wool, Polyester/Acrylic, Polyester/Elastane, Polyester/Viscose, Viscose/Elastane, Wool/Acrylic, Wool/Polyester | 1s | Mobile app | UK |
| **Spectral Engines** | **NIRONE S** | NIR | Point | Whole garments | - | a few seconds | Mobile app | Germany |
| **TrinamiX** | **PAL Two** | NIR | Point | Whole garments, clippings, shreds | Acrylic, Cotton, Elastane, Polyamide, Polyester (PET et PTT), PP, Silk, Viscose, Wool + 21 blends in total, including 15 with identified % of materials | 1s | NO | Germany |

**Table 4 : Overview of handheld spectrometers – Textiles**

*Please note: Senorics (mentioned in the previous version of this report) is no longer in operation.*

## Automated sorting machines - Footwear

| Supplier | Equipment | Maturity | Sorting | Possibility of automated feeding | Detection (technology) | Application et formats | Recognised materials (supplier claims) | Capacity / Speed (Data in t/h depend on the stream) | Type of ejection | Supplier nationality |
|---|---|---|---|---|---|---|---|---|---|---|
| **CETIA** | **IDSHOES** | Pilot | Articles | YES | Typology (VIS) | Footwear | - | 720 p/h | Mechanical | France |
| **PICVISA** | **ECOFLAKE** | Industrial | Binary-Ternary | YES | Material (NIR) | Shredded soles | ABS, EVA, Leather, PA, PC, PU, PVC, RUB, TPU | 0.4 t/h à 2 t/h | Blowing | Spain |
| **Plas'tri** | **HyperID** | Pilot | Binary-Ternary Multi-category | NO | Material (NIR) | Shoe soles | *Shoe soles:* ABS, EPDM, EVA, PU, PVC, RUB (NR), SBR, TPU *Shoe uppers:* Cotton, Polyamides (PA6 or PA66 / PA11 or PA12), Polyester, PP, Viscose, Wool | NC | Depending on needs | France |

**Table 5 : Overview of automated sorting machines – Footwear**

## Handheld spectrometers - Footwear

| Supplier | Equipment | Technology | Sensor type | Application | Recognised materials (supplier claims) | Measurement time | PC software / Mobile app | Supplier nationality |
|---|---|---|---|---|---|---|---|---|
| **MATOHA** | **ShoeTell prototype** | NIR | Point | Footwear | *Shoe soles:* ABS, EVA, Leather, PU, PVC, RUB, RUB/SBR, SBR, SBS, TPU *Shoe uppers:* Cotton, Leather, Polyamide, Polyester, PP, Viscose, Wool | 1s | Mobile app | UK |
| **Plas'tri** | **Tri'Scan** | NIR | Point | Footwear | *Shoe soles:* ABS, EPDM, EVA, PU, PVC, RUB (NR), SBR, TPU *Shoe uppers:* Cotton, Polyamides (PA6 or PA66 / PA11 or PA12), Polyester, PP, Viscose, Wool | 1s | No | France |
| **TrinamiX** | **PAL Two** | NIR | Point | Footwear | *Shoe soles:* EVA, Leather, PEBA, PU or TPU, PVC, SBR *Shoe uppers:* Cotton, Leather, Polyamide, Polyester, Wool | 1s | No | Germany |

**Table 6 : Overview of handheld spectrometers – Footwear**

## 1.8. Existing and planned automated sorting lines

Several automated sorting lines, already operational or planned, have been identified during this study. The map below shows the main equipped facilities in Europe for both textiles and footwear sorting *(non-exhaustive list)*.

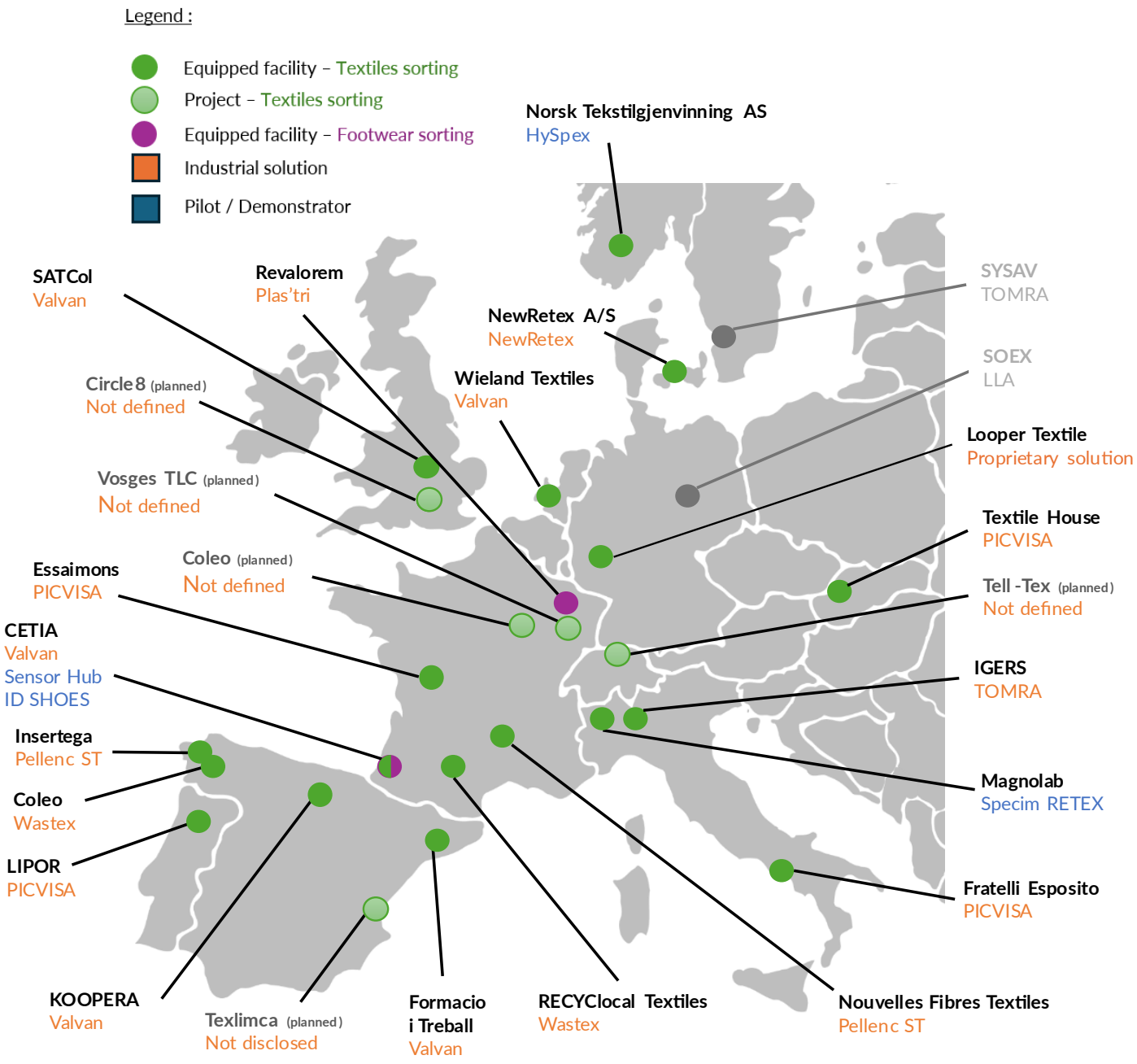


**Figure 31 – Existing and planned automated sorting lines in Europe** *(non-exhaustive)*

# 2. Textiles trims removal

Textiles trims removal encompasses all processes aimed at removing external disruptors to textile recycling, such as buttons, fasteners, linings, eyelets and labels, in order to obtain homogeneous material that can be processed through the various recycling routes. These disruptors are detailed in the Study on Recycling Disruptors and Facilitators in Clothing, Household linen and Footwear, published by Refashion in 2025.

Historically carried out manually, textiles trims removal is now the subject of significant automation efforts, driven by the growing need for productivity and material quality. The different automated processes are:

- **Tearing lines with hard points removal modules;**
- **Mechanical separation (of clippings or shreds);**
- **Separation of clippings with AI;**
- **Custom automated cutting.**

This section provides an overview of the available technologies, suppliers and ongoing European projects related to automated textiles trims removal.

## 2.1. The different trims removal technologies

### Manual or semi-automated trims removal:

Manual or semi-automated trims removal is carried out using a variety of tools, such as manual or electric scissors, circular or band saws, and die cutters. It produces textile pieces free from trims, whose shapes and dimensions vary depending on the cut made. This process remains widespread while automated technologies are being deployed.

### Tearing lines with hard points removal modules:

Automated mechanical trims removal, carried out through physical actions such as friction, impact or shearing, as well as through density-based separation, is already integrated in the form of modules into existing industrial tearing lines. The main stages of this process are:

- Producing clippings using cutters or shredders, to reduce textiles to pieces of uniform size;
- Mechanically opening the textile clippings using openers or pin drums which break up the material and help tear off rigid or thick components (fasteners, buttons, reinforcements), commonly referred to as “hard points”. The removal of flexible components (labels, embroideries, logos, etc.) remains limited;
- Tearing / fibre opening, carried out using a succession of rotating cylinders fitted with pins or needles, which separate and refine fibres.

This is currently the most mature and readily available form of automated textiles trims removal. It is preferred for spinning applications because tearing produces fibres as an output.

### Separation of clippings or shreds:

Automated trims removal from textile clippings consists in sorting textiles that have previously been cut into clippings, to separate the clippings free from recycling disruptors from those containing disruptors.

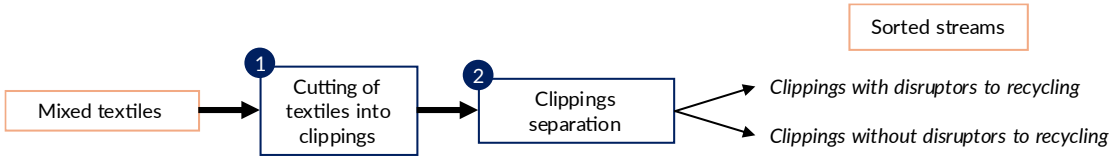


**Figure 33 : Operational diagram of trims removal on textile clippings**

## Mechanical separation:

Clippings are separated by density and/or airflow, using mechanical separation devices such as vibrating screens, air separators, magnetic drums or density-sorting systems. These devices can extract the clippings containing heavy components (metallic or plastic hard points). The removal of clippings containing flexible components (labels, embroideries, logos, etc.) is more limited.

The same principle applies to **shredded material (shreds)**. Textiles are fully shredded and reduced to fragments of a controlled size. The textile shreds are then subjected to air separation in a zig-zag separator using airflow, in order to separate the lightweight components (mainly fibrous) from heavier contaminants (buttons, zippers, eyelets, etc.). A densimetric table can also be used, in addition to or instead of the zig-zag separator, to achieve finer separation of components with a different density than that of the textile fragments. This preparation method is primarily developed for **preprocessing textiles for chemical recycling**, which does not require to preserve some specific fibre length.

- **Many suppliers** offer textile shredding and granulation equipment followed by mechanical separation equipment (zig-zag separators, densimetric tables). Examples include WEIMA who designed the pre-treatment line for Carbios (enzymatic recycling of polyester textiles), ELDAN RECYCLING, MTB RECYCLING and UNTHA.


**Figure 34 - Example of shredding and air separation line - ELDAN RECYCLING** (Source : Eldan Recycling)

## Separation with computer vision (AI):

Clippings containing heavy or lightweight disruptors are detected and removed from the stream of "clean" (100% textile) clippings by automatic ejection using air nozzles. This type of automated trims removal is currently only carried out on clippings and can supply a textile stream for all types of recycling (mechanical, chemical or enzymatic, thermomechanical).

These systems can be supplemented with magnetic devices (magnets) for ferrous metals, Eddy-Current separators for non-ferrous metals, or inductive sensors to remove metallic residues and improve the prepared textile stream purity.

## Custom automated cutting:

Automated cutting aims to replicate and automate targeted cutting operations, drawing inspiration from manual trims removal. It is based on automated pattern-cutting machines used in the textile industry. This technology uses vision systems, AI and automation to identify disruptors and carry out custom cutting, using a blade or laser, thereby preserving large textile pieces and optimising fibre length for mechanical recycling. This technology is much less mature and therefore more costly than tearing or separation of clippings, limiting its use to high-value applications.

## 2.2. Tearing lines with hard points removal modules

### 2.2.1. ANDRITZ Laroche (Austria/France)

**Figure 35 : Andritz line**
Source : Andritz Laroche

ANDRITZ Laroche is a long-standing player in textile mechanical recycling, designing complete tearing lines. Their lines incorporate several modules: cutting systems (guillotine, Starcut), **Picker Shredder** system, multi-cylinder lines with **hard points removal** (via **Cadette, Exel, or Jumbo**, depending on target capacity), metal detection and automatic extraction, dust filtration, etc. The lines can be fed with full garments or clippings.

**Performance:**
Capacities from 50 kg/h (Cadette) to 3,000 kg/h (Jumbo)
Purity rate of up to 99% for metallic hard points

**Locations:**

| Testing centres | Examples of equipped facilities |
|---|---|
| Cours-la-Ville (France)<br>**CETI (France)** | Nouvelles Fibres Textiles (France)<br>Frankenhuis (Netherlands)<br>Rester Oy (Finland) |

**Contact:** Benoit ROMBAUT – Technology Director – benoit.rombaut@andritz.com

### 2.2.2. Dell'Orco & Villani (Italy)

**Figure 36 : Dell'Orco & Villani line**
Source : TexCycle

Dell'Orco & Villani is an Italian manufacturer developing equipment for textiles cutting & opening and fibre cleaning, aiming to preserve fibre length while eliminating contaminants. Their **Titan Line,** based on a succession of spiked metal drums and rollers enabling a gradual opening of textiles, incorporates a module for hard points removal. Automatic systems for discarding hard and denser elements ensure a high purity of the obtained fibre flow.

**Performance:**

Capacity: from 50 kg/h to 2 t/h depending on the system;
Purity: up to 99% for lines equipped with all cleaning modules.

**Locations:**

| Testing centre | Examples of equipped facilities |
|---|---|
| Capalle (Italy) | Ouateco (France) / CETIA (France)<br>IGERS (Italy) / TexCycle (Bulgaria)<br>GEA-Greenthesis (Italy) / ROSECO (Romania) |

**Contact:** Massimo PISANESCHI – Sales Manager – massimo@dellorco-villani.it

### 2.2.3. MARGASA (Spain)

**Figure 37 : Margasa line**
Source : Margasa

MARGASA is a Spanish company specialized in the design and manufacture of textile fraying lines (up to 6 cylinders) with cutting machines, mixing systems and cleaning cyclones. Hard spots are extracted by density.

MARGASA offers two main configurations: **Compact** (400/800 kg/h), and **Master** (1-2 t/h). MARGASA claims performance of up to 99% defibrated material without hard spots (metals, plastics).

#### Current developments:

- 5-cylinder mini-machine of 200 kg/h, connected to a card;
- Compatibility with Valvan's Trimclean for the recovery of cutting waste.

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Barcelona (Spain) | The Post Fiber (Spain) / Texamira (Spain)<br>Sanko (Turkey) |

**Contact:** Jordi MARLASCA – Managing Director – jordimarlasca@margasa.com

### 2.2.4. OMMI (Italy)


**Figure 38 : RECOMOVER®**
Source : OMMI

OMMI is an Italian manufacturer offering a patented tearing/defibration technology which acts as a soft friction, progressive and gentle, aiming at preserving the length and quality of fibres while effectively removing contaminants. In 2024, OMMI launched the **RECOLINE®** high-quality defibration line, specially designed to process post-consumer textile waste and optimize recycled fibres' quality. The RECOLINE® line integrates the system:

- **RECOMOVER®**: a patented unit dedicated to the removal of hard points and other trims (zips, labels, elastic bands, plastic or metal inserts) before defibration. Claimed hard points removal of more than 90% in one pass, up to 99% with two modules.

#### Current developments:

Energy optimization, dust reduction and preservation of fibre quality

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Augsburg (Germany) – ITA Recycling Atelier | Undisclosed |

**Contacts:** Marco BENEDETTI – Sales Manager – marco.benedetti@ommi.it
Claudio ZELONI – General Manager – claudio.zeloni@ommi.it

## 2.3. AI-based clippings separation solutions

### 2.3.1. PICVISA (Spain)

| | |
|---|---|
| Equipment | ECOCLIP |
| Application | Textiles |
| Input format | Clippings (≥ 25mm) |
| Maturity | Industrial solution |

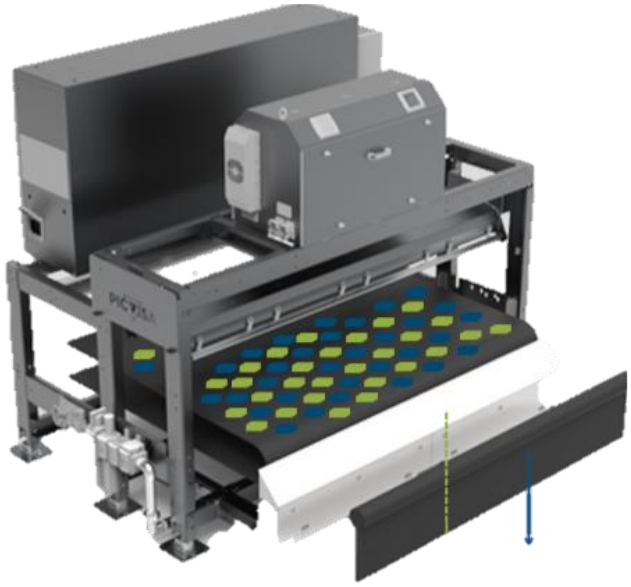

**Figure 39 : ECOCLIP**
Source : Picvisa

PICVISA is a Spanish company specializing in the development of optical sorting systems combining spectroscopy, computer vision and AI.

PICVISA has designed **ECOCLIP**, a solution available in different sizes that can either be configured for binary/ternary sorting of textiles by material composition and colour, or for the detection and automatic ejection of textile clippings with external disruptors to recycling (buttons, zippers, seams, metallic elements).

ECOCLIP combines several detection technologies – hyperspectral and colour cameras, metal and AI sensors – to automatically identify clippings containing hard points or other contaminants.

In this configuration, sorting is binary: 100% textile clippings are directed towards the main flow, whereas "polluted" clippings are ejected. The machine requires a preliminary step of cutting garments into clippings of dimensions compatible with the detection and sorting system (≥ 25mm).

**Performance:**

Throughput: from 0.8 to 1.3 t/h depending on clippings' size and density
Clippings' recommended size: as of 25mm.

**Locations:**

| Testing centre | Examples of equipped facilities |
|---|---|
| Calaf (Spain) | Undisclosed |

**Contact:** Silvia GREGORINI – Business Development – sgregorini@picvisa.com

### 2.3.2. VALVAN (Belgium)

| | |
|---|---|
| **Equipment** | **TrimClean** |
| **Application** | **Textiles** |
| **Input format** | **Clippings (20 to 100mm)** |
| **Maturity** | **Industrial solution** |

**Figure 40 : TrimClean**
Source : Texpertise Network

VALVAN is a Belgian manufacturer of industrial solutions for the sorting and preparation of textiles for reuse or recycling.

In 2022, Valvan launched the **TRIMCLEAN**, an industrial solution designed to automatically remove external disruptors to recycling (labels, zips, buttons…) on textile clippings (cut textile pieces). It processes the clippings and performs a binary sorting between clean textile clippings and clippings containing disruptors.

A key feature is its dual-side detection (top and bottom), ensuring that contaminants are identified regardless of their position or orientation. This significantly increases detection reliability, especially for hidden elements such as internal metal parts or partially visible defects. By combining multi-sensor detection with dual-side inspection, the TrimClean ensures a high-quality output stream, acting as a critical pretreatment step for mechanical or chemical textile recycling.

The system integrates four complementary detection technologies:

- Metal detection (internal and external) that identifies both embedded and visible metallic components such as zippers and buttons;
- VIS (colour camera) to detect visible defects like labels, seams and irregular structures;
- AI-based vision analysis for enhancing detection by recognising complex patterns and hard points beyond simple visual cue;
- NIR for fibre recognition and identification.

#### Performance:

- Throughput: up to 1,200 kg/h depending on the size and density of the clippings
- Clippings' recommended size: 2×2cm (chemical recycling) to 5x5cm (max 10×10cm) (mechanical recycling)
- Recommended pollutant input level: ≤ 25% for optimal machine operation
- Adjustable rejection rate according to customer-specific quality targets.

The TrimClean is designed to remove a wide range of disruptive elements, however multi-layered materials such as padded structures can remain challenging when the contaminant is not visible or detectable due to its internal positioning. If padding is sufficiently dense and consistent with the defined input recipe, it can typically be processed without any issue and may not necessarily require rejection.

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Menen (Belgium) | 5 facilities in Europe including:<br>Wieland Textiles (Netherlands)<br>Frankenhuis (Netherlands) |

**Contact:** Jean-François GRYSPEERT – Sales & Development Manager – jfg@valvan.com

## 2.4. Custom automated cutting

### 2.4.1. CETIA (France)

| | |
|---|---|
| Equipment | FABRICUT |
| Application | Textiles |
| Input format | Whole items |
| Maturity | Pilot / Demonstrator |


**Figure 41 : FABRICUT machine**
Source : CETIA

CETIA, a technical centre based in Hendaye, develops innovative solutions for sorting and dismantling textiles and footwear, combining robotics, vision and AI.

CETIA is currently developing a trim removal solution via automated die-cutting: **FABRICUT**.

This solution consists of an X-ray cell and an RGB camera to identify external disruptors to recycling both outside and inside garments, followed by a mechanical cutting table. CETIA develops the AI algorithms for disruptors' automated detection and location. Information is then transmitted to the cutting machine to perform trim removal as close as possible to disruptors.

The commissioning of this machine is scheduled for 2026, with a view to transfer it to industrial companies. Tests and production series can be carried out at CETIA.

**Contact:** Pauline ARROUASSE – Responsable commerciale – pauline.arrouasse@cetia.tech

### 2.4.2. LOSANJE (France)

Losanje is a company that was created in 2020 in Nevers, specializing in textiles recovery through upcycling. In 2023[5], Losanje developed the first robotic solution for the automated cutting of garments / textiles in pieces ready for assembling into new products. This first pilot line has been designed to process main clothing typologies: trousers, T-shirts, shirts, etc., and is composed of several modules (trims removal, cutting…).

Losanje is currently working on improving and adapting their **proprietary technology** to enable industrial-scale precise production that is adapted to complex textiles like multilayered textiles, at a competitive cost.[6]

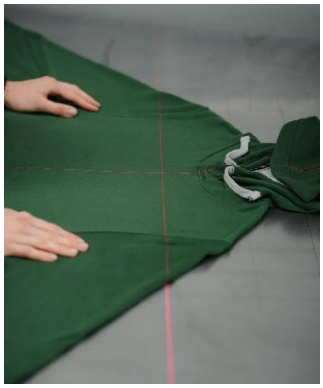

**Figure 42 : Losanje technology**
Source : losanje.com

**Contact:** Simon PEYRONNAUD – Co-founder – simon@losanje.com

[5] ADEME ORMAT 2023 winning project
[6] New ADEME ORMAT 2025 winning project

# 3. Footwear preprocessing for recycling

Two methods currently exist for preparing non-rewearable footwear for recycling:

- Manual or automated **shoe disassembly** (particularly **upper/sole separation**) for separately recycling the sole (mainly) and the upper;
- **Complete shoe shredding** (or **grinding**), **followed by the separation of the various materials** using different sorting systems (residual contaminants limit the purity of material streams).

The following section presents the different footwear disassembly technologies, followed by the main industrial solutions and projects identified in Europe.

## 3.1. The different disassembly technologies

The separation of footwear components can be carried out manually (semi-automatically) or automatically, following three technological approaches depending on the type of footwear assembly.

### Thermomechanical separation:

This type of separation only works for footwear with a welded (glued) assembly. The upper/sole junction is heated, usually in an oven, to soften the adhesive, then the components are separated by pulling them apart, either manually or robotically. This method requires precise control of the temperature and exposure time but is highly effective and can process large volumes of footwear.

### Separation by automated cutting:

Vision systems define a cutting path on the shoe placed flat (cutting performed using a blade, water jet or laser), to separate its components, primarily the upper and the sole. This approach can be adapted to different shoe designs and assembly types (welded, stitched or injection-moulded), but requires complex calibration to avoid any significant material loss or material contamination.

### Separation by delamination:

This type of separation only works for footwear with a welded (glued) assembly. Supercritical fluids (e.g. high-pressure $CO_2$) dissolve the adhesives, enabling the bonded components to be delaminated without any mechanical action. This method is suitable for complex footwear types but is more costly and currently at the industrial pilot stage.

## 3.2. Shredding / grinding & densimetric sorting

Whole shoes are reduced to fragments using shredders (grinders), without any prior separation of their components. The shredded materials are then sorted by screening, air separation (zig-zag) or densimetric separation in order to obtain relatively homogeneous material fractions (foams, rubber, textiles, plastics, metals). This proven method can process large volumes, but the fine separation of components remains complex and the purity of the different material fractions varies significantly depending on the shoe type and the quality of the shredding, particularly the selected particle size. Upstream sorting by shoe type and the integration of downstream material-sorting solutions are therefore necessary to improve the purity of the different shredded fractions.

## 3.3. Footwear disassembly solutions

### 3.3.1. INESCOP (Spain)

| | |
|---|---|
| Equipment | DIS4REC<br>Circular Industry |
| Application | Footwear |
| Input fomat | Whole items |
| Maturity | Pilot / Demonstrator |

**Figure 43 : DIS4REC demonstrator**
Source : Revista del calzado

**Figure 44 : Circular Industry demonstrator**
Source : INESCOP

INESCOP is a Spanish technology centre based in Elda (Alicante), developing innovative technological solutions and research for the footwear sector. Since 2019, INESCOP has been working on the development of shoe dismantling and recycling processes through various projects. These projects have led to the creation of two demonstrators available at INESCOP for testing:

**DIS4REC: Shoe upper/sole separation by tearing or robotic cutting**

The DIS4REC demonstrator greatly improves the material purity of the separate shoe components. The efficiency of the process is reduced for some complex shoe types such as heels or sandals. The throughput has not yet been estimated, since the prototype has been validated on a pilot scale and still requires further development before its industrial deployment.

**Circular Industry: Grinding, densimetric sorting and magnetic separation line**

The fractions obtained include dense polymers, textile fibres, leather and foams, ferrous/non-ferrous metals. The claimed purity rate can exceed 98% depending on the composition of the input stream. The Circular Industry demonstrator has a capacity between 300 and 500 kg/h in a semi-industrial configuration. The technology, which is already operational, is deemed replicable and suitable for industrial integration to process more than 3,000 kg/h.

**Contact:** Ana Belén MUÑOZ – Recycling and Circular Economy Manager – anabelen@inescop.es

### 3.3.2. CETIA – Re_SHOES (France)

| | |
|---|---|
| Equipment | Re_SHOES |
| Application | Footwear |
| Input format | Whole items |
| Maturity | Pilot / Demonstrator |

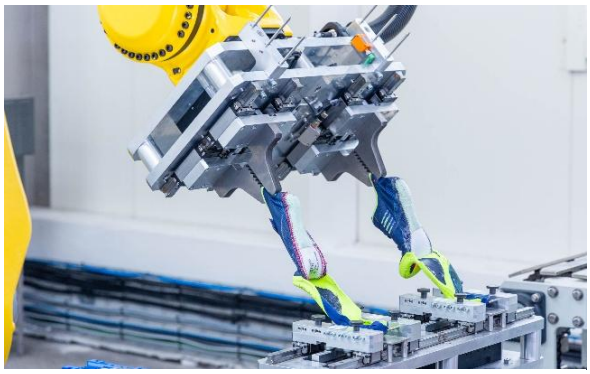

**Figure 45 : SNATCH cell**
Source : CETIA

**Figure 46 : SLICE cell**
Source : CETIA

CETIA, a technical centre based in Hendaye, develops innovative solutions for sorting and dismantling textiles and footwear, combining robotics, vision and AI. CETIA has developed **Re_SHOES**, an innovative pilot line dedicated to footwear preprocessing for recycling, that is composed of three cells: SNATCH, SLICE and SPLIT. The feeding of the shoes can be manual or automatic via a robot.

**SNATCH: Upper/sole separation by tearing**

This cell is designed to process welded shoes (glued sole and upper). Shoe soles are torn from the uppers by a robot, after glue reactivating by heating. This process enables to process a wide variety of shoe types at a throughput of 4 shoes per minute. The SNATCH cell is currently being adapted for stitched shoes.

**SLICE: Cutting of the soles by water jet**

For shoes with injected, vulcanized or stitched assembly, the SLICE cell performs an automatic cut using a water jet. A photo of the shoe is taken to define the cutting path, which is then transmitted to the cutting water jet nozzles. This system enables to process 2 shoes per minute, with great flexibility on shapes and materials.

**SPLIT: Sorting by material composition** via 2 Matoha NIR sensors (EVA, PU, PVC, TPU, RUB, TPR, SBR)

The Re-SHOES line is available at CETIA for trials and production runs, and ready to be replicated, adapted and transferred.

**Contact:** Pauline ARROUASSE – Sales Manager – pauline.arrouasse@cetia.tech

### 3.3.3. IDELAM (France)

| | |
|---|---|
| Technology | Supercritical $CO_2$ delamination |
| Application | Footwear |
| Input format | Whole items |
| Maturity | Pilot / Demonstrator |

**Figure 47 : IDELAM solution**
Source : IDELAM

IDELAM is a French company based in Pessac (33), specialized in the development of innovative recycling and waste treatment processes. Its technology is based on a CNRS patent, using a **supercritical $CO_2$ delamination** process to dissolve adhesives and separate components from complex items such as footwear. A 30L demonstrator is available in Pessac for industrial use and development projects.

#### Performance:

Process duration: a few minutes depending on the nature and thickness of the shoes.
Adaptable capacity according to the volume of the treatment chambers.

#### Current developments:

IDELAM is working on assessing the recyclability of materials derived from the various separated shoe components, and at optimizing the process for the technology's upcoming industrialization[7].

**Contact:** Thomas VOISIN – Managing Director – tv@idelam.fr

### 3.3.4. MOB-E-SCRAP (France)

| | |
|---|---|
| Technology | High frequency & high intensity impact delamination |
| Application | Footwear, Textiles |
| Input format | Whole or shredded items |
| Maturity | Industrial demonstrator (1t/h) |

**Figure 48 : Industrial demonstrator in Martignat**
Source : MOB-E-SCRAP

The MOB-E-SCRAP start-up has developed innovative mechanical recycling technology for complex multilayered and composite waste. The process is based on **high intensity** (up to 5,000 G) **and high frequency impact** (up to 4,000 impacts/sec) **delamination**, without any heating nor solvent. The items' different layers react differently according to the physical properties of materials, leading to their separation (by shearing effect) without chemical alteration.
Conclusive trials were performed on shoe soles (and on coated textiles), but some complementary tests are needed to fully validate the process performance across all shoe types.

#### Performance:

- Purity: clear separation of the different layers; textiles come out in the form of bundles of fibres.
- Process limitations: need for sorting and separating the delaminated materials (by density, granulometry, optical sorting…); some materials tend to fragment (e.g. EVA).
- Trials possible from 10 kg of material.

**Contact:** Eric LOUVERT – President – eric.louvert@mob-e-scrap.com

[7] Refashion 2024 Innovation Challenge winning project

## 3.4. Grinding & densimetric sorting

### 3.4.1. ELDAN RECYCLING (Denmark)

| | |
|---|---|
| Technology | Grinding & densimetric sorting |
| Application | Footwear, Textiles |
| Input format | Whole items, shredded material |
| Maturity | Industrial solutions |

ELDAN RECYCLING is a Danish company developing shredding and material separation equipment for different waste streams, including footwear as well as textiles, based on size reduction via shredding / grinding, and on densimetric separation of components & materials.


The different machines can be tested at Eldan Recycling's testing centre in Faaborg (Denmark).

**Figure 49 : Shoe recycling line**
Source : Eldan Recycling

**Contact :** François Gouriou – Area Sales Manager – fg@eldan-recycling.com

### 3.4.2. ESO RECYCLING (Italy)

| | |
|---|---|
| Equipment | SHOEBERTH |
| Application | Footwear |
| Input format | Whole items |

**Figure 50 – Shoeberth**
Source : ESO RECYCLING

ESO RECYCLING, based in Italy, is specialized in the recycling and recovery of sports waste, fashion waste, and PPE waste. In 2009, they launched the esosport Run project dedicated to the collection and recycling of worn-out sports shoes. The project led to the creation of the **SHOEBERTH** line located at their Amato Cannara facility in Tolentino.

Shoeberth is an innovative machine capable of separating shoe soles from the uppers and transforming them into granules. It combines grinding, aeraulic sorting with magnetic and Eddy Current sorting.

ESO Recycling then works on recovering the obtained fractions (rubber, plastics, textiles, leather, metals) by thermocompression or moulding, to produce boards, insulating panels, sports surfaces or fashion accessories.

**Location:** Tolentino (Italy)

**Contacts:** Cristina Lupini – Sales – cristina.lupini@esorecycling.it
Nicolas Meletiou – Managing Director – nicolas.meletiou@eso.it

### 3.4.3. FastFeetGrinded (Holland)

| | |
|---|---|
| Technology | Grinding & densimetric sorting |
| Application | Footwear |
| Input format | Whole items |
| Maturity | Industrial solution |

**Figure 51 – FastFeetGrinded line in Heerhugowaard (NL)**
Source : FastFeetGrinded

FastFeetGrinded, part of the HEILIG Group, is a Dutch company specializing in advanced footwear mechanical recycling. It has developed a **complete line enabling the separation of the different shoe materials** (foams, textiles/leather, rubber and metals). Sorting footwear by shoe type and brand is carried out before feeding the line to improve performance. The process is based on a succession of mechanical steps: controlled grinding of the whole shoes, granulometric and densimetric separation, then extraction of foam, textiles (in the form of small pieces or fluff), leather, rubber fractions and metals. FastFeetGrinded then works with various partners on recycling the extracted materials.

**Performance:**

- Feeding: automatic;
- Capacity: approx. 2,500 shoes/h;
- Average purity > 90%: depends on shoe type and line calibration;
- Limitations: extraction of soft disruptors (logos, embroideries, prints, etc.).

**Current developments:** Optimization of output streams' purity and improved material sorting after grinding.

**Contact:** Mike KUNST – Operations Manager – info@fastfeetgrinded.eu

### 3.4.4. The 8 Impact (France)

| | |
|---|---|
| Technology | Grinding & densimetric sorting |
| Application | Footwear |
| Input format | Whole items |

**Figure 52 – Shoe sole shreds**
Source : The 8 Impact

The 8 Impact, based in Saint-Remy (01), specializes in the regeneration of elastomers from post-consumer goods, including post-consumer sneakers.

THE 8 IMPACT's patented technology regenerates elastomers from post-consumer sneakers and produces the OKTARA™ materials range.

A preliminary sorting by sneaker type is performed prior to the 8-stage mechanical process using densimetric separation (without any water). The process extracts and separates the various shoe materials (rubber, EVA, textile "fluff", metallic hard points), up to a claimed 98% purity level[8].

Veja and Decathlon already incorporate OKTARA™ in some marketed shoes.

**Location:** Saint-Remy (France)

**Contact:** Marie SOUDRE-RICHARD – President – msr@the8impact.com

[8] State of the art of recycling solutions for shoe soles in Europe – Refashion – July 2025

## 3.5. Existing textiles and footwear disassembly equipment

Several automated disassembly lines, already operational or planned, have been identified during this study. The map below highlights the main equipped facilities in Europe for both textiles' trims removal and footwear disassembly *(non-exhaustive list)*.

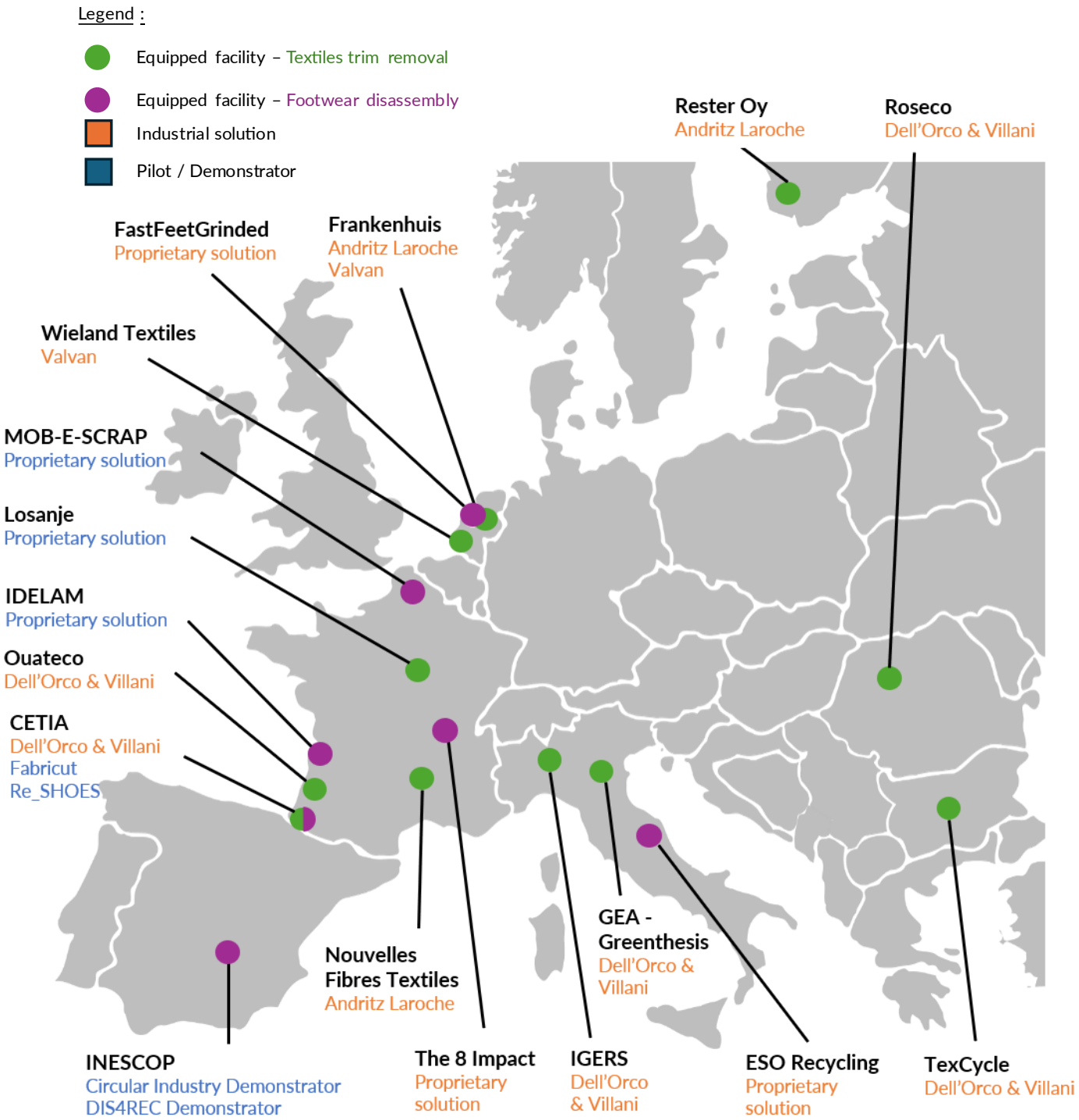


**Figure 53 – Existing textiles trims removal and footwear disassembly equipment in Europe** *(non-exhaustive)*

## 3.6. Ecodesign solutions

Integrating solutions that facilitate disassembly and material compatibility in products right from the design stage is a key lever for industrializing the recycling of non-reusable post-consumer CHF.

### Manufacturing with special threads:

The integration of special sewing threads, designed to degrade once the item reaches the end of its useful life, enables the recovery of its different components without altering them. Two approaches exist:

- **Thermal disassembly:** a thread with a lower melting point than the other fibres, which can be melted (e.g. Resortecs), or a thread that can be dissolved through the application of heat, pressure and water (COATS, CLIMATEX).
- **Microwave disassembly:** a thread containing metallic particles that react to microwaves and degrade (e.g. Wear2Go).

The advantage of this method is that it minimises material loss while preserving the size of the fabrics and other components, as separation takes place at the seams without any cutting. One limitation is that items made with these threads must be identifiable so that they can be directed to the appropriate disassembly process.

### Reactivatable adhesives:

Among the solutions deployed are high-temperature reactivatable bonding primers (adhesives), designed to facilitate the separation of a shoe upper and sole (e.g. Applus+ Rescoll).

### 3.6.1. Resortecs (Belgium)

| | |
|---|---|
| **Technologies** | ***Smart Stitch™ + Smart Disassembly™*** |
| **Application** | **Textiles, Footwear** |
| **Input format** | **Whole items** |
| **Maturity** | **Pilot / Demonstrator** |

Resortecs is a Belgian company that created **Smart Stitch™** heat-activated stitching threads. These threads activate at a lower temperature than other fibres and enable garment disassembly through the **Smart Disassembly™** thermal process. The technology thus supports circular uses such as components recovery and recycling, as well as repair.

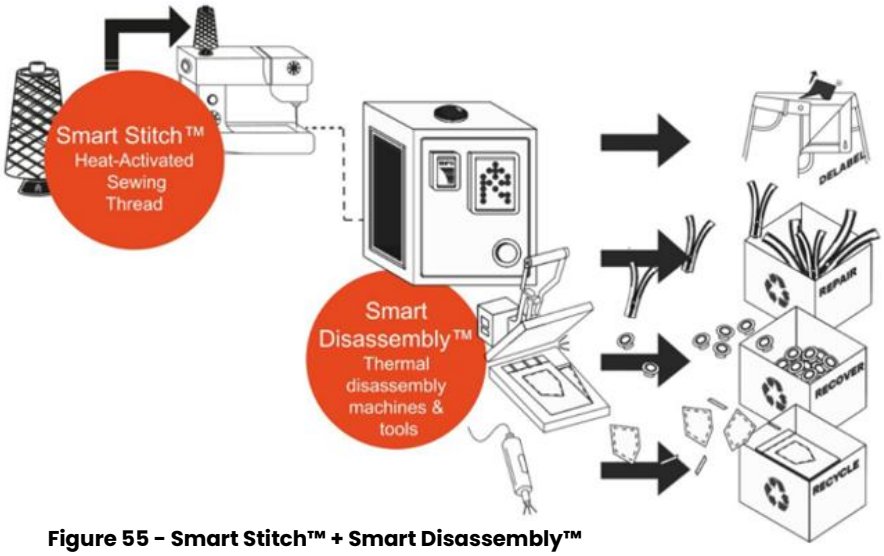


**Figure 55 – Smart Stitch™ + Smart Disassembly™**
Source : Resortecs,

In partnership with AMANN Group, Smart Stitch™ is being industrialized for large-scale adoption. A Smart Disassembly™ pilot is available for testing in Brussels, and an industrial plant with a capacity of 10 tonnes per day will be available in the next few years.

**Contact:** Anouk Teulings – Sales and Sustainability Manager – anouk@resortecs.com

# 4. Automated sorting for 2nd hand

Automated sorting for second-hand aims to identify items that can be reintroduced to the market, either directly or after reconditioning. In response to increasing collected volumes, product diversification and pressure on operating costs, assistance and automation technologies based on visual recognition and artificial intelligence (AI) are being developed alongside the manual approach. These technologies are mainly being developed for clothing.

This section presents how automated sorting for second-hand works to detect, classify and sort items according to their condition, type and resale potential. It also provides an overview of the main European solutions currently available, knowing that other solutions are developing rapidly.

### General operating principle:

These systems operate through a multi-stage processing chain:

1. **Image acquisition**: A camera captures the visible surface of the item placed on a table or conveyor using VIS/RGB sensors, which are the most widely used, or multispectral or hyperspectral systems to obtain more detailed information, particularly on the material composition.
2. **Preprocessing and object detection**: Images are processed to isolate each item from the background (segmentation). Algorithms then detect contours, colour areas, logos or patterns, etc.
3. **Classification using machine learning**: A trained AI model predicts the type of item (T-shirt, jumper, jeans, jacket, etc.) and/or assesses its condition (new, worn, stained, etc.) or other product-specific information (e.g. size or brand) based on visual criteria.
4. **Ejection and sorting assistance**: The result is transmitted to the operator or to an automated device (robotic arm, diverter), allowing to **pre-classify** items before a final manual sorting step or to automatically direct the flows to dedicated sorting containers (second-hand, recycling).

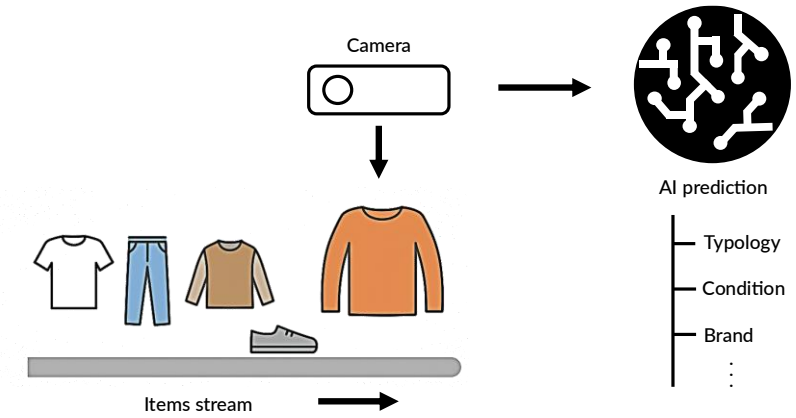


**Figure 56 : Operational diagram of automated sorting for second-hand technologies**

### Limitations and points to consider:

Despite significant advances in computer vision and machine learning, several technical and methodological limitations still hinder the widespread deployment of AI-assisted sorting for second-hand:

- **Image quality and item positioning:** A controlled environment, with uniform lighting and items properly positioned without any overlapping, is essential to avoid any identification errors.
- **Assessment of wear and condition:** Although AI can correctly identify item types, assessing the items' condition remains a challenge, as the analysis is limited to their visual appearance. Non-visible defects, such as odours, comfort loss or localised wear, cannot be detected.
- **Building and diversity of image databases:** AI models require large and representative databases in order to perform effectively. Potential biases in the databases, such as the over-representation of certain brands or types of items, can affect classification.

## 4.1. Automated sorting solutions for 2nd hand

The main European stakeholders offering automated sorting solutions for second-hand are presented below. Projects can be found in the Appendix.

### 4.1.1. DESION (Germany)

| | |
|---|---|
| Equipment | Classifly 180 |
| Detection (technology) | Typology + Condition (VIS + AI) |
| Application | Clothing |
| Maturity | Pilot / Demonstrator |

Desion GmbH is a German-based technology company, founded in 2020 as a spin-off of the Fraunhofer IGD institutes and the Technische Universität Darmstadt, specializing in automating inspections and sorting of products, using machine vision and AI applied to industrial processes. For textiles, Desion has developed a range of automated classification and inspection solutions: **Classifly**.

Using five cameras and AI, this technology allows to evaluate garments as they fall freely in a column, making possible to identify up to 1,800 items per hour with high accuracy (or 3,600 small items, e.g. gloves).

The Classifly system can also be equipped with UV or IR sensitive sensors to detect any specific contaminants, such as organic residues.

Clothing items are fed mechanically via conveyors or robotic grippers, or manually via an operator. The classification is then carried out, for example via a conveyor belt with compressed air ejection.

**Figure 57 : Classifly pilot at Wargön Innovation**
Source : Desion Gmbh

#### Performance:

The Classifly 180 can process up to 1 item/sec (average of 2 items/sec with the smaller Classifly 40) and detect the following characteristics:

- Holes, tears
- Different types of stains / organic contaminations / colour deviation
- Fabric structure
- Types of garments (45 typologies)

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| N/A | Wärgon Innovation (Sweden) – pilot site |

**Contact:** Dirk Siegmund – CEO – dirk.siegmund@desion.de

### 4.1.2. MATOHA Instrumentation Ltd. (UK)

| | |
|---|---|
| **Equipment** | **S-Bench** |
| **Detection (technology)** | **Materials (NIR) + Colors (VIS) + Typology (VIS) + Condition (VIS) + Fabric structure (VIS) + Branding (VIS) + Metals + Weight + RFID/QR** |
| **Application** | **Clothing** |
| **Maturity** | **Pilot / Demonstrator** |

**Figure 58 : S-BENCH solution**
Source : MATOHA Instrumentation Ltd.

MATOHA is a British company specializing in the detection and rapid analysis of materials. It designs NIR spectroscopy solutions for the textile and plastics industries.

MATOHA has developed **S-BENCH**: a semi-automated sorting solution for 2nd hand. This solution is a multi-sensor table with the following features:

- Recognition of the item typology
- Single/multi-colour detection
- Defects/anomalies detection
- Branding detection
- Material composition detection (via their FabriTell)
- Weight measurement (scales embedded in sorting containers)
- Fabric structure recognition
- RFID chip and barcode reading
- Metal detection
- Customisable outcome routing recommendation (e.g. re-sellable vs recycling)

#### Current developments:

Garment size estimation and price estimation.

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| London (United Kingdom) | 2 in Scotland, 1 in London, England |

**Contact:** Chris NEWTON – Chief Commercial Officer – chris@matoha.com

### 4.1.3. reverse.fashion (Germany)

| | |
|---|---|
| Equipment | co.sort<br>line.sort |
| Detection (technology) | Condition (VIS)+ Colours (VIS) + Typology (VIS) + Materials (NIR) |
| Application | Clothing |
| Maturity | Pilot / Demonstrator |

reverse.fashion is a German company based in Berlin, specializing in the automation of textile sorting by AI and machine vision, that develops software and hardware solutions to identify garment condition, typology, brand, colour and style. The company designs two complementary pieces of equipment:

- **co.sort:** Intended to assist operators on manual workstations to identify valuable pieces for reuse. The operator unfolds and lays the garment flat, a camera captures the image, the AI analyses the category, style and brand, and proposes a classification on the screen. The operator validates and drops the garment in the appropriate container. The solution is compatible with existing manual sorting stations, without the need for any additional space.

**Figure 59 : co.sort**
Source : reverse.fashion

**Figure 60 : line.sort**
Source : reverse.fashion

- **line.sort**: Multi-sensor sorting line combining computer vision, RFID/DPP reading and NIR spectroscopy (optional). Feeding is manual but can also be automated. The system recognizes the item type, style, brand, colour, size (measurements), visible condition, textile structure, season, gender category, and with the NIR option, the material composition. Ejection is then carried out by compressed air nozzles, multiple conveyors or robotic arms. The solution can also be used to digitize products for recommerce including AI generated model images and cross-listings on different ecommerce platforms.

#### Performance:

- **co.sort:** speed is dependent on laying the garment flat, but overall improvement of the sorting quality and reliability. Equipment released since end 2025.
- **line.sort:** can process up to 3,600 items/hour, with >98% claimed accuracy for certain attributes (visible defects). In pilot phase, launch scheduled for summer 2026.

#### Current developments:

reverse.fashion is working on improving systems, recognizing the condition and visible defects of garments (stains, wear, tears) and refining the multi-sensor calibration.

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Berlin (Germany) | Looper Textile (Germany and Poland)<br>Deutsche Kleiderstiftung (Germany)<br>Texcycle (Bulgaria) |

**Contact:** Mario OSTERWALDER – Managing Director – mario@reverse.fashion

### 4.1.4. TROSORT (Belgium)

| | |
|---|---|
| Equipment | Sort Mate |
| Detection (Technology) | Materials (NIR) + Colours (VIS) + Typology (VIS) + Condition (VIS) |
| Application | Clothing |
| Maturity | Pilot / Demonstrator |

TROSORT is a Belgian company specialising in automated sorting of textiles for reuse and recycling. The project started in December 2023, with the official entity creation in January 2025.

Its solution combines computer vision, AI and optical sensors to recognize material composition, garment condition and estimated value.

In partnership with a Belgian automation manufacturer, TROSORT has developed a semi-automatic line capable of evaluating and classifying items according to their resale or recyclability potential. The **Sort Mate** system integrates a scanning module (camera + NIR sensor + AI) coupled with a blowing system towards the dedicated sorting containers. Its modular architecture adapts to any existing conveyor. The machine performs a double-sided 2D analysis of the garment laid flat, identifying material composition and visual characteristics (11 data points in total: brand, typology, gender, size, colours, defects, resale price, material composition, style, recycling disruptors and seasonality). A microphone interface allows operators to give any additional indications (e.g. smell). The solution also takes photos and provides smart pricing with real-time marketplace data. The system can integrate the customer rate base and connect to ERPs.

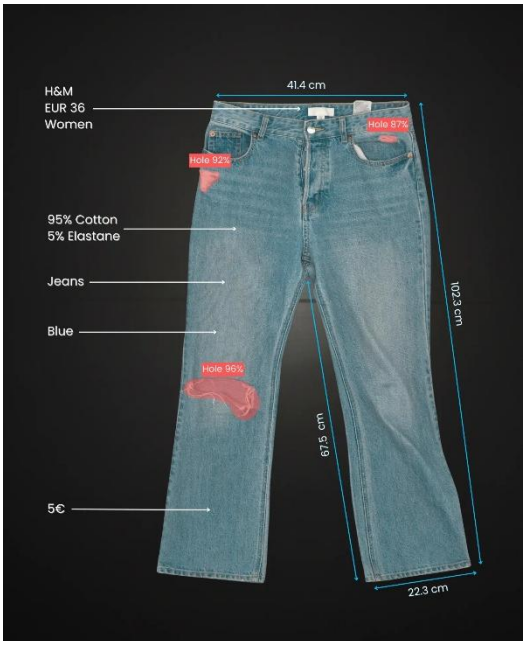


**Figure 61 : TROSORT**
Source : TROSORT

#### Performance:

- Speed: 4sec (1sec front/back photo + analysis) – 1200 garments per hour
- Detection of 3mm ≥ defects (stains, holes, pilling, fading – non-exhaustive list) and material identification with the integrated NIR sensor

The detection performance depends on the quality of the garment's placement on the module (positioning and visibility of the label). The analysis remains limited to the visible surface of the textile.

#### Current developments:

- Continuous improvement of the system (feeding, categorization, ...) to reach 90t/day.
- Automated evaluation of repairability and associated cost as well as recyclability depending on the materials detected;
- Inclusion of seasonality,
- Deployment of a globalized pricing engine (already available for Europe);
- Automated physical labelling of garments;
- Integration of RFID modules.

#### Locations:

| Testing centre | Examples of equipped facilities |
|---|---|
| Antwerp (Belgium) – customer site | Kringwinkel (Belgium)<br>Les Petits Riens (Belgium) |

**Contacts:** Achille MATHOT – CEO – achille@trosort.com
Matthieu BRABANT – CTO – matthieu@trosort.com

### 4.1.5. Siemens (Germany)

**Figure 62 : Siemens system**
Source : Siemens

Siemens, a global leader in industrial technology, has developed a modular system integrating generative AI software:

- Image capture of textiles,
- Analysis of the item type, brand, colour, patterns, gender and size,
- Identification of the corresponding sorting container.

The system uses two cameras positioned around an enclosure in which the operator places the item on a hanger. Image analysis determines the product's characteristics and guides the operator during sorting, within 6 to 10 seconds. A user interface completes the system, enabling operators to define or modify sorting categories without reprogramming the system.

### 4.1.6. ValueSort.AI (Holland)

ValueSort.AI is a company specialising in optimising second-hand textiles sorting. It has developed a solution that combines computer vision and AI to quickly identify items, assess their condition and estimate their commercial value. The aim is to enable efficient sorting based on market demand and trends. The platform also offers smart pricing and digitalisation features, directly connecting workshops with points of sale or customers.

### 4.1.7. Valvan (Belgium)

| | |
|---|---|
| **Equipment** | **Hypersort®** |
| **Detection (technology)** | **Typology (VIS) + Branding (VIS) + Colours (VIS) + Condition (VIS+AI)** |
| **Application** | **Clothing** |
| **Maturity** | **Industrial pilot** |


**Figure 63 : Hypersort®**
Source : Valvan

VALVAN is a Belgian manufacturer specialising in the design of machines for textiles sorting. The company develops automated solutions integrating NIR spectroscopy, vision and AI.

In 2026, Valvan launched Hypersort®, an AI-powered pricing & grading solution of post-consumer clothing for the 2nd hand market. The solution enables consistent pricing across operators and locations, and delivers item-level traceability through QR codes.

The **fully integrated Hypersort® system** analyzes the category, brand, condition, and other characteristics of each item laid flat on the conveyor by automatically capturing high resolution images on both sides of the item, to recommend accurate pricing in real time, without any manual intervention.

Valvan also offers the **software solution** on its own for seamless integration into existing operations and supporting operators in items grading and pricing. A QR code label can be printed and attached to the item, to ensure its traceability.

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# 5. Appendix

## 5.1. European projects – automated sorting for textiles recycling

### 5.1.1. AUTOLOOP

The European AUTOLOOP project (September 2025 to August 2029) aims to develop a scalable technology (TRL 5) for the intelligent automated sorting and advanced chemical recycling of non-reusable textiles, while ensuring the traceability of additives and the digitalisation of the textile value chain. The AI-powered hyperspectral sorting technology and optical recognition system is developed by Zori Tex.

### 5.1.2. CISUTAC

The European CISUTAC project (2022–2026), coordinated by Centexbel and bringing together 27 partners, aims to strengthen textile circularity in Europe. It focuses on three use cases: clothing, personal protective equipment (PPE) and accessories, with a focus on polyester and cotton fibres. A pilot demonstrator is being developed for sorting for reuse and recycling, with the implementation of standardised protocols and automation technologies, including a decision-support tool for classification and flow planning.

### 5.1.3. ISORTx

The ISORTx project (August 2023 to December 2025) is a Norwegian regional project aimed at developing intelligent automated sorting and trims removal solutions for textile waste, mainly multilayered garments, based on spectral imaging and machine vision.

### 5.1.4. MISTERY

The MISTERY project, conducted by the CEA and selected as a winner of the Refashion 2021 Innovation Challenge, explored the use of hyperspectral sensors (NIR/SWIR) to improve the sorting of end-of-life textiles. The work focused on detecting fibres such as elastane present in small proportions, polyamide (PA6 vs PA66), and distinguishing between cotton and viscose. The tests confirmed the feasibility of classifying and quantifying blends, with optimal performance in the SWIR band (1,700–2,500 nm).

### 5.1.5. PESCO-UP

The European PESCO-UP project (Textile Fibre Recycling from Mixed Streams of PES/CO Textiles), launched in January 2024 and funded under the Horizon Europe programme, aims to develop a sustainable and economically viable process for recovering polyester/cotton (PES/CO) textile waste and converting it into new materials with a quality equivalent to that of virgin materials. Its approach covers the entire value chain, with workstreams focusing on the automation of textile identification and sorting, as well as the creation of a digital marketplace and of a product passport to facilitate exchanges between stakeholders.

### 5.1.6. SOLSTICE

SOLSTICE (2024 – 2027) is a European Horizon Europe project aimed at developing regional solutions for the circular transition of the textile sector. The project is based on the principles of the 5Rs (Reduce, Reuse, Repair, Repurpose and Recycle) and explores four areas: raising consumer awareness; improving sorting, particularly through spectroscopy, and recycling, including chemical recycling; developing digital traceability through a product passport; and scaling up the identified solutions for industrial deployment. Four pilot regions (Grenoble, Berlin, Prato and Catalonia) are testing these approaches. Initial analyses conducted in 2025 focused on mapping material flows, sorting infrastructure and local circular practices.

### 5.1.7. SORT4CIRC

The SORT4CIRC project (December 2025 to November 2028) brings together seven European partners, including IRIS and RECYC'ELIT, and aims to develop a high-tech traceability system for the automated sorting of textiles with AI, multi-sensor technologies and digital product passports.

### 5.1.8. STREP

The STREP project (Streamlined Textile Waste Streams for Recycling Optimization), launched in 2025, funded by Horizon Europe and coordinated by Aalborg University (Denmark), aims to optimise closed-loop recycling of post-consumer textiles. It brings together 13 European partners, including NewRetex and Kapdaa, to develop integrated solutions combining automated sorting, disruptors removal, disassembly and mechanical or chemical recycling. The project also explores digital traceability through product passports and promotes the design of "recyclable-by-design" garments. STREP therefore aims to significantly increase textile recycling rates in Europe while reducing the sector's energy impact.

### 5.1.9. T-REX

The T-REX project (Textile Recycling Excellence, 2022 - 2025) brought together 13 European stakeholders from across the textile value chain with the aim of creating a common roadmap for household textiles closed-loop recycling. The consortium developed technologies and published recommendations to accelerate the industrialisation of textile recycling in Europe including:

- Increased investment in automated sorting technologies, supported by public and private funding;
- Standardisation of feedstock specifications, sorting protocols and data systems to ensure interoperability between sorters and recyclers.

### 5.1.10. WHITECYCLE

The WhiteCycle project, coordinated by Michelin and launched in 2022 with the support of 15 European partners, including IRIS Technology Solutions, aims to develop an industrial solution capable of recycling complex waste containing PET, such as multilayered textiles, hoses and tyres. The project is structured around three areas: developing innovative sorting technologies to identify and separate multilayered materials; developing an enzymatic recycling process capable of regenerating plastic equivalent to virgin material; and manufacturing products from these new recycled materials.

Within this framework, IRIS Technology Solutions plays a key role by developing an automated sorting solution that combines computer vision and AI to detect the presence of PET and estimate its proportion in multi-material textile waste streams.

## 5.1. European projects – automated sorting for 2nd hand

### 5.1.1. AI for resource-efficient circular fashion (Sweden)

The "AI for resource-efficient circular fashion" project, led by Wargön Innovation in Sweden in collaboration with RISE Research Institutes of Sweden and several second-hand sector partners, has created an open database for analysing and adding value to second-hand clothing using AI. The aim is to stimulate innovation and enable organisations of all sizes to develop tools tailored to their needs.
The database contains thousands of annotated images of post-consumer garments (more than 31,000 images) with information on item typology, material composition, the presence of patterns, brand, level of wear, stains and damage. This enables training AI models to recognise and assess items. The objective is to automate textile sorting to direct items to the appropriate second-hand channels or sales platforms. The project has also already been incorporated into pilot projects and tests exploring the practical use of AI in sorting facilities and as part of the European CISUTAC programme.

### 5.1.2. Sorting used textiles with the help of AI (Germany)

The "Sorting used textiles with the help of AI" project is an initiative in Germany led by students from *Hochschule Albstadt-Sigmaringen*, in collaboration with *Striebel Textil* and the *Schülerforschungszentrum Südwürttemberg*. The project is currently in the research pilot phase. The objective is to automate the pre-sorting of textiles using AI-based image recognition capable of identifying and classifying 26 item categories, including adult and children's clothing, footwear and household linen. A standardised photo booth was developed to generate training data, with approximately 300 to 360 images per category. The tests show an accuracy rate of 90%, making it possible to speed up the process, improve operators' working conditions and optimise the routing of textiles to second-hand, recycling or disposal channels.

### 5.1.3. ReUseTex (Austria)

The ReUseTex project, led by Saubermacher, TU Graz and several industrial partners, runs from August 2025 to July 2028. It involves developing an automated sorting system based on AI and robotics to analyse and classify post-consumer textiles according to their potential for second-hand use or recycling at a sorting facility in Graz, Austria. The process is progressively optimised using deep-learning algorithms. The aim is to develop a scalable sorting system that can serve as a basis for future industrial applications.

### 5.1.4. REWEAR (Europe)

In 2024, Fashion for Good launched an 18-month project aimed at improving the sorting processes for reusable textiles, in order to optimise the value recovery of garments intended for resale and promote circularity in the fashion industry. The REWEAR project involves 15 partners, including reverse.fashion, Erdotex and Valvan, across four key regions: Lithuania (the Nordic and Baltic countries), the Netherlands (Western Europe), Poland (Central and Eastern Europe) and Spain (Southern Europe). The project is testing automated sorting technologies using AI and machine learning to collect information on items, such as colour, style, garment type and condition, for enabling sorters and brands to efficiently identify items intended for resale.

## 5.2. Automated sorting solution providers outside Europe

### 5.2.1. DATABEYOND (China)

**Figure 64 : FASTSORT machine**
Source : Databeyond

Databeyond, through its **FastSort-Textile** solution, uses NIR-HSI hyperspectral imaging and AI to accurately identify (claimed at > 90%) colour and material compositions (polyester, cotton, nylon, elastane, etc.), as well as recycling disruptors (buttons, zippers, sequins, etc.).

The technology enables high-throughput sorting, up to 2 tonnes per hour, and is fully automated.

### 5.2.2. HKRITA (Hong Kong - China)

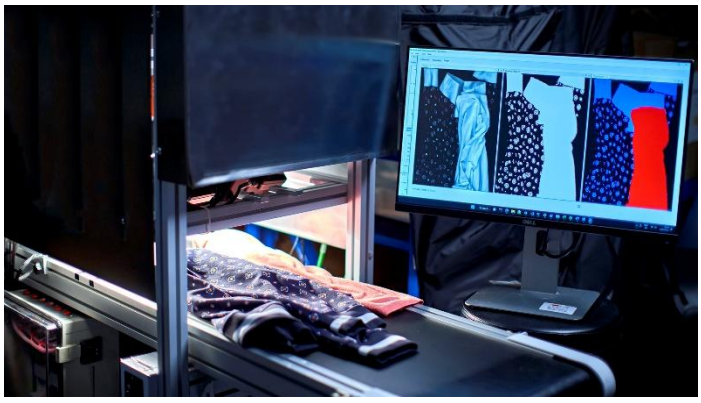

**Figure 65 : Smart Garment Sorting System**
Source : HKRITA

HKRITA has developed the **Smart Garment Sorting System for Recycling**, an integrated solution combining AI, hyperspectral imaging and visible imaging to sort post-consumer garments. The system consists of classification modules that automatically identify the garment type, its material composition and fabric structure in order to correctly direct the streams towards recycling or reuse.

A robot at the beginning of the process can also feed the system.

### 5.2.3. PADE Technology (Taïwan)


**Figure 66 : TX-5000N machine**
Source : PADE Technology

PADE Technology, a Taiwanese company founded in 2023, develops advanced optical sorting solutions combining NIR and AI for the automated identification of post-consumer textiles. Its technology can recognise a wide range of fibres, including cotton, polyester, nylon, wool and acrylic, as well as blends such as polycotton, while estimating their respective proportions.

The solution is available in two versions: a high-throughput fixed unit (TX-5000N) designed for industrial sorting facilities, and a lighter mobile version (TX-5500N) suited to decentralised collection points. The fixed unit has a capacity of approximately 740 tonnes per year, with a claimed detection accuracy of over 90%, including for blends.

### 5.2.4. Refiberd (USA)

Refiberd is an American company that uses AI and hyperspectral imaging for precise and fast textiles' material identification. Their innovative contact-free technology detects materials with an error margin of less than 2%, including for complex blends (up to four or more fibres) and traces of elastane, polyamide or acrylic (< 2%). Recognised fibres include cotton, polyester, nylon, elastane, man-made cellulosic fibres (MMCF), wool and acrylic. The claimed accuracy exceeds 90%. Although Refiberd does not provide physical infrastructure like conveyors or air-ejection systems, their solution is designed to be integrated into existing equipment, offering a comprehensive approach, adaptable to industrial operations.

### 5.2.5. SAGITTO (New-Zealand)

**Figure 67 : Lab-In-The-Hand**
Source : Sagitto

Sagitto is a New Zealand company specialising in applying machine learning to spectroscopy. It has developed **Lab-in-the-Hand**, a handheld spectrometer fully controlled via a smartphone app. The device uses a NIR sensor (900–1,700 nm) to analyse material composition and display the result on the screen in approximately ten seconds.

The system identifies the main textile fibres (polyester, cotton, silk, nylon, wool, linen, viscose and acrylic) according to the predominant material in the sample. For blends containing cotton, polyester and elastane, the model estimates the relative proportion of materials and indicates the possible presence of elastane, together with a confidence score for each measurement.

### 5.2.6. SORTILE (USA)

**Figure 68 : Sortile NIR scanner & software**
Source : Sortile

Sortile is a New York-based start-up founded in 2021, specialising in the management and traceability of textiles intended for 2nd hand or recycling. Their technology combines a handheld NIR sensor with AI models to identify textiles' material composition (cotton, polyester, polycotton, wool, acrylic, silk and viscose).

In addition, Sortile has developed a digital platform that centralises detection data and the volumes analysed, while estimating the associated environmental impacts. The solution can be used with Sortile's NIR sensor or integrated into other partner devices.

## 5.3. Textiles trims removal solution provider outside Europe

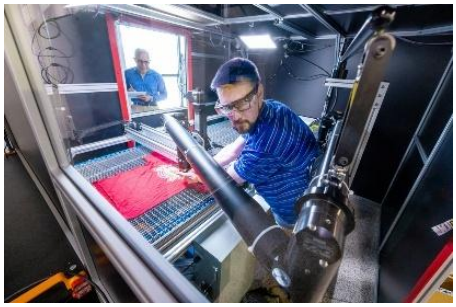

**Figure 69 : Laser cutting machine**
Source : Carlos Ortiz/RIT

The solution developed by the Golisano Institute for Sustainability – RIT (USA) combines AI, computer vision and laser cutting to remove external recycling disruptors and sort materials for recycling at a high throughput (approximately one garment every 10 seconds).