# Research and Pilot Activities at GeMMe – ULiège:

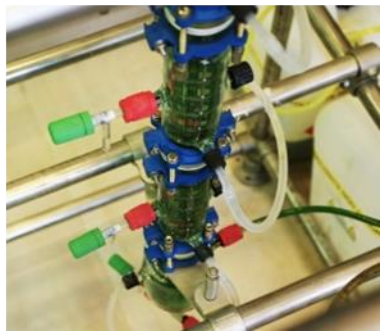
# The REEfine, BIOLIX, NOVA and PICKIT Projects

Ir David Bastin
David.Bastin@ULiege.be









*6 th Prometia Scientific Seminar, October 2019.*

GeMMe

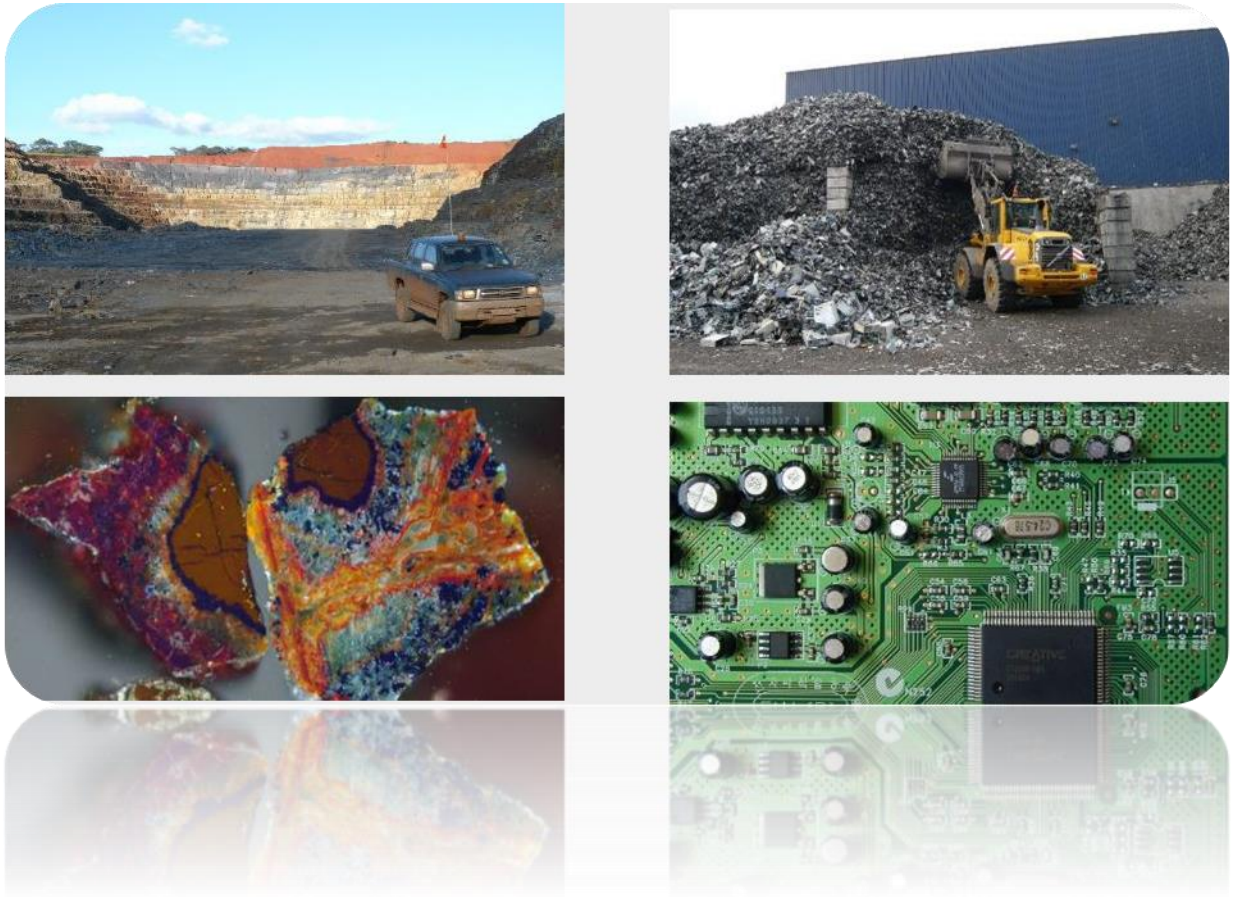
## *Georesources, Minerals Engineering and Extractive Metallurgy*

- 30⁺ Research Staff
- 3 M€ annual turnover
  - *40% contracts with private partners*

- ***Resource***
  - Particular attention given to **MINERAL** and **METALLIC RESOURCES**
  - Interest for both **MINING** and **URBAN MINING**
- ***Efficiency***
  - Contribute to developing a more **CIRCULAR ECONOMY**
  - Privilege a **HOLISTIC** approach of the material cycle
  - Put engineering to the service of a more **SUSTAINABLE** societal project
- ***Engineering***
  - Contribute to the **EDUCATION** of creative and open-minded engineers
  - Be a source of **TECHNOLOGICAL INNOVATION** for increased recovery of valuable metals

# *From Mining to Urban Metallurgy*

***GeMMe operates on the characterization, beneficiation, transformation, use and recycling of mineral materials at any stage of their life cycle.***



Kansanshi Cu Mine (Zambia)

Cu-Au WEEE Mine (Belgium)

# 4 Research Lines

## SMART SORTING

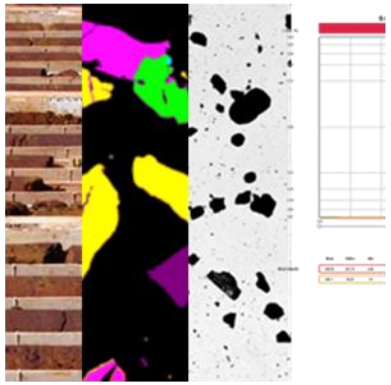
*Advanced 3D imaging and hyperspectral sorting*

## PHYSICAL PRE-PROCESSING

*Energy-Efficient fragmentation and conditioning*

## GEOMETALLURGICAL CHARACTERIZATION

*Process oriented "mineralogical" mapping*



## BIO - HYDROMETALLURGY

*Resource efficient processes for end-of-life goods*

# Member of Knowledge Innovation Communities

## ○ Walloon Region

- Reverse Metallurgy (61 M€/5yrs)

## ○ Europe

- EIT Raw Materials – Core Partner

Reverse Metallurgy


EMERALD
ERASMUS MUNDUS MASTER IN GEORESOURCES ENGINEERING

LIÈGE université

CReSus
Centre for Resource Efficiency & Sustainability

LIÈGE université

CRM GROUP

CTP
member of EMIRA

Citius Engineering

COMET TRAITEMENTS SA

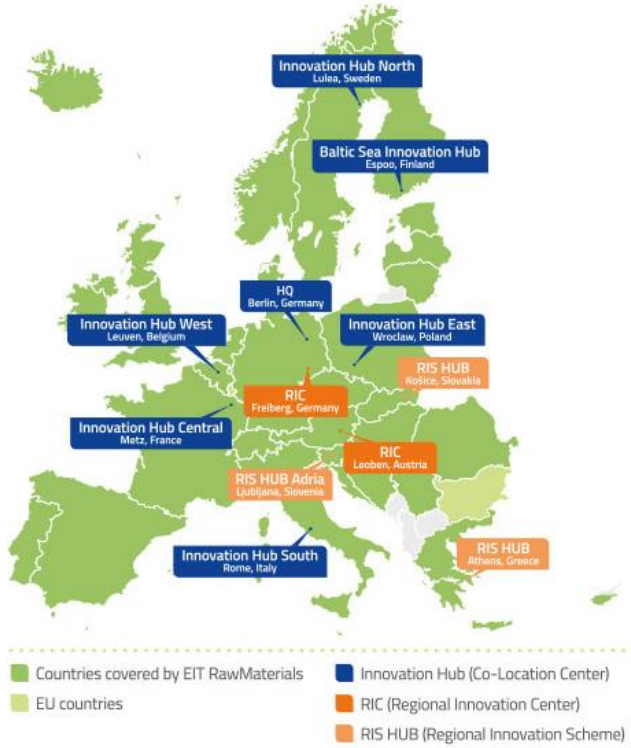
HYDROMETAL

CARMEUSE

MARICHAL KETIN

MAGOTTEAUX

eit RawMaterials
Connecting matters




**128**
Core and associate partners

**200**
Project partners

**27+**
European countries

**339**
Number of projects 2016-2018

**€ 130+ M**
Total projects funding

**617**
Number of jobs created

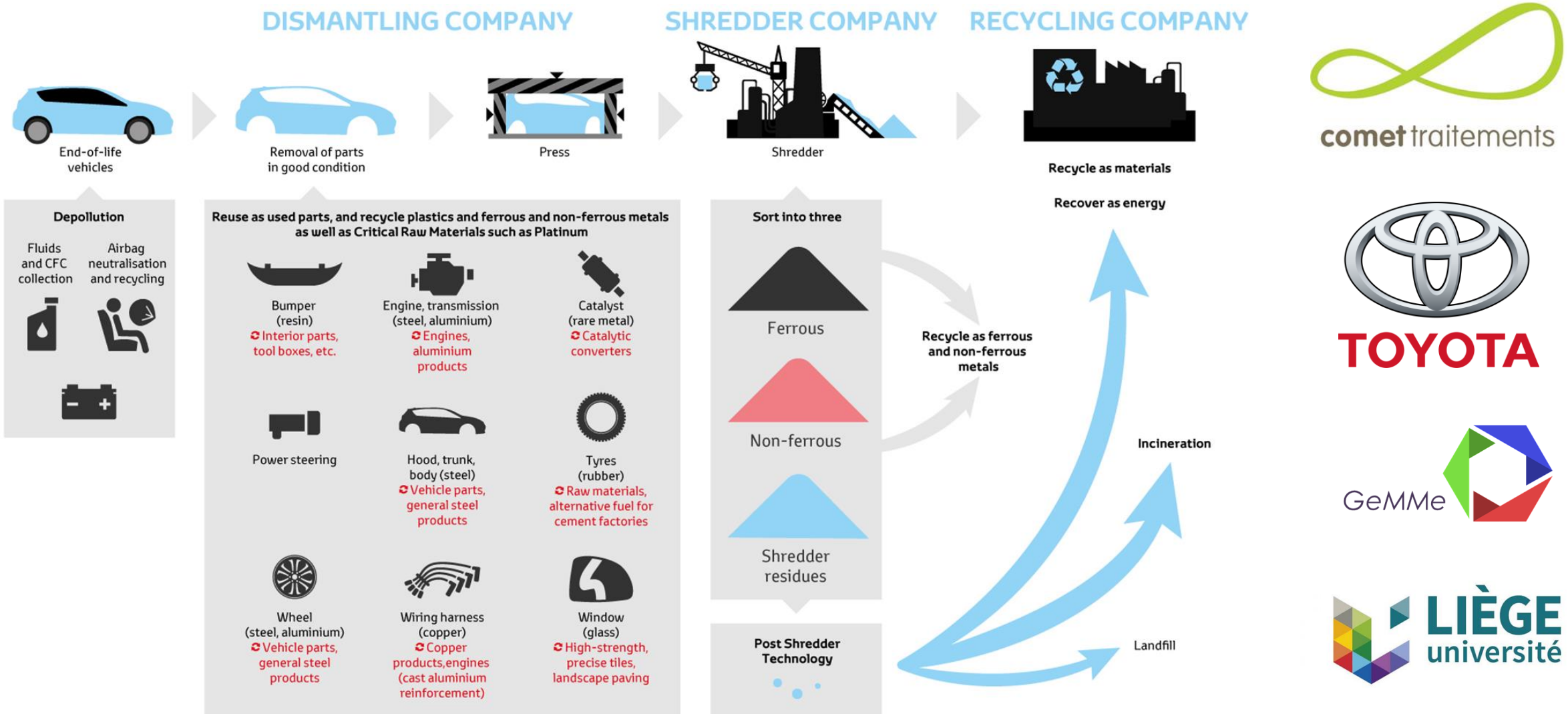
**€ 26 M**
Total RIS funding

Reverse Metallurgy

REEfine

# *The Toyota Industrial Recycling Trial @ Comet Traitements in Belgium:*

Recycling of 165 Prius Hybrid Plug-in to determine the achievable Recycling Rate with best available technologies from dismantling to post shredder technologies.




comet traitements

TOYOTA

GeMMe

LIÈGE université

Reverse Metallurgy

REEfine

TOYOTA

GeMMe

comet traitements

LIÈGE université


Reverse Metallurgy

REEfine

TOYOTA

GeMMe

comet traitements

LIÈGE université

| | Recycling | Energy Recovery | Landfill |
|---|---|---|---|
| Securing | 12.0% | 0.0% | 0.0% |
| Depollution | 4.0% | 0.3% | 0.0% |
| Dismantling | 14.5% | 0.0% | 0.0% |
| Shredding | 43.8% | 0.0% | 0.0% |
| PST Metals | 5.0% | 0.0% | 0.1% |
| PST Plastics | 7.5% | 0.0% | 0.0% |
| PST Minerals | 1.5% | 0.0% | 0.9% |
| PST Phoenix | 2.8% | 5.4% | 2.1% |
| **TOTAL** | **91.2%** | **5.7%** | **3.1%** |


# Permanent Magnets Sourcing at Industrial Scale

Securing and depollution

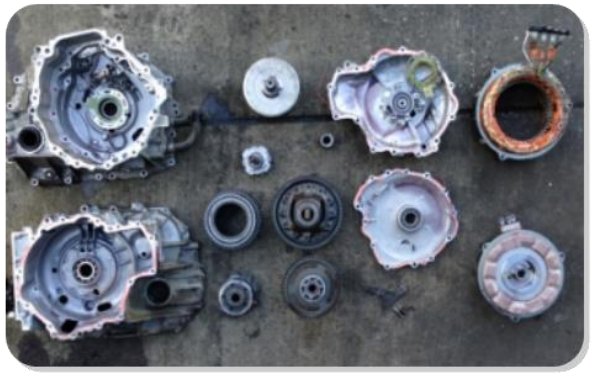
Manual dismantling

***Depolluted vehicles***

Reverse Metallurgy

REEfine

***$Nd_2Fe_{14}B$ magnets***



***REE magnets rotor***

***REE magnets wheels***

Demagnetization
Mechanical separations
*(Pilot scale)*

Manual dismantling

## Advantages of the thermo-mechanical process

- High ***recoveries***
- ***Low*** operating time (2 hours)
- Fine grinding avoided
- Independent of rotor design
- Independent of the magnet composition

## Currently in progress

- Volume ***securisation***
- Feed ***diversification***




Pilot plant commissioned with ***5 kg permanent magnets/day***

## ADVANTAGES OF THE HYDROMETALLURGICAL PROCESS

- High ***recoveries*** : 95.5% Nd and 94.4% Dy
- Several products with variable grade and OPEX associated

| Standard grade | | High grade |
|---|---|---|
| 75% $Nd_2O_3$ + $Dy_2O_3$<br>2% Fe | ***Purity*** → ***OPEX*** | 99% $Nd_2O_3$ + $Dy_2O_3$<br><25ppm Fe<br><1% impurities |
| *Pilot production:*<br>*2.4 kg/day* | | *Pilot production:*<br>*1.9 kg/day* |

- Good ***selectiviy***
- ***Low*** OPEX
- No liquid effluent in normal operations
- ***Valorisation*** of a Fe-Co by-product (no solid residue)
- ***Simple*** and ***flexible*** technology

Reverse Metallurgy

BIOLIX

# Cu cathodes production from ELV and WEEE shredder dusts.

LIÈGE université

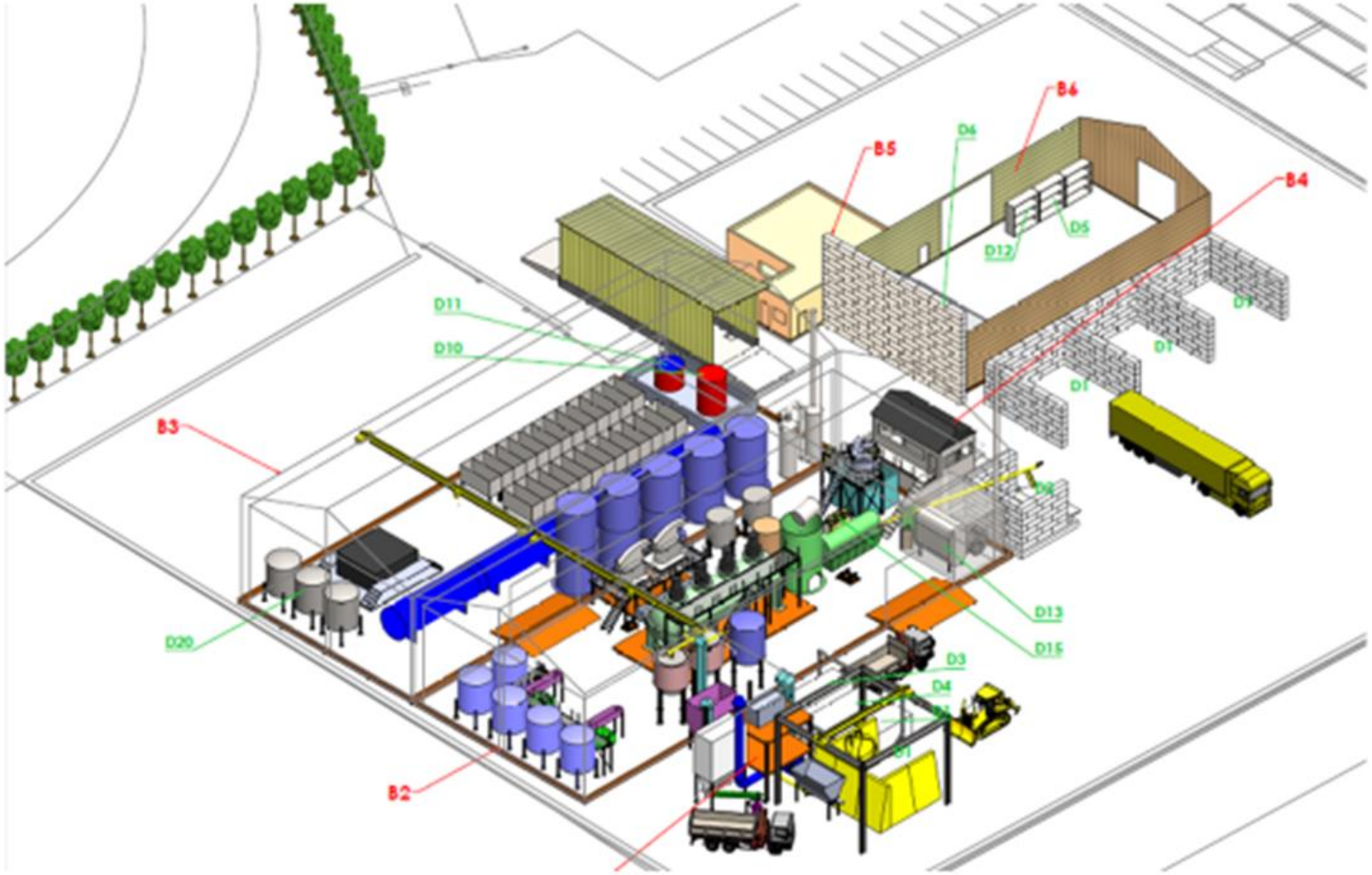
**Leaching & Fe-Al Management** → **Solid/Liquid Separation** → **SX** → **EW**

From batch labscale to continuous pilot scale

GeMMe

comet traitements

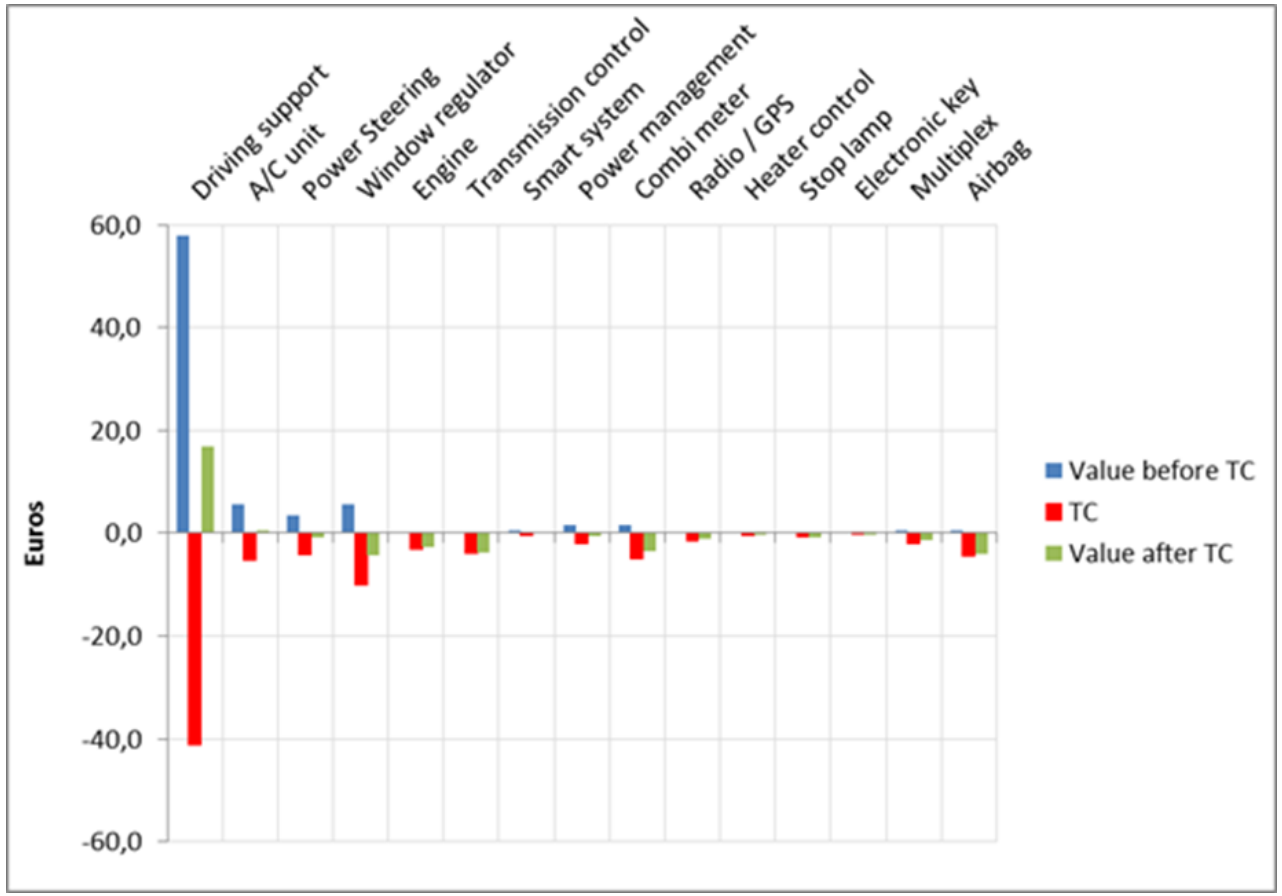
- ❑ 12.7 M€ Investment
- ❑ Treatment Capacity: 20 000 t/y of Shredder dusts.
- ❑ Production: 1500 t/y Cu Cathodes Grade A (99.99%)



# Dismantling vs Shredding

High Grade (Precious Metals) PCBs

Pyrometallurgy Smelter

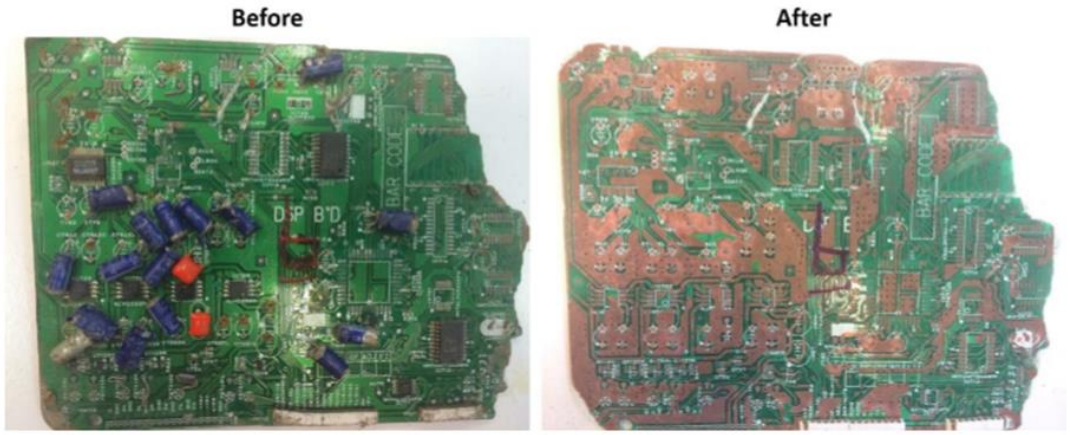



From 15 Electronic Control Units (ECU) of the Toyota Prius Plug-in, only 2 could be dismantled economically.

Low to Medium Grade PCBs

Reverse Metallurgy

NOVA




LIÈGE université

GeMMe

Low to Medium Grade PCBs

Reverse Metallurgy

NOVA

Sn Concentrate @ 50.1 % Sn

Cu Concentrate @ 18.8 % Cu

Au-Ag-Cu Concentrate @ 300 g/t Au 4635 g/t Ag 33.8 % Cu

Pyrometallurgy

Reverse Metallurgy

BIOLIX

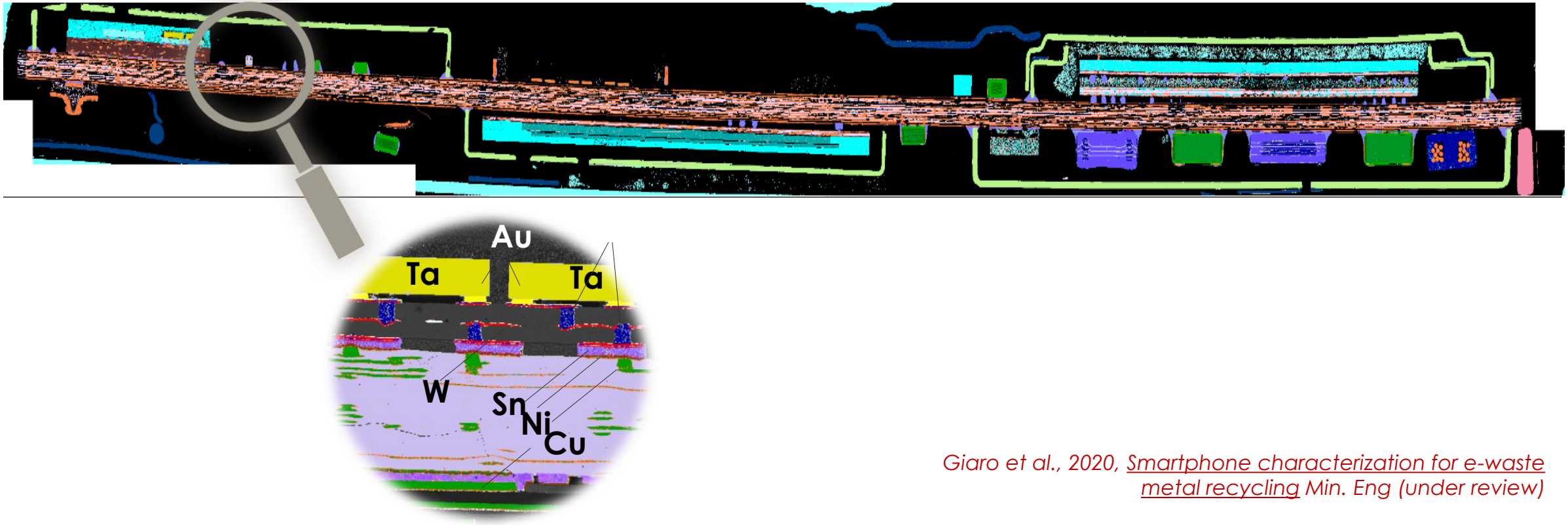
Smelter

- *Metal mapping in complex primary and secondary resources*


*Advanced Automated Metal Mapping*

ZEISS

Gold in e-waste




*Giaro et al., 2020, Smartphone characterization for e-waste metal recycling Min. Eng (under review)*

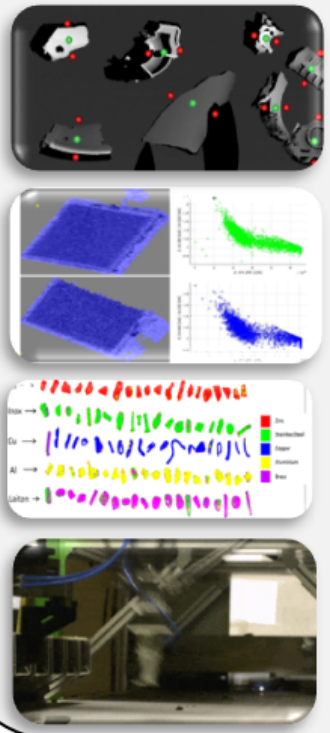
GeMMe

Reverse Metallurgy

LIÈGE université

# PICKIT

## The PICKIT Concept and Technology



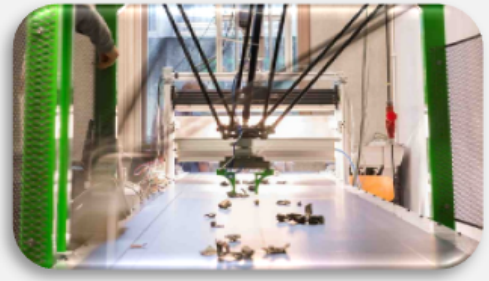
**Multi-Sensors Hub**

- 3D Imaging
- UV-VIS Hyperspectral Imaging
- X-Ray Transmission (XRT)
- Laser Induced Breakdown Spectroscopy (LIBS)

**Artificial Intelligence**

*Deep and Machine Learning*

Ultra-fast **Robotic Sorting** plateform combined with high capacity **Pneumatic Ejection**.

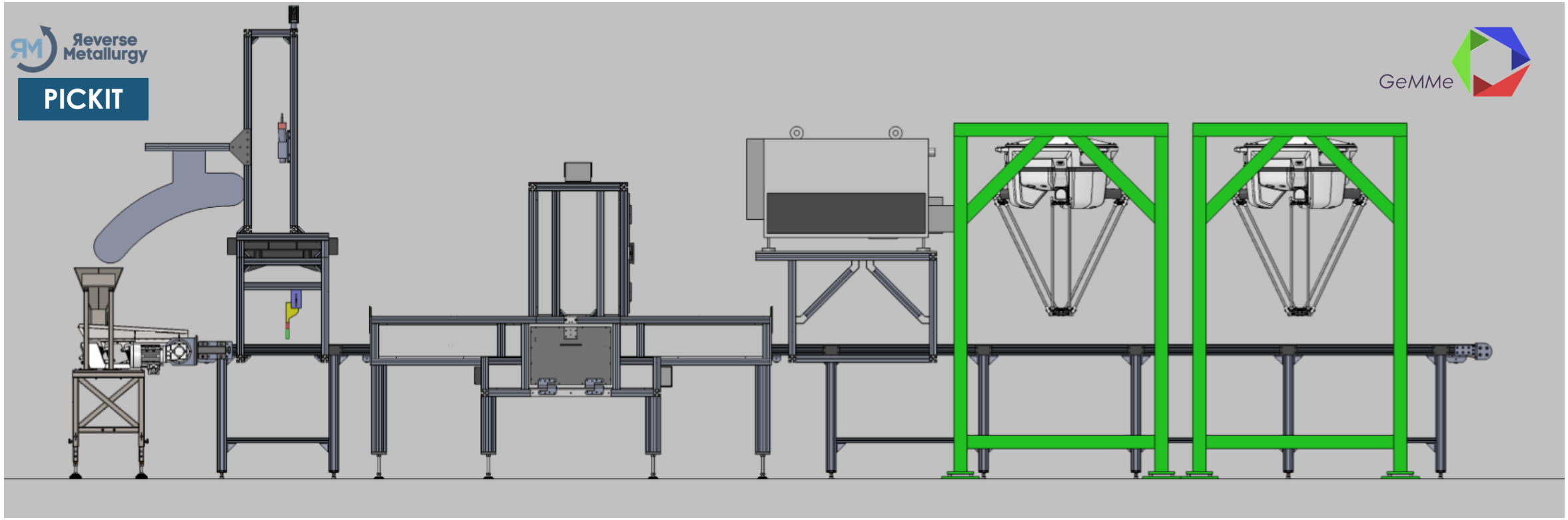


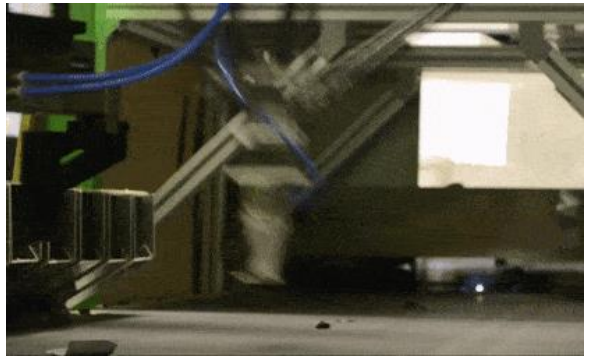
**Single Pass Multi-Class Sorting**

Reverse Metallurgy

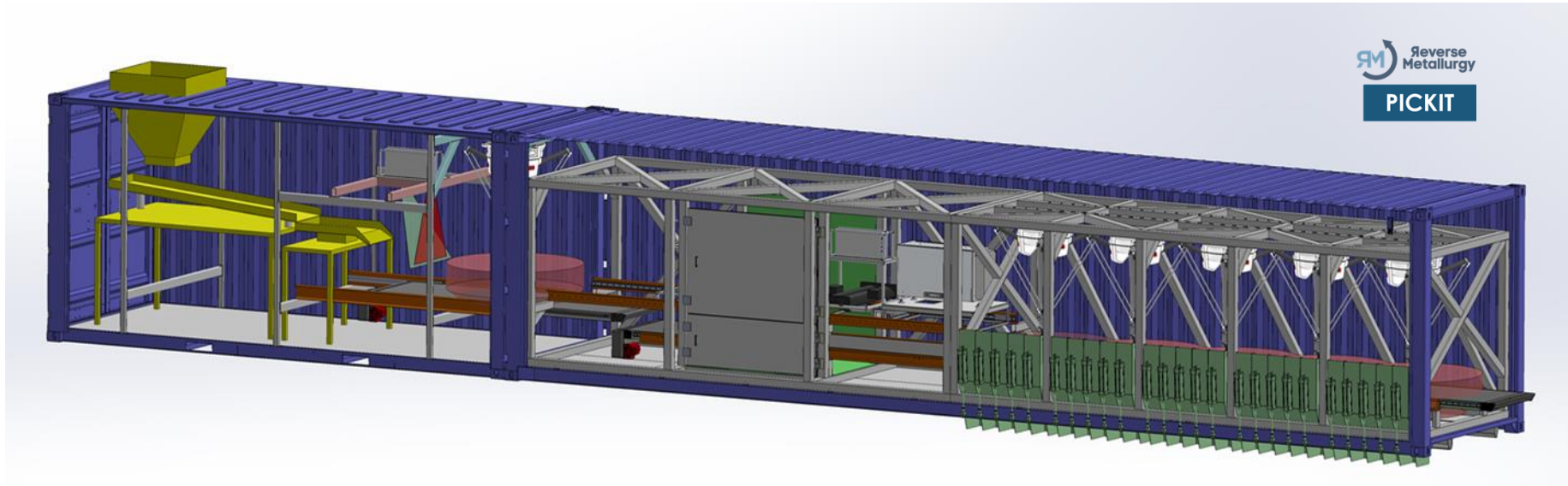
**PICKIT**

GeMMe

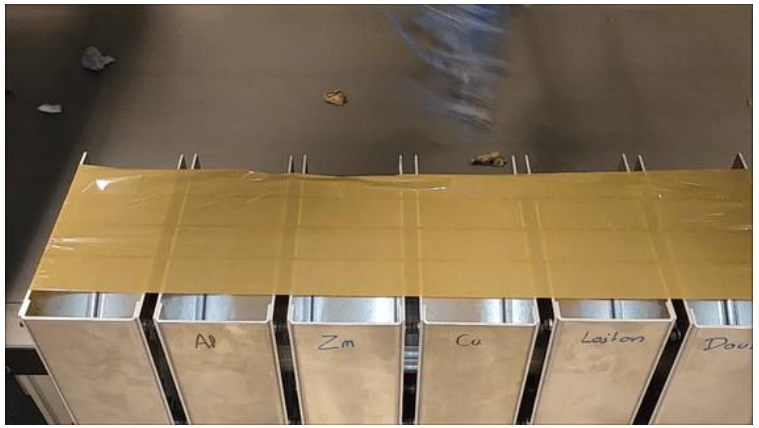


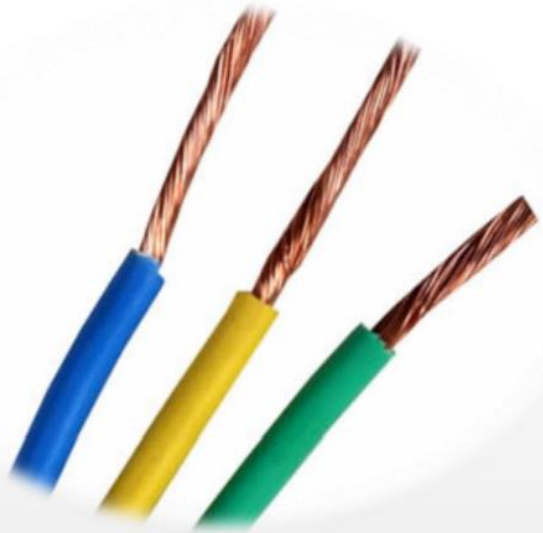


**3D, Color, Hyperspectral Reflectance Spectrum, XRT, LIBS.**



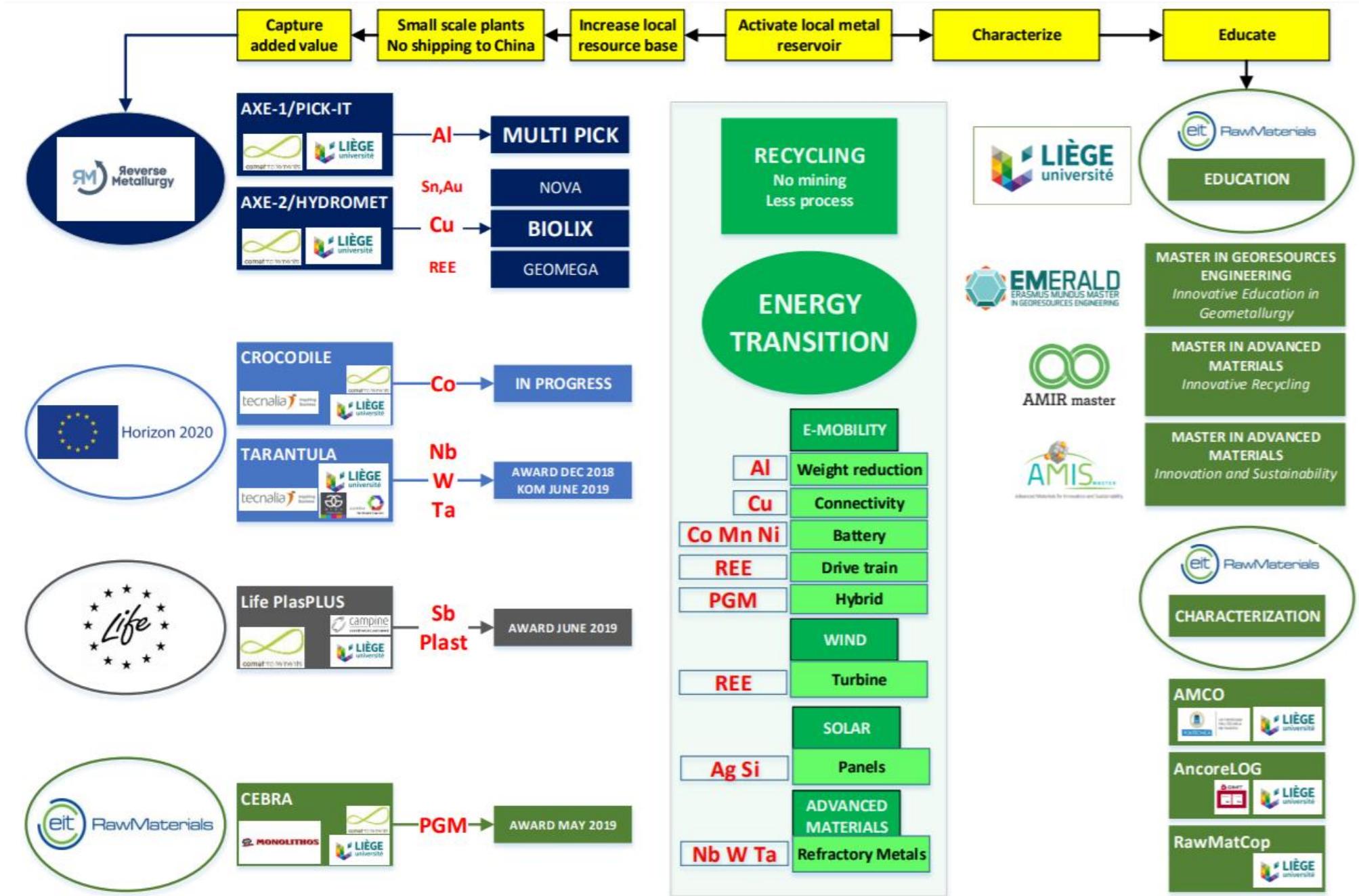

Identification of the elemental composition of up to **20 pieces/s** on a 1 m wide belt moving at **1m/s**, Pick and place of **2 pieces/s per robot in up to 14 class**, **5 to 6 t/h on 20 to 100 mm Zorba scraps** for the current prototype including **5 delta robots**.



Câbles en cuivre

Copper Clad Aluminium (CCA) cable



Capture added value
Small scale plants No shipping to China
Increase local resource base
Activate local metal reservoir
Characterize
Educate
Reverse Metallurgy
AXE-1/PICK-IT
Al
MULTI PICK
Sn,Au
NOVA
AXE-2/HYDROMET
Cu
BIOLIX
REE
GEOMEGA
Horizon 2020
CROCODILE
Co
IN PROGRESS
TARANTULA
Nb
W
Ta
AWARD DEC 2018
KOM JUNE 2019
Life
Life PlasPLUS
Sb
Plast
AWARD JUNE 2019
eit RawMaterials
CEBRA
PGM
AWARD MAY 2019
RECYCLING
No mining
Less process
ENERGY TRANSITION
E-MOBILITY
Al
Weight reduction
Cu
Connectivity
Co Mn Ni
Battery
REE
Drive train
PGM
Hybrid
WIND
REE
Turbine
SOLAR
Ag Si
Panels
ADVANCED MATERIALS
Nb W Ta
Refractory Metals
LIÈGE université
eit RawMaterials
EDUCATION
EMERALD
ERASMUS MUNDUS MASTER IN GEORESOURCES ENGINEERING
MASTER IN GEORESOURCES ENGINEERING
Innovative Education in Geometallurgy
AMIR master
MASTER IN ADVANCED MATERIALS
Innovative Recycling
AMIS
MASTER IN ADVANCED MATERIALS
Innovation and Sustainability
eit RawMaterials
CHARACTERIZATION
AMCO
AncoreLOG
RawMatCop