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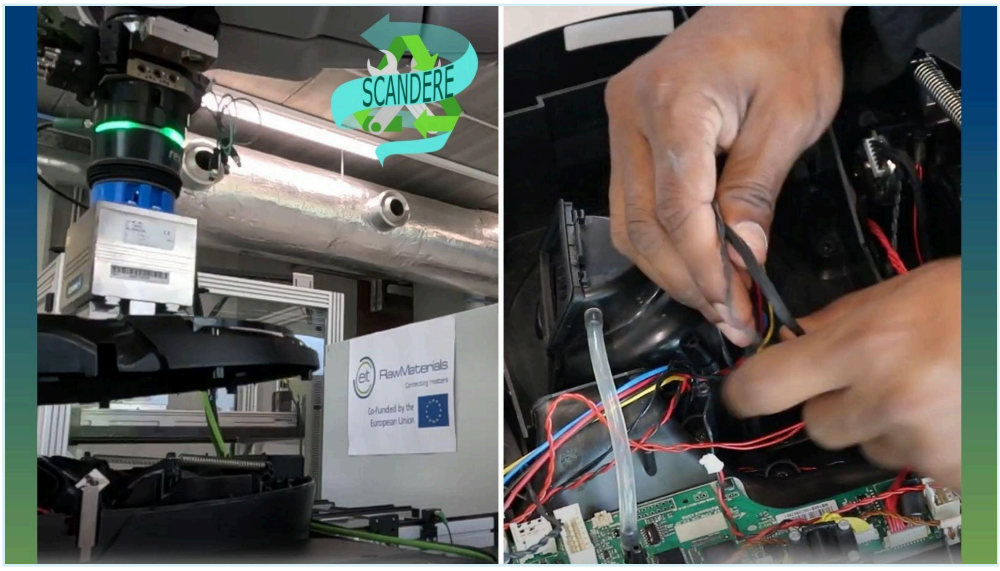
Ecodesign in action: how automation is transforming CRM recovery



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As the demand for electronic devices continues to rise, so does the urgency to address the challenges of resource scarcity and waste management. Critical raw materials (CRMs), essential for modern technologies from electronics to electric car batteries, are at the heart of this challenge. To meet the goals of the European Commission's Critical Raw Materials Act (https://www.era-min.eu/sites/default/files/publications/factsheet_gd_european_critical_raw_materials_act_.pdf.pdf), we need new, innovative ways to recover and reuse these vital resources efficiently. Here at Life Cycle Engineering research group (https://www.mech.kuleuven.be/en/research/LCE/home) at KU Leuven, we are looking at how ecodesign and automated re- and demanufacturing can help solving the CRM challenge.

What is ecodesign?

Ecodesign refers to the integration of environmental sustainability considerations into the features of a product, and into processes throughout its value chain. When ecodesign is combined with automated re- and demanufacturing, it offers a powerful solution to the CRM challenge, for example, by redesigning products to enable robotic disassembly. In this manner, manufacturers can overcome commonly faced barriers for CRM recovery, such as high labor costs and scalability. The research in the SCANDERE project explores how cooperative human-robot disassembly can pave the way for scalable, sustainable solutions in the electronics industry.

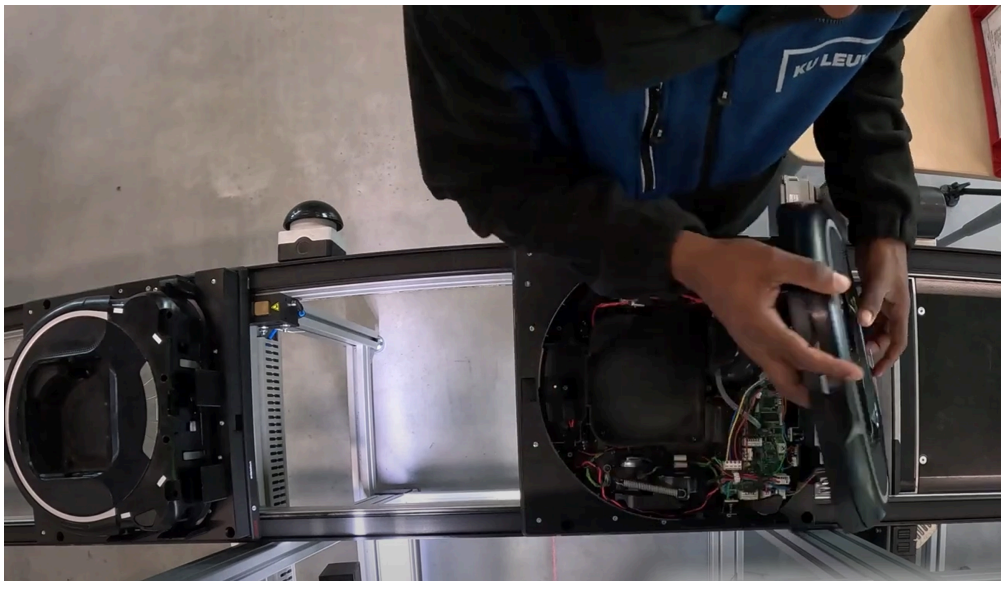
SCANDERE research project (Scaling up a circular economy business model by new design, leaner remanufacturing, and automated material recycling technologies) is financially supported by the ERA-MIN3 program under grant number 101003575. To learn more about the project, visit the website (https://scandere.nu/) or Linkedin page (https://www.linkedin.com/company/scandere-era-min3).

Robotic vacuum cleaner case study

Many products, such as robotic vacuum cleaners, often contain valuable CRMs in components like motors, circuit boards, and batteries. However, most of them are not designed with end-of-life manual nor robotic disassembly in mind. This results in inefficient component disassembly and recovery.

With technologies advancing rapidly and Industry 4.0 tools becoming more common, it's important to consider that today's products may only reach their End-Of-First-Life decades from now. This means designs must not only support manual disassembly but also allow for semi or fully automated processes, making it easier to recover critical materials in an efficient manner.

In the SCANDERE project, we evaluated the original design of a robotic vacuum cleaner using the Re-DiM metric, a method developed to assess the ease of disassembly across manual and human-cooperative scenarios. The results highlighted key design barriers that complicated disassembly and CRM recovery, such as the integration of critical components into inaccessible areas.



Redesigning for human-robot cooperative disassembly

Using the Re-DiM metric and ecodesign principles, we iteratively quantified the improvements in ease of human-robot cooperative disassembly for the vacuum cleaner's redesigns. The

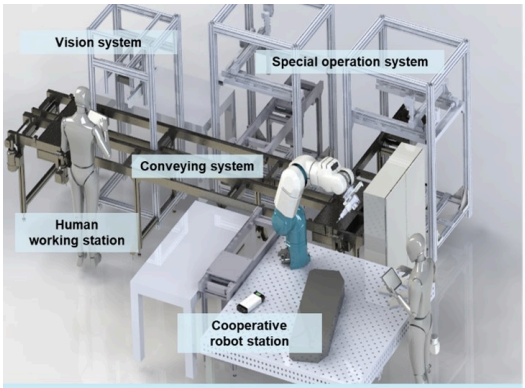
redesign aimed to maintain the exterior design and functionality of the original product while ensuring manufacturability. Key changes included:

- Focus on critical components: redesigned to ensure that CRM containing parts, such as motors and batteries, are more accessible for disassembly
- Standardized fasteners: reduced reliance on specialized tools and eliminated tool changes by adopting consistent fastening mechanisms
- Improved fastener accessibility: ensured that all fasteners are positioned to allow efficient robotic unscrewing operations
- Connector optimization: redesigned connectors, such as wire connections, to be compatible with robotic tools like two finger grippers, minimizing the need for manual intervention by an operator

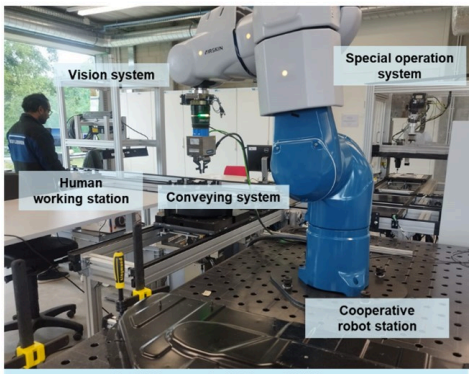
The changes allowed a robotic arm to efficiently dismantle products, recovering CRM-rich components and reducing manual disassembly time. This increased the efficiency of the human-robot cooperative process, highlighting its potential for scalable circular economy solutions. To learn more about Re-DiM metric, read our recent article. (https://doi.org/10.1016/j.procir.2024.02.021)

Watch the human-robot cooperative disassembly in action

Our project video showcases the human-robot cooperative re- and demanufacturing research platform available at the Professor Jef Peeters (https://www.linkedin.com/in/jefrpeeters/)' Re- and Demanufacturing Lab at KU Leuven (see picture below). It demonstrates the transformation from a design that hindered dismantling to one that enables automated recovery. To follow the recent updates of the re- and demanufacturing lab, visit our Linkedin page (https://www.linkedin.com/company/re-and-demanufacturing-lab-ku-leuven).



Planned Re-FMS research platform



Re-FMS research platform at KU Leuven

Watch the video of human-robot disassembly here (https://youtu.be/dgpRw1gqTYA?si=Pu-P-gbiX9cs9YVS).

Ecodesign for CRM recovery

The European Union's Critical Raw Materials Act highlights the urgent need to recover and reuse CRMs to reduce reliance on external supply chains and promote sustainable resource use. The transition towards a circular economy demands innovative approaches that consider the entire lifecycle of a product. Tools like Re-DiM metric, combined with ecodesign principles for an Industry 4.0 prepare products for human-robot cooperative disassembly and enhance access to CRM-rich components. This minimizes waste and reduces the need for new material extraction.

The SCANDERE project demonstrates how innovative product design can tackle global challenges. By aligning ecodesign with automation, manufacturers can create scalable, sustainable solutions for CRM recovery, advancing the EU's circular economy goals.

About the author: Dr. Núria Boix Rodríguez (https://www.linkedin.com/in/n%C3%BAria-boix-kul/) is a postdoctoral researcher in the Life Cycle Engineering (https://www.mech.kuleuven.be/en/research/LCE/home) group at KU Leuven. Her research specializes in life cycle engineering and eco-design, aiming to enhance product sustainability and extend their lifespan.